The MnDOT Bikeway Facility Design Manual is being updated (scroll down to see manual). Until updates are complete, please also see:

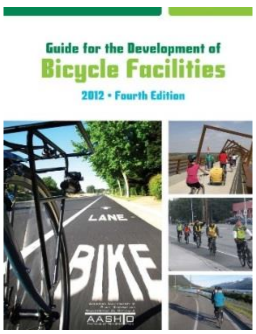
1. AASHTO's *Guide for the Development of Bicycle Facilities*

   NOTE:
   - Available to MnDOT staff at: http://ihub/library/ASTM-Portal.html
   - If outside MnDOT: guide available for purchase

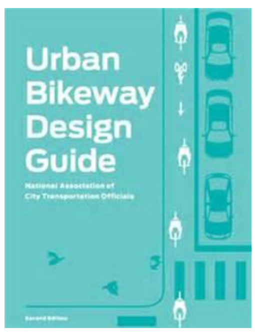
2. NACTO's *Urban Bikeway Design Guide*

3. FHWA's *Separated Bike Lane Planning and Design Guide*

4. FHWA's *Small Town and Rural Multimodal Networks*

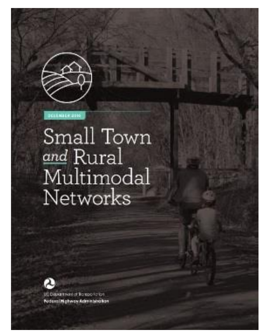


Cover image: AASHTO Guide for the Development of Bicycle Facilities



Cover image: NACTO Urban Bikeway Design Guide

Cover image: FHWA Separated Bike Lane Planning and Design Guide

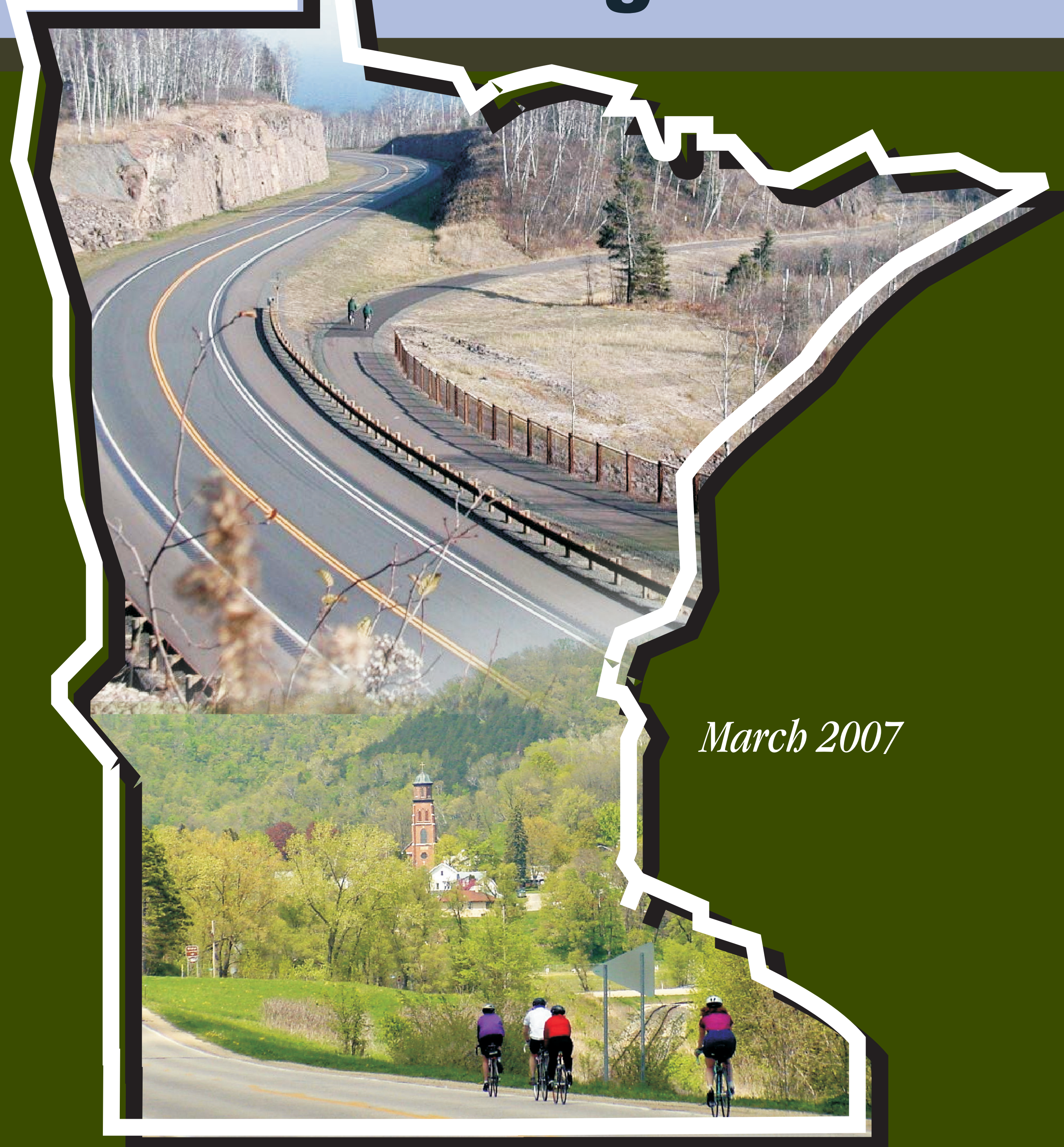


Cover image: Small Town and Rural Multimodal Networks

For More Information

- Melissa Barnes; State Bicycle & Pedestrian Safety Engineer
  Email: Melissa.Barnes@state.mn.us
  Phone: 651-234-7376
  OR
- Liz Walton; Landscape Architect
  Email: Liz.Walton@state.mn.us
  Phone: 651-366-4186

Mn/DOT Bikeway Facility Design Manual



March 2007

Acknowledgments

A number of Mn/DOT's professional staff along with key stakeholder organizations provided valuable technical review contributions that make this manual a useful bicycle design and planning tool for a number of years to come.

Particular appreciation for completion of this manual goes to members of Mn/DOT's Bicycle and Pedestrian Section. A special thanks to Bruce Holdhusen, P.E., Mn/DOT Office of Technical Support, for his detailed engineering edits and constructive suggestions, and Kuen Lai-Nelson, Electronic Publishing Coordinator, Publishing and Design, Mn/DOT Office of Civil Rights and Administrative Services for her layout design and production ready final product.

Table of Contents

Figures

Chapter 1: Introduction

1-1.0 Purpose

The purpose of the *Minnesota Bikeway Facility Design Manual* is to provide engineers, planners, and designers with a primary source to implement the Minnesota Department of Transportation (Mn/DOT's) vision and mission for bicycle transportation in Minnesota. This manual also provides citizens, developers, and others involved in the transportation planning process, guidance on the critical design and planning elements to promote bicycle safety, efficiency, and mobility.

Figure 1-1:

The Stone Arch Bridge into downtown Minneapolis was one of Minnesota's first Transportation Enhancements projects, and is a key link in the city's planned bicycle freeway system

Mn/DOT's vision for bicycle transportation:

> Minnesota is a place where bicycling is a safe and attractive option in every community. Bicycling is accommodated both for daily transportation and for experiencing the natural resources of the state.

Mn/DOT's mission for bicycle transportation:

> Mn/DOT will safely and effectively accommodate and encourage bicycling on its projects in Minnesota communities, plus in other areas where conditions warrant. Mn/DOT will exercise leadership with its partners to simular results on their projects.

1-2.0 Scope

1.2.1 General

The *Minnesota Bikeway Facility Design Manual* supersedes the *Minnesota Bicycle Transportation Planning and Design Guidelines (1996)*. This manual provides the information necessary to develop safe and consistent bicycling facilities. Bicycle safety, education and training, promotion of bicycle use, and the application and enforcement of the rules of the road as they pertain to bicyclists are further addressed in The *Mn/DOT Bicycle Modal Plan (2005)* and other resources.

The *Mn/DOT Bikeway Facility Design Manual* is provided to promote flexibility and innovation in planning, designing, constructing and maintaining bicycle facilities. These guidelines shall be used to the maximum extent possible. Professional judgment shall be used to determine the appropriateness of applying guidelines to a particular situation. Under no circumstance shall application of the guidelines be used to justify building to a lesser standard or denying accommodation.

1-2.2 Relationship to Other Technical Guidance

The *Mn/DOT Bikeway Facility Design Manual* should be used in conjunction with the current versions of the *Mn/DOT Road Design Manual,* the *Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD)*, the *American Association of State Highway and Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities (1999)*. In addition, *Minnesota Rules* Chapter 8820 must be applied to a project if local agencies are using any State Aid and/or Federal Aid funding on a project. Additional design and planning information for pedestrian transportation is addressed in *Design and Safety of Pedestrian Facilities* (Institute of Transportation Engineers; 1998).

1-3.0 Federal and State Laws and Policy

The requirements to accommodate bicyclists in our transportation system have their basis in state and federal law and policy. Mn/DOT project managers, designers, and planners should become familiar with this federal legislation, FHWA guidance, and state law and policy that exists to accommodate, protect, and enhance bicycle transportation.

1-3.1 Federal Transportation Law and Policy

Mn/DOT relies upon direction from the federal government through the United States Department of Transportation, FHWA, in planning and developing transportation infrastructure. Key among those directions is the Federal Highway Administration's (FHWA) Non-motorized Design Guidance pursuant to the Transportation Equity Act for the 21st Century (TEA-21), February 28, 2000, which states, "Bicycle and pedestrian ways shall be established in all new construction and reconstruction projects in urbanized areas (unless prohibited by law, excessive cost, or sparse population or other factors indicate absence of need)".

- Bicyclists and pedestrians shall be given due consideration in the comprehensive transportation plans developed by each metropolitan planning organization and State. [TEA-21, Section 1202(a)]
- Bicycle transportation facilities and pedestrian walkways shall be considered, where appropriate, in conjunction with all new construction and reconstruction and transportation facilities, except where bicycle and pedestrian use are not permitted. [TEA-21, Section 1202(a)]
- Transportation plans and projects shall provide due consideration for safety and contiguous routes for bicyclists and pedestrians. [TEA-21, Section 1202(a)]
- In any case where a highway bridge deck is being replaced or rehabilitated with Federal

financial participation, and bicyclists are permitted on facilities at or near each end of such bridge, and the safe accommodation of bicyclists can be provided at reasonable cost as part of such replacement or rehabilitation, then such bridge shall be so replaced or rehabilitated as to provide such safe accommodations. (23 U.S.C. Section 217)

- The Secretary of Transportation shall not approve any project or take any regulatory action under this title that will result in the severance of an existing major route or have significant adverse impact on the safety for non-motorized transportation traffic and light motorcycles, unless such project or regulatory action provides for a reasonable alternate route or such a route exists. [23 U.S.C. Section 109(n)]
- All projects using federal funds must identify and address the effects of all programs, policies, and activities on minority populations and low-income populations. (Presidential Executive Order 12898, Environmental Justice)
- The State is required to implement pedestrian access requirements from the Americans with Disabilities Act of 1990 (ADA) and Section 504 of the Rehabilitation Act of 1973 (Section 504). The FHWA promotes accessible transportation systems through technical assistance and guidance on ADA and Section 504. Off-road bicycle facilities must be designed for shared use with pedestrians and Mn/DOT must comply with these requirements in the planning, construction and maintaining highways, roadways, and bikeways and walkways.

Developing bicycle transportation systems, along with other non-motorized transportation, helps Minnesota meet six Federal Planning Requirements published by the FHWA pursuant to TEA-21:

1. Support the economic vitality of the United States, and states and metropolitan areas especially by enabling global competitiveness, productivity, and efficiency.
2. Increase the safety and security of the transportation system for motorized and non-motorized users.
3. Increase the accessibility and mobility options available to people and freight.
4. Protect and enhance the environment, promote energy conservation, and improve quality of life.
5. Enhance the integration and connectivity of the transportation system, across and between modes throughout the state, for people and for freight.
6. Emphasize the preservation of the existing transportation system.

1-3.2 State Law and Policy

By state law, bicyclists have the same rights and responsibilities as drivers of motor vehicles, except when provisions in law address bicyclists specifically (169.01, 169.22, and 169.305. Bicyclists are allowed to use public streets and highways in the state, except controlled-access freeways (MN statute 169.222, subd. 1, 169.305, subd. 1c). Generally, bicycling is allowed on all roads unless the road is signed indicating bicycling is prohibited. Bicycling is not allowed on sidewalks in business districts unless authorized by local authorities. Local authorities may prohibit bicycling on any sidewalk under their jurisdiction. Bicyclists must yield the right-of-way to pedestrians on sidewalks or in crosswalks (MN statute 169.222, subd.4d). Bicycling is allowed on road shoulders and is one way to effectively accommodate bicycling.

By state law, Mn/DOT has substantial authority and responsibility for accommodating and encouraging safe bicycling. Minnesota Statute Chapter 174.01, Subd. 2, (14), creating the Department of Transportation, specifically refers to bicycle transportation as part of the state's transportation system goals: "to promote and increase bicycling as an energy-efficient, nonpolluting, and healthful transportation alternative."

State law also parallels federal law in the goal to protect bicycle and pedestrian infrastructure, as Minnesota Statutes Chapter 160.264 describes:

> "Whenever an existing bikeway, pedestrian way, or roadway used by bicycles or pedestrians or the sole access to such is destroyed by any new, reconstructed, or relocated federal, state, or local highway, the road authority responsible shall replace the destroyed facility or access with a comparable facility or access. Replacement is not required where it would be contrary to public safety or when sparsity of population other available ways or other factors indicate an absence of need for such facility or access."

In addition, Minnesota Statutes, Chapter 160.265 states that the commissioner shall:

- Establish a program for the development of bikeways primarily on existing road rights of way.
- Compile and maintain a current registry of bikeways in the state.
- Provide technical assistance to local units of government in planning and developing bikeways.

The transportation goals for Minnesota are outlined in Minnesota Statutes, Chapter 174.01, which bicycling is a vital component:

- Promote and increase bicycling as an energy-efficient, non-polluting and healthful transportation alternative.
- Provide safe transportation to users throughout the state.
- Provide multimodal and intermodal transportation that enhances mobility, economic development, and provides access to all persons and businesses in Minnesota while ensuring that there is no undue burden placed on any community.
- Increase transit use in the urban areas by giving highest priority to the transportation modes with the greatest people moving capacity and to provide transit service throughout the state to meet the needs of transit users.
- Ensure that the planning and implementation of all modes of transportation are consistent with the environment and energy goals of the state.

To the fullest extent practicable the policies, rules, and public laws of the state shall be interpreted and administered in accordance with Minnesota Statutes, Chapter 116D.02, State Environmental Policy, which reads: "State government shall use all practicable means:

- To assure safe, healthful, and aesthetic surroundings for all citizens;

- To maintain variety of individual choice;
- To encourage styles of living that minimize environmental degradation;
- To reduce the deleterious impact on air quality from operation of motor vehicles with internal combustion engines, and;
- To minimize noise.

State policy is also described in the following:

- State Aid for Local Transportation, Minnesota Rules Chapter 8820

  This provides minimum design requirements for projects receiving State Aid or Federal Aid funding.
- Minnesota Statewide Transportation Plan

  This outlines the agency's goals and measures for Minnesota's transportation system.
- Mn/DOT Bicycle Modal Plan

  This provides the policy framework for integrating bicycle accommodation on Mn/DOT roads and Minnesota's transportation system.

1-4.0 Organization of Manual

Chapter 1: Introduction

The scope of this manual and its relation to other technical guidance is described, along with the state and federal policies and laws that influence bicycle facility planning and design.

Chapter 2: Planning and Project Coordination

A summary of the bicycle network planning process, funding sources, project planning and project development is provided. How Mn/DOT integrates bicycle transportation into its projects is presented, including specific recommendations for stakeholder participation, preparing environmental documents and evaluating alternative designs.

Chapter 3: General Design Factors

The characteristics of bicyclists, bicycle dimensions and operating space are presented. Basic types of on-road and off-road accommodations are described along with a discussion of the importance of designing for other users such as inline skaters, adult tricycles, bicycle trailers, recumbent bicyclists, and wheelchair users.

Chapter 4: On-Road Bikeways

Design for on-road bicycle accommodation is presented along with guidance on choosing on-road bikeway type according to roadway characteristics and other factors. Bicycle lanes, paved shoulders, shared lanes, shared-use and wide outside lanes are described.

Chapter 5: Shared-Used Paths

Design for off-road bicycle accommodation is presented, as well as guidance on intersection selection and design. Shared-use paths are described, including the design and construction of shared-use paths, speed and safety considerations, geometrics and pavement material and construction.

Chapter 6: Bridges, Over/Underpassess, Rest Areas and Shuttle Sites

Guidelines are provided for bikeways on bridges, underpasses and overpasses. Information on bike accommodations at rest areas and scenic overlooks, and methods for addressing gaps in bicycle accommodation are also presented.

Chapter 7: Traffic Control

Requirements and guidelines are presented for using pavement markings and symbols, curbs and medians, signs, detection systems and other techniques for improving safety, mobility and accessibility.

Chapter 8: Bicycle Parking

Information on bicycle parking types and dimensions is outlined, including guidelines on where to locate parking facilities and ways to consider security.

Chapter 9: Maintenance

Guidelines and requirements for maintaining bikeways are summarized. A list of bikeway-related items is included for development of a maintenance plan.

Chapter 2: Bikeway Network Planning and Project Coordination

2-1.0 Introduction

Successful bicycle networks are created when bicycle transportation is integrated within the overall transportation plan and bicycle accommodation is included in individual transportation projects. Federal and state law intends for bicyclists and pedestrians to have safe, convenient access to the transportation system. Every transportation improvement is an opportunity to enhance the safety and convenience for bicyclists and pedestrians. The AASHTO Guide for the Development of Bicycle Facilities (1999) states:

> "All highways, except those where cyclists are legally prohibited, should be designed and constructed under the assumption that they will be used by cyclists. Therefore, bicycles should be considered in all phases of transportation planning, new roadway design, roadway reconstruction, and capacity improvement and transit projects."

This chapter provides a background on the Federal Highway Administration (FHWA) guidance and the legal basis for integrating bike transportation into planning processes, describes the regional and state planning processes, outlines the principal elements of bike network planning, including bicycle and motorist education and public involvement. This chapter also describes Mn/DOT's project development process and bicycle accommodation integration into Mn/DOT projects.

2-1.1 Applying a Context Sensitive Solutions Philosophy

The FHWA defines Context Sensitive Solutions (CSS) as:

> "a collaborative, interdisciplinary approach that involves all stakeholders to develop a transportation facility that fits its physical setting and preserves scenic, aesthetic, historic, and environmental resources, while maintaining safety and mobility. CSS is an approach that considers the total context within which a transportation improvement project will exist."

Mn/DOT employs a context-sensitive approach that integrates design standards and criteria, safety concerns, cost considerations, environmental stewardship, and aesthetics with community-sensitive planning and design to create excellence in project development. This approach relies upon collaborative and interdisciplinary processes that involve stakeholders early and continuously in project development. Identifying and resolving important concerns early helps to eliminate costly rework cycles later on, when design options are constrained by earlier decisions.

To support this vision, Mn/DOT advocates six key principles of successful project development:

1. Balance safety, mobility, community, and environmental goals in all projects.
2. Involve the public and affected agencies early and continuously.
3. Address all modes of travel.
4. Use an interdisciplinary team tailored to project needs.
5. Apply flexibility inherent in design standards.
6. Incorporate aesthetics as an integral part of good design.

CSS encourages the exploration of design flexibility in order to better balance economic, social, and environmental objectives. Experience has shown that time spent discussing project development needs and options with the public as early as possible results in more successful projects, while saving overall time and expense in project development by avoiding rework cycles.

2-1.2 Design Flexibility

Stakeholders are more likely to embrace projects when design standards are flexible enough to respond to community values. The foreword of the American Association of State Highway and Transportation Officials' (AASHTO) 2004 publication, *A Policy on Geometric Design of Highways and Streets* (The Green Book) states:

> "As highway designers, highway engineers strive to provide for the needs of highway users while maintaining the integrity of the environment. Unique combinations of design requirements that are often conflicting result in unique solutions to the design problems … Sufficient flexibility is permitted to encourage independent designs tailored to particular situations."

Planners and designers are encouraged to think and act broadly to explore the full range of design objectives, needs, alternatives, and potential trade-offs (what may be gained vs. what may be lost) in decision-making applicable to a bikeway plan or project.

The project team must consider all alternatives within the range of flexible design alternatives appropriate for the project. The cost of these alternatives should be weighed against the physical, safety and social benefits of the project.

2-2.0 Mn/DOT Planning Process

The goal is to develop a bicycle-friendly transportation system by helping to establish a bicycle network by several different approaches, for example, providing adequate space on the road for bicyclists, installing bicycle sensitive traffic signals, and assisting in the coordination of local jurisdictions.

In planning Mn/DOT projects, project managers need to evaluate the impact of design and traffic factors on bicycle accommodations and take the needed actions to maintain bicycle accessibility. Some of the design and traffic factors to assess include:

- Posted vehicle speeds
- Motor vehicle traffic composition, traffic volumes, turning movement counts, and projected data
- Crash history along the corridor
- Signals that may impact safety and flow of the proposed design
- Changing the road to controlled-access or eliminating accesses
- Geometry of turn lanes, shoulders, raised medians, streets, lanes, and entrance widths

Mn/DOT funds the State Bicycle and Pedestrian Coordinator position to promote and facilitate the increased use of nonmotorized transportation. This includes assisting in the development of bikeway facilities on Mn/DOT projects and providing education, promotional, and safety information for citizens and local governments. The State Bicycle Coordinator helps develop and coordinate bicycle and pedestrian policies and programs at the State level. Mn/DOT also provides technical assistance on bicycle accommodations for Mn/DOT projects and to local governments in their planning and developing bikeways.

Mn/DOT maintains a current registry of bikeways in the state, publishes, and distributes the registry, primarily through a state bicycle map. The list of bikeways is generated through the collaboration of other state agencies and local governments.

Mn/DOT provides programs and materials to encourage safe and effective bicycling, and coordinates with other state offices and bicycle advocates to improve conditions for biking. The State Bicycle Advisory Committee in conjunction with Mn/DOT provides advocacy for bicycling and is comprised of both citizen and state agency representatives.

Environmental Justice

Environmental Justice, an Executive Order issued on February 11, 1994 (EO 12898) was established to identify and address disproportionately high and adverse human health or environmental effects including interrelated social and economic effects of the programs, policies, and activities of government agencies on minority populations and low-income populations in the United States.

To address the concerns identified by Environmental Justice order, Mn/DOT works with local governments and other partners to create transportation system connectivity, to increase travel options, and to improve safety for bicycling and walking. Low-income and minority residents, as well as other citizens, benefit from a developed bicycle system interconnected with pedestrian transportation and transit service as well other modes of travel.

THE AMERICANS WITH DISABILITY ACT

The FHWA states:

"Shared use paths and pedestrian trails that function as sidewalks shall meet the same requirements as sidewalks. Where shared use paths and pedestrian trails cross highways or streets, the crossing also shall meet the same requirements as street crossings, including the provision of detectable warnings."

Figure 2-1:

Adding or improving paved shoulders can be the best way to accommodate bicyclists in rural areas and can extend the service life of a road surface

2-2.1 Statewide Transportation Planning

Since the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 and the Transportation Equity Act for the 21st Century (TEA-21), adopted in 1998, a multimodal transportation system has been an integral part of transportation planning. As directed by the FHWA and described in federal law, Mn/DOT and metropolitan planning organizations (MPOs) must carry out cooperative transportation planning processes that result in a long-range statewide plan and a State Transportation Improvement Program (STIP).

Mn/DOT has decentralized its program decision-making process to a more regional level (i.e. the districts) by asking each district to establish its own Area Transportation Partnership (ATP) to broaden input into the project selection process. Each year the ATPs develop an Area Transportation Improvement Program (ATIP). ATP membership includes traditional and non-traditional transportation partners that include Mn/DOT, municipalities, counties, state agencies, regional planning organizations (i.e. MPOs), transportation modal interests, Indian communities and citizens. The long-range plan provides for the development and management of multimodal transportation systems, including pedestrian and bicycle transportation. According to federal law, bicycling and walking must be given due consideration in the planning process in the STIP and MPO's Transportation Improvement Programs (TIPs) and the ATPs Area Transportation Plan (ATIP).

The STIP provides a list of proposed federally and Mn/DOT supported projects for the next four years consistent with the long-range plan. Projects and strategies are developed to increase the safety and security of the transportation system for non-motorized travel by developing transportation facilities that will function as an intermodal transportation system.

The statewide plan sets the long-term direction for transportation investment and typically includes a broad vision statement, long-term goals and objectives, policy statements, and priority areas for the State and metropolitan areas. Metropolitan plans will identify specific projects, and statewide plans may provide this level of detail. These plans must address goals and issues for all modes of transportation within each metropolitan planning area.

The plans typically identify important corridors that need study, or programmatic areas such as improving access for people to bicycle to work or improving access for people with disabilities. Bicycle and pedestrian transportation should be integrated into the overall transportation plan or in a separate plan within the overall plan to show how these modes will be developed and enhanced in the years ahead.

The STIP lists specific projects by Mn/DOT in each of the following four years, each with a short description of the actions to be taken. The projects must be consistent with projects, programs, and/or policies contained in the long-range plan and must have an identified source of funding.

Specific requirements for the TIP/STIP include the following:

- Contain all capital and non-capital transportation projects (including transportation enhancements, Federal lands highway projects, bicycle transportation and pedestrian facilities), or identified phases of transportation projects ...; and (23 CFR 450.216)

- All transportation projects, or identified phases of a project, (including pedestrian and bicycle transportation facilities and transportation enhancement projects) within the metropolitan area proposed for funding under title 23, U.S.C., (23 CFR 450.324)

The FHWA allows states to streamline the approval and implementation of bicycle and pedestrian projects so that states can speed up the implementation of projects that improve conditions for bicycling and walking.

The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) builds on its predecessors, which created a new focus for transportation. These Federal transportation acts have emphasized development and management of a seamless multimodal transportation system for the movement of people and goods.

Non-metropolitan local transportation needs must be included in the STIP development process according to federal rules and SAFETEA-LU. Through the participation of Mn/DOT's ATPs, non-metropolitan needs are presented and addressed. Each ATP is responsible for ensuring that its process for Area Transportation Improvement Program (ATIP) development includes public participation. ATP meetings must be publicized, and review and comment opportunities must be provided for the draft ATIP. For many ATPs, elements of the public involvement process may be somewhat informal, but should be well documented. The Twin Cities Metropolitan Council must hold a formal public meeting since it is a transportation management area (TMA) as defined in SAFETEA-LU.

SAFETEA-LU also requires that MPOs involve bicycle and pedestrian representatives and representatives of people with disabilities, freight shippers and haulers, employees of public transit agencies, and other groups in the development of the MPO's public participation plan. The State must also provide for public comment on existing or proposed procedures for public involvement.

2-3.0 Public Involvement

Early and continuous public involvement is an essential part of Mn/DOT project planning and development process. For bikeway projects, public involvement may include working with local and regional transportation organizations and government entities, coordinating with local or regional bike network plans, and conducting public meetings to exchange information about a project. The Mn/DOT project manager may need to develop a public involvement plan specifically for the project.

Public involvement should occur during development of the local or regional bike network plan, frequently including local participation by citizen groups, government advisory committees, area transportation partners, regional development commissions, and metropolitan planning organizations.

2-3.1 Roles and Responsibilities

Since there may be several overlapping jurisdictions within a plan or project area, it is important to understand the unique perspectives and responsibilities of the different levels of government. Communicating as early as possible with representatives of these various jurisdictions will provide valuable insights to document a potential project's purpose and need during the scoping and planning process.

All stakeholders must understand who has primary responsibility and empowerment for making specific decisions, and what specific areas are open for discussion. Mn/DOT, as a funding agent, designer, and constructor, is often a primary project stakeholder. Ownership, operations, and maintenance of the bikeway facility must also be thoroughly discussed and understood to sustain long-term acceptance and use. Advocates and special interest groups are encouraged to work with local government and state agencies to find individuals who can champion issues, respond to questions, steer appropriate resources, and direct assistance. Additionally, there are individuals who will aid in identifying construction and operation funding sources.

Cities often initiate the bike network planning process, and act as the keeper and caretaker of the plan. Citizen involvement and input is necessary to hold the planning process accountable, and to verify and authenticate the design objectives and establish performance measures. Mn/DOT may assist with guidance and technical support, and often acts as the primary funding agency. Municipal planning organizations and regional development commission provide input, oversight, and programming priorities. Area transportation partnerships develop programming priorities for federally funded projects.

To be effective advocates for bikeways in Mn/DOT projects, local governments need to complete a bike network plan and update the plan as land development and other changes occur. Mn/DOT's ability to include bikeways in some highway and bridge projects may be dependent on the completeness of the local bike network plan. State and local cost participation percentages may depend on how the local bike network plan integrates bikeways with trunk highways, bridges, and local roads.

Mn/DOT's cost participation policy exists to provide cooperative construction with LGUs where mutual benefits and demonstrated transportation needs exist. The policy is written for application to Mn/DOT-initiated projects; however, it may also be applied to a locally initiated project with eligible trunk highway items. Mn/DOT cost participation will typically be within the range amounts identified in the policy. Further information on Cost Participation Policy can be by contacting the District State Aid Engineer.

2-3.2 Identifying Stakeholders

Before any design work begins, community and stakeholder values must be thoroughly discussed and understood. Identifying stakeholders and understanding their motivation, mission, and culture will provide valuable insight and result in successful project implementation. While there will be many areas of agreement, some issues may be contradictory and mutually exclusive, requiring a good deal of negotiation to find the appropriate balance.

Some examples of typical stakeholders and a sample of their bike network and facility issues include:

- **Local governments** will be especially tuned to the needs, vision and desires of their communities and proactively protect the health, safety, and welfare of their citizens, and may include funding participants.

- **Mn/DOT** will be a funding participant and will be concerned with balancing priorities, design standards, and the project purpose and need during the planning, design, and construction of a facility, as well as the long-term operations and maintenance of many facilities.
- **Federal government** could be a funding participant and could have design approval authority.
- **The Minnesota Department of Natural Resources** (DNR) will want to understand the intended use of the bicycle facility and how user connections can be made to state parks, existing trails, and other recreation facilities in addition to possible environmental interest.
- **Regulatory agencies** protecting air, water, and other aspects of the environment will defend and protect resources.
- **Advocate and special interest groups** such as tourism associations, cycling groups, and charity organizations may champion development of facilities for use by their constituency.
- **Environmental and sporting groups** may be concerned about the potential impact of the project on natural resources.
- **Various business and commercial ventures** might be concerned about the perceived impacts on their enterprises.
- **Residents in close proximity to the project area**, likely to use the bikeway upon completion may be concerned of project's impact on other transportation facilities.
- **Residents who currently bike in the project area** have an interest in potential transportation impacts during construction and concern for the how the bicycle transportation will be after the construction project.
- **Transit providers.** Bicycle routes may also be transit routes, so transit providers would want feedback and input into sharing lanes, and the possibility of providing more bicycle facilities such as bike racks on buses or bike parking at bus stops.

Understanding non-participatory stakeholders can be a great challenge. Mn/DOT and local governments should make a special effort to involve diverse or scattered groups or individuals who could have an unexpected desire for a bike network connection. For example, commuting to a central business area via bike network may not have been considered viable when initially choosing a home or lake cabin location, but could be a real option if bike facilities are properly planned and implemented.

Early and inclusive planning can benefit all stakeholders. It is recommended that both Mn/DOT and local governments hypothesize who non-participatory stakeholders may be and what they may gain from the network or project, and then prepare strategies for involving this hidden segment of the public. A wide range of public involvement examples and techniques are found in Mn/DOT's public involvement plan, *Hear Every Voice*.

2-3.3 Working With Stakeholders

Mn/DOT should focus on understanding community values as early as possible in project planning and scoping. Continual engagement with stakeholders throughout the planning, scoping, design and construction process is strongly encouraged. One-time or occasional meetings will not truly represent the public and will not necessarily reveal the most important issues. Significant, inclusive involvement with the public will identify more issues early on, thus avoiding delays that occur when issues arise later in the project development process.

Public involvement at the project level in the form of outreach, data gathering, or public participation may include the following methods:

- Newsletters
- Web sites
- Mass media
- Phone hotlines
- Public hearings
- Informal meetings
- Personal contacts
- Direct mail

Developing a written public involvement plan or communication plan is an important early step in project development. Since public involvement may occur throughout project development and construction, the plan should be reevaluated periodically and revised as needed. The project public involvement plan typically includes the following elements:

- Project history and background
- Goals, objectives, and expected outcomes of public involvement
- Identification of stakeholders, participants and audiences
- Public involvement strategies and techniques
- Budget and schedule for public involvement efforts, and responsibilities for implementing public involvement.

Involving the public is necessary to define community vision and validate the bike network plan and individual facility needs. This involvement creates the opportunity to support community values, goals and unique perspectives that affirm a sense of place for a community.

Due to funding constraints, Mn/DOT may not be able to implement all features identified during the public involvement process. If portions of the identified community vision go beyond the scope of the project, action should be taken to document these ideas during the public involvement process and to reintroduce them into subsequent transportation planning at the state, regional or local level.

2-4.0 Mn/DOT Project Planning and Project Development

Each Mn/DOT project takes years to plan and design before it is constructed. This section describes the planning and design process, and provides information that will help incorporate bike facilities into Mn/DOT projects. Although bike facilities are a relatively small part of highway and bridge projects, Mn/DOT has a responsibility to consider bicycle and pedestrian issues in all projects, and to coordinate with local bikeway planning efforts.

It is important to understand that the most effective time for considering bicycle transportation in Mn/DOT projects is during project scoping and early in preliminary design.

2-4.1 Overview of the Mn/DOT Highway Project Development Process

Mn/DOT projects follow a process that starts with statewide and district long-range planning, then moves through project scoping, preliminary design, final design and construction. Planning and project scoping includes:

- Identifying transportation needs
- Proposing projects that address those needs
- Prioritizing transportation needs and projects
- Identifying the major elements to be included in individual projects
- Establishing project and program funding, budgets, and schedules
- Establishing a public involvement process.

2-4.1.1 Project Scoping Process

Once a transportation need is identified as a priority, Mn/DOT projects go through a scoping process where project needs are balanced with program funding. The District project manager prepares a project scoping report summarizing information on project scope, cost estimate, and input received from Mn/DOT functional groups and other stakeholders, and District management approves the project scope. (Note that the project scoping report is not the same as the EIS Scoping Document, which is a separate document prepared only for projects that require an Environmental Impact Statement.)

Involving stakeholders during the scoping phase of a project is generally necessary to appropriately define project issues and problems. Mn/DOT is the primary stakeholder at this phase and takes the leadership role of forming and directing this discussion. Many Mn/DOT functional groups must be included in this discussion, such as planning, design, construction, maintenance, traffic, bridge, State Aid, materials, and hydraulics. Before proceeding, the purpose and need of the project must be clearly defined, and an understanding of the project direction reached by all stakeholders. While complete consensus may be impossible, informed consent, in which all stakeholders understand mutually acceptable solutions, will allow the project to move forward.

2-4.1.2 Preliminary Design Process

The preliminary design phase includes further evaluation of alternatives, environmental reviews, confirmation of the project scope, and development of a project layout drawing, if required. Preliminary design documentation includes a project environmental document, a geometric layout drawing, and geometric design standards tables. Following preliminary design, the final design is developed and construction plans are prepared.

Projects with a limited scope, such as pavement preservation (mill and overlay), may require minor environmental review and may not require the preparation of a geometric layout. Such projects may, in practice, proceed directly from project scoping to final design. These projects have great potential for improving bicycle accommodation by offering opportunities for improvements such as adding signing and striping, improving lighting, reducing on-street parking, changing accesses, improving driveways, and installing new curb ramps. Major construction projects, however, require extensive environmental reviews, which can take several years to complete, as well as evaluation of alternatives and development of geometric layout drawings and tables

2-4.1.3 Mn/DOT Project Development Guidance

The Mn/DOT Highway Project Development Process (HPDP) web site provides guidance and documentation to ensure that all laws and regulations are followed during the preliminary design phase of project development. The HPDP web site is updated frequently to provide current policy and contact information. Access it and the project development handbook at the Office of Technical Support via the "Mn/DOT A to Z" function on the Mn/DOT home page (www.dot.state.mn.us).

The HPDP web site includes a web page of guidance for Mn/DOT project managers on Bikeways and Pedestrians issues. This web page provides such information as:

- The legal basis of the requirement to accommodate bicycles and pedestrians
- Threshold criteria for determining the projects to which the guidance is applicable
- Bikeways and pedestrians in project environmental documents
- Bikeways and pedestrians in preliminary design documentation
- Web links to guidelines, regulations and other sources of information.

2-4.2 Bikeway Considerations in Project Environmental Documents

Mn/DOT projects receive environmental review as required by state and federal laws, and FHWA rules. Certain types of small projects are exempt from environmental review, but must comply with environmental rules. There are several types of project environmental documents that may be used to satisfy the requirements of the National Environmental Policy Act (NEPA) and its Minnesota law counterpart, depending on project size and location and the likelihood of the project to have significant environmental effects. Each of the following types of environmental documents follow a specific process for preparation, review, and approval:

- A combined state/federal Environmental Impact Statement is prepared for large, complex projects and for projects that are likely to have significant environmental impacts.
- A Federal Environmental Assessment document and/or state Environmental Assessment Worksheet is prepared for certain types of large projects, as specified in state law, and for projects where it is not certain if there will be significant environmental impacts
- A Mn/DOT Project Environmental Memorandum is prepared for small projects that will not have significant environmental impacts.

2-4.2.1 Statement of Purpose and Need

All environmental documents, as well as the project scoping report, include a project Statement of Purpose and Need. In the context of project environmental documents, "need" includes a listing all of the underlying justifications for the project, and "purpose" should be broad enough to allow consideration of alternatives for meeting the need.

Justifications for the project need generally consists of such items as pavement quality measures, crash statistics, level of service statistics, and geometric deficiencies. FHWA guidance specifically requires consideration of all transportation modes in the Statement of Purpose and Need (FHWA Technical Advisory T6640.8A; 1987). Needs or justifications that are relevant to the bicycle mode of transportation include, but are not limited to, considerations such as:

- Bike facility linkage
- Safe accommodation of bicyclists
- Barriers to bicycle mobility
- Linkage with other modes
- Driver and bicyclist behavior

2-4.2.2 Social, Economic and Environmental Considerations

Bikeways should be considered in the social, economic and environmental portion of the environmental document in the following specific areas:

- Construction impacts
- Land use
- Environmental justice
- Social (and community) impacts
- Accessibility
- Bikeways and pedestrians

The project environmental document is prepared at approximately the same time as the preliminary design layout drawing, but coordination may be difficult because the design is generally developed by a different group or consultant than the environmental document.

2-4.3 Bike Facility Considerations in Preliminary Design Documentation

Design documentation in the preliminary design phase includes a layout drawing and a geometric design standards table. The project development process includes the following two steps that consider bike facilities in preliminary design:

- Geometric design standards tables include a checklist regarding bikeways, as listed below.
- The Bicycle and Pedestrian Section of the Transit Office reviews preliminary or draft geometric layouts to provide comments to the District design group, as described below.

2-4.3.1 Geometric Design Standards Tables

Geometric design standards tables and a project design memorandum are required for projects to which new construction/reconstruction standards or preservation standards apply. (Forms and guidance are available on the Mn/DOT web site.) The following checklist is included in the geometric design standards table to verify that bicycle accommodations are considered in preliminary design.

Bicycle and Pedestrian Considerations

(Check all that apply)

1. Select one of the following (a or b) if bicycles and pedestrians will not be allowed on this roadway:
   ( ) a. crossing of this roadway by bicycles and pedestrians ( ) will be ( ) has been evaluated in the development of this project
   ( ) b. accommodation for crossing of bicycles and pedestrians has been evaluated and found to be not required for this project (see HPDP Bikeways and Pedestrians Guidance – Threshold Criteria).
2. ( ) Bicycles and pedestrians are not prohibited from this roadway, and accommodation of bicycles and pedestrians ( ) will be ( ) has been evaluated.
3. ( ) Existing access for bicycles or pedestrians will be eliminated by this project (an alternative route for bicycles and pedestrians must be provided).
4. If 1(a), 2 or 3 is checked, list the local units of government that ( ) will be ( ) have been contacted for information to coordinate this project with existing and proposed bikeways:
5. ( ) Preliminary layouts and/or draft layouts ( ) will be ( ) have been provided to the Bicycle and Pedestrian Section of the Transit Office for advisory comment in accordance with the HPDP project review guidelines (see *HPDP Bikeways and Pedestrians Guidance – Threshold Criteria*).

2-4.3.2 Review of Project Layout Drawings for Bikeways

The Bicycle and Pedestrian Section of the Office of Transit reviews preliminary or draft layout drawings for all projects with a Level 1 or Level 2 layout, and those with Level 3 layouts at the request of the District project manager (see the HPDP Geometrics guidance for an explanation of layout levels). The bicycle and pedestrian section then sends advisory recommendations to the District project manager. A scale of 1:100 is preferred for preliminary or draft layouts reviewed by the Bikeways and Pedestrians Section.

All final geometric layouts that require staff concurrence by the State Geometrics Engineer or formal approval by the State Design Engineer are reviewed by the Bicycle and Pedestrian Section as well as the Geometrics Design Support Unit. The purpose of a Bicycle and Pedestrian Section review is to avoid having a final geometric layout submitted for approval without accommodating bicycles and pedestrians, which could result in rework or delay. For projects that do not require a project layout drawing, the District must still review each project for bicycle and pedestrian accommodation.

2-4.4 Bike Facility Design in Mn/DOT Project Layouts

For Mn/DOT Project Managers and others following guidance of the HPDP, there are many specific bicycle facility elements that need consideration, evaluation and coordination. Project layout drawings are required for certain types of projects, and optional or unnecessary for other projects. The following types of projects require a project layout and are likely to involve bike facilities:

- Interstate projects
- Non-interstate national highway system (NHS) projects with major construction or major reconstruction
- Federally-funded design/build projects
- Major bridges (over $10 million)
- Projects with major changes in freeway access
- Raised channelization projects
- Projects with a change in the number of lanes
- Major intersection revisions
- Moderate changes in access
- Any project involving approval of design exceptions

A project layout drawing is also required for any project that needs Municipal Consent. State law requires Municipal Consent, in the form of city council approval of the final geometric layout, for any trunk highway project that, within the limits of a city, results in alteration of access, increase or decrease of traffic capacity, and/or acquisition of permanent right of way (*Minn. Statutes 161.162, et. seq.*). The city's review and approval of the layout is limited to the project elements in the final layout that are within the boundaries of that city.

For many small projects, a layout drawing is optional or unnecessary. A project layout may be optional for the following types of projects that are likely to have bikeways involvement:

- Guardrail work
- Culvert extensions, elimination or replacement
- Overlays, widening and standard turn lanes
- Minor painted re-stripping or channelization
- Minor changes in access
- Minor intersection revisions
- Rest areas (non-NHS)
- Signal installation
- Frontage road construction
- Lighting.

2-4.4.1 Project Factors Affecting Bicycle Accommodation

During the project development process, the Mn/DOT project manager must research and evaluate the existing facility that will be integrated with a bikeway network plan. As early as possible during the planning, scoping, and development stages of a project, the following information needs to be understood relative to bikeways. A more extensive layout checklist is available on the Mn/DOT web site by locating "Geometric Design & Layout Development" through the Mn/DOT A to Z function.

- **Existing Speed Zones**. Analyze existing posted speeds and understand potential geometric impacts on the proposed bike facility.
- **Traffic Data.** Consider the impacts on bike facility safety and capacity on traffic composition, traffic volumes, turning movement counts, and projected data.
- **Crash Data.** Evaluate any recorded crash history along the corridor.
- **In-Place Signals.** Evaluate the locations of existing signals that may impact safety and flow of the proposed design.
- **In-Place Widths**. Examine the geometry of turn lanes, shoulders, raised medians, streets, lanes, and entrance widths, and their relationship to the intended bike facility.
- **Existing Accesses and Entrances.** Review current alignment to verify location of new entrances.
- **Land Uses.** Evaluate current adjacent land use and potential relationship to the bike facility.
- **Proposed Developments.** Review any proposed development plans to understand potential impacts of new traffic generators, especially for large commercial developments and civic facilities such as libraries, parks, or zoos.

2-4.4.2 Proposed Layout Design Evaluation

As a project moves into final design, a project manager should evaluate and review a proposed transportation project for bike accommodation. Mn/DOT project managers and planners need to ensure continued bicycle access during and after construction by providing bicycle accommodation within the project, a parallel street serving as the new bicycle route, or as a last resort, to provide shuttle bus service where it is difficult or too costly to add bicycle infrastructure. The following design and traffic elements should be reviewed:

- **Signals.** Evaluate the locations of proposed signals that may have positive or negative impacts on road bicycle use, flow and safety.
- **Transit Facilities.** Evaluate transit stops, turnouts, special lanes, park and ride lots and their functional interaction and relationships with the proposed bicycle facility.
- **Widths and Lengths.** Assess the safety and geometric impact on the proposed bike facility of bypass, turn, auxiliary, HOV, and climbing lanes, shoulders, medians, bridge features, etc., and consider what, if any, areas of design flexibility may be appropriate.
- **Minimum Sight Distances and Corners.** Evaluate the safety of horizontal and intersection sight lines that may cross or otherwise affect the bike facility.
- **Property Entrances and Widths**. Assess the impact that new or modified entrances may have on crossings and continuity of bike facilities.
- **Vehicle Turn Path, Tapers and Radii.** Calculate the geometric design footprint and wheel paths of vehicles to determine how they may interact with bicycles.
- **Typical Sections.** For bridges, physically constraining site features such as retaining walls, guardrails, or fencing, or other special circumstances, evaluate the footprint, inter-relationships, and safety implications on the proposed bicycle facility.
- **Paths and Trails.** Evaluate the accessibility and locations of shared use paths, trails, and their connections to the larger system network.
- **Pedestrian Facilities.** Evaluate for possible pedestrian and bicyclist conflicts and determine if adequate pedestrian facilities are provided.
- **Design Exceptions.** If appropriate, evaluate and document design exceptions and their impacts on the proposed bicycle facility.

2-4.4.3 Technical Support and Functional Group Review

The following functional groups within Mn/DOT provide guidance and technical support and review during project development:

- **Geometrics.** The Geometrics Unit, in the Office of Technical Support, encourages and welcomes the submittal of preliminary design concepts and layouts for comments prior to the final layout phase.
- **Traffic.** Mn/DOT district traffic engineers should be involved early to offer initial observations and comments regarding the interaction of vehicular traffic with the intended bike facility. Understanding the functional classifications and constraints will help form design solutions.

- **Maintenance Operations.** Mn/DOT district maintenance and operations need to be addressed, especially if on-road facility designs have special requirements.
- **State Aid.** If State Aid or Federal Aid funding is used on a project that incorporates a bicycle facility, Mn/DOT's State Aid Office needs to be involved for guidance regarding design standards and eligibility of project items for dedicated funding.
- **Bridge.** If the proposed facility or corridor contains bridges or crossings, Mn/DOT's Bridge Office should be involved for coordination with any bridge planning, design, construction, and maintenance.
- **Landscape Architecture.** The Office of Technical Support provides support and guidance on ensuring that Context Sensitive Solutions approach is followed and provides training and technical support to help multimodal safety, accessibility, mobility with environmental and community objectives.
- **Bicycle and Pedestrian Section** reviews scoping reports, preliminary or draft layouts, provides advisory comments to the Mn/DOT project manager, and provides guidance on ADA requirements. The Section also provides planning and design resources, coordination with local government agencies, project reviews and training.
- **Municipal, Maintenance or Operational Agreements**. Determine the need for any agreements for the construction, maintenance or operations of bicycle facility, and conduct early discussions with local government agencies to facilitate agreements and timely decisions. The project manager may need to arrange for a maintenance agreement that will assign a local government agency the responsibility of routine, minor, or major maintenance of the bicycle facility. See Chapter 9 of this manual for specific information about maintenance and maintenance agreements.

2-4.5 Planning and Design Checklists for Mn/DOT Projects

Planning and design checklists for bicycle accommodation are provided in Appendix C, and are intended for use by project managers, planners, and designers to help plan and design bicycle and pedestrian facilities on Mn/DOT projects. See Table C-1 and Table C-2 in Appendix C of this manual. The checklists serve as a starting point to query assumptions and identify issues and opportunities regarding bicycle and pedestrian accommodations for a proposed Mn/DOT project. The checklists promote efficient and comprehensive project development and verification of project purpose and need.

Bicycle and pedestrian facility design usually affects other aspects of the road and bridge design including typical section widths, profiles, drainage, lighting, landscaping, barriers, striping, utility relocation, snow storage, maintenance responsibilities, interagency coordination and planning, municipal approval, funding, cost participation, and others. Therefore, it is important to seek technical assistance for bicycle and pedestrian facility planning early in the scoping, planning and design processes. Bicycle and pedestrian facility design should not be considered an "add on" or "after-thought" issue.

Consult other sources of technical information including water resources, bridge design, traffic, signing and striping, lighting, right-of-way, State Aid, and the Mn MUTCD.

2-5.0 Federal Funding for Bicycle Transportation

Bicycle and pedestrian projects are broadly eligible for funding from almost all the major Federal-aid highway, transit, safety, and other programs. Bicycle projects must be “principally for transportation purposes rather than for recreation.” These projects must be coordinated with the transportation plans required of the State, ATPs and MPOs.

The Bicycle Transportation and Pedestrian Walkways provisions of Section 217 of Title 23, as amended by TEA-21, describe how Federal-aid funds may be used for bicycle and pedestrian projects. These projects compete with other transportation projects for available funding at the State and MPO levels. Funding availability is a typical limiting factor in carrying out improvements, so identifying funding options and opportunities early on in the planning process helps to achieve bicycle and pedestrian system improvements.

The FHWA assembled a list of funding opportunities available through FHWA and Federal Transit Administration (FTA) funding programs in which bicycle and pedestrian activities are eligible. Appendix B of this manual lists these programs. Table B-1 in Appendix B lists FHWA programs that may be used for bicycle and pedestrian activities, and Table B-2 lists FTA programs that may be used for bicycle and pedestrian activities.

2-6.0 Bicycle Network Planning

Mn/DOT integrates bicycle facilities into its long-range plan, the STIP, and coordinates with Metropolitan Planning Organizations (MPOs) and Area Transportation Partnerships and other regional planning organizations to promote bicycling safety and transportation. This coordination helps to ensure an interconnected bicycle system that is coordinated with other jurisdictions and other modes of travel. In this way, Mn/DOT district plans will be coordinated with other jurisdictions’ bicycle network plans, with both on and off-road bicycle facilities.

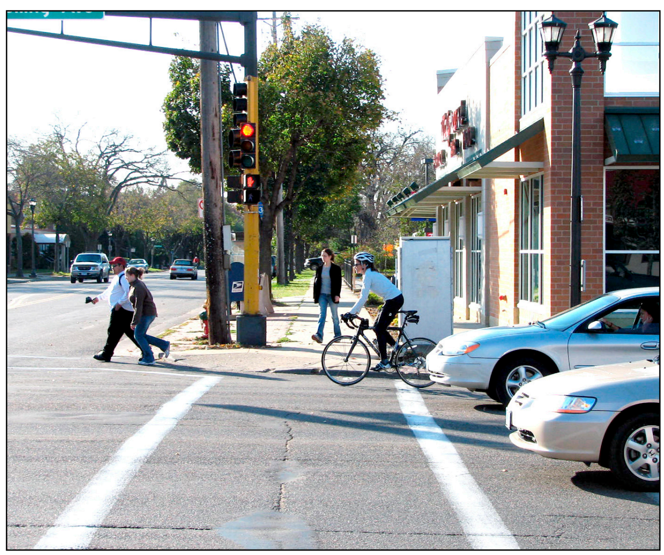


Figure 2-2:

Bicyclist shares the road with pedestrians and motor vehicles on Snelling Avenue (Highway 51) in St. Paul

The *Mn/DOT Bicycle Modal Plan* outlines Mn/DOT’s role in providing bicycle transportation. One of the roles is to develop a coordinated transportation network that promotes travel efficiency, safety, and mobility. Mn/DOT Districts can develop a bicycle network plan starting with a vision and mission of a transportation system that integrates bicycling with other modes.

The planning process involves the following steps:

1. Define mission, vision, policies, goals and objectives.
2. Establish performance criteria for the bicycle network.
3. Inventory existing bicycle facilities, roadway system, crashes, gaps and barriers.
4. Identify bicycle travel corridors.
5. Evaluate and select specific bicycle routes and design treatments.
6. Develop an implementation strategy.
7. Evaluate the plan

Developing a bicycle network plan requires coordination with other jurisdictions and citizen groups. A public involvement strategy should be developed. Regional and local plans and other information and data from other jurisdictions should be consulted and integrated into the plan as needed. A bicycle network plan should identify:

- Opportunities for upgrading existing bikeways
- The needs for regional or local bicycle routes
- Environmental impacts of new or existing bike facilities
- New, planned, and expanded road networks
- How the needs of a wide range of bicyclist types, from advanced bicyclists to children will be addressed

Figure 2-3:
Mn/DOT and the Department of Natural Resources coordinated on a road construction project that involved constructing a bridge for the Luce Line State Trail

2-6.1 Define mission, vision, policies, goals and objectives

One of the first steps in developing a network plan is to develop vision and mission statements and to address the key issues in bicycle accommodation. The goals and objectives help to define the outcomes to achieve with a bicycle network plan.

Mn/DOT's vision for bicycle transportation:

> Minnesota is a place where bicycling is a safe and attractive option in every community. Bicycling is accommodated both for daily transportation and for experiencing the natural resources of the state.

Mn/DOT's mission for bicycle transportation:

> Mn/DOT will accommodate and encourage safe bicycling on its projects in Minnesota communities and in other areas. Mn/DOT will exercise leadership with its partners to promote high-quality bicycle accommodation on their projects.

The goals and objectives help to define the outcomes to achieve with a bicycle network plan. These outcomes may include:

- Improved safety for bicyclists in general and for those who do not drive a motorized vehicle
- Removal of physical barriers to bicycle travel
- Improved bicycle connections with transit systems for transit users
- Enhanced physical activity among residents
- Improved bike routes for children to schools, playgrounds, parks, libraries, and establish links between neighborhoods
- Reduced user conflicts on shared use paths
- Increase bicycle trips to replace motor vehicle trips

The goals and objectives should address the needs of the full range of bicyclists, funding of bicycle facilities, integration with other modes, and public involvement. In this way, a bicycle network is developed that serves a variety of bicyclists and identifies and addresses safety, mobility, and accessibility issues.

2-6.2 Establish Performance Criteria

A bicycle network plan includes performance criteria. Developing the criteria includes consulting with design engineers and planners, bikeway planning and design staff, traffic engineers, citizen advocates, local bicyclists, and transit representatives as well as other transportation modes. The performance criteria should be used to evaluate bicycle facilities according to safety, directness, access, mobility and connectivity:

- **Safety:** Both traffic and personal safety is critical in planning a bicycle network system. Primary objectives are to minimize chance of conflict with motor vehicle or other users, install lighting along corridor, roads, and intersections, provide efficient access for emergency response, provide adequate bike parking spaces and secure bike parking, target improvements to areas with safety issues, and evaluate improvements over time by reviewing crash reports and obtaining citizen feedback.
- **Directness:** Routes to major destinations are direct with minimal detour distance.
- **Access**: This refers to the spacing or distance between routes or the distance a bikeway is from a specific origin or destination. For example, spacing between main bicycle routes of 1 km (0.5 mile) and 200 to 500 m (650 - 1650 ft) between local routes provides access for bicyclists to enter the system and be able to identify a route close to their origin and destination points.

- **Mobility and connectivity:** Minimize missing links in the network. If gaps exist, they are communicated by road, path signing and striping and through the distribution of bike maps and kiosks throughout the system. The bicycle routes should link employment centers, residential areas, shopping centers, schools, universities and other locations such as libraries, health clinics and bike shops. Bicycle routes are maintained throughout the year and are available for both day and nighttime use.

2-6.3 Inventory Bicycle Facilities, Roadway System, Crashes, Gaps and Barriers

Planning a bicycle network system requires gathering data and information on existing bicycle facilities, the roadway system, transit routes and their implications for bicycle travel. Motor vehicle traffic volumes and speeds have a large impact on the quality of bicycle travel and therefore should be included in the inventory. Safety issues, travel inefficiencies, and bicyclists' needs should be identified through public involvement processes. This includes conducting surveys of citizens to identify their travel needs and preferences. The available bicycle parking should be evaluated as well.

Figure 2-4:

Bicycle parking in downtown Bemidji welcomes bicyclists to the lakefront and helps to keep bicyclists from locking their bicycles to trees, parking meters or railings

An inventory of existing bikeways helps to identify missing links in the system network. This requires coordinating with other jurisdictions and involves researching and integrating community needs. The most detailed and helpful information often comes from local stakeholders, including local residents, advocacy groups, local governments, park and recreation boards, school representatives, so it is imperative that their feedback is included in the inventory process.

Existing bicycle facilities should be evaluated for their condition and change in use to determine needed improvements. If existing bicycle facilities are the backbone or main route of a new or expanded network, the inventory should list and describe what is needed to improve the existing bicycle facility to provide efficient and safe bicycle travel in the new network. Missing segments between existing bicycle facilities should be identified as a part of the inventory for needed improvements.

The entire roadway network should be evaluated by performance criteria since bicyclists can use most roads. An inventory of the roadway system could be conducted by using Average Daily Traffic (ADT) for motorized vehicle on each road segment. Reviewing crash data is important to identify potential safety issues and potential gaps in a bike network system. It is important to note that bicycle and pedestrian crashes are reported to the Minnesota Department of Public Safety only if the crash also involves a motorized vehicle. Therefore, only a portion of the total bicycle and pedestrian crashes are represented. Analyzing bicycle and pedestrian crash data should be used to help identify potential or existing safety issues in a project area, corridor or geographic area.

Mn/DOT evaluates potential improvements for bicycle and pedestrian transportation by ranking sections of trunk highways by bicycle and pedestrian crash costs per mile. Mn/DOT staff also analyzes individual crash records to determine the nature of the crash problem and to propose infrastructure, enforcement, educational or other improvements that will alleviate the problem. The appropriate improvement may not be obvious; however, providing project-specific and location-specific infrastructure improvements from a proactive perspective is part of the planning process.

Factors that help to determine existing bicycling conditions:

- Number of traffic lanes
- Width of the outside lane
- Right-of-way widths
- Geometric layout
- Grades, topography
- Pavement material and condition
- Median barriers and guardrails
- Signal locations
- Obstructions or hazards
- Railroad crossings
- On-street motor vehicle parking
- Frequency of commercial driveways
- Actual average operating speed or the posted speed limit
- Overall crash data
- Transit routes and connections
- Heavy vehicle volumes, peak hour motor vehicle traffic volumes
- Bicycle and pedestrian volumes and timing of peak use
- Land use

Identifying barriers and gaps that deter bicycle transportation or generate safety issues is instrumental in helping to provide safe and efficient bicycle transportation. Barriers or gaps include both natural features, such as rivers, steep terrain, wetlands and streams, and in-place infrastructure, such as railroad tracks, interstates and other controlled access roads, complicated intersections, and roads that carry high speed and high volume motorized vehicle traffic. Bridges or tunnels without bikeway accommodation can be significant barriers to the bicycle transportation system, and generate safety issues if not addressed. Therefore, the planning process should include:

1. Evaluate the number and location of crossing opportunities along interstates, controlled access roads, high volume and high-speed roads, and rivers.
2. Identify a sufficient number and locations of bicycle and pedestrian crossings.
3. Integrate information from analysis into bicycle network plan.

Without a grade separated crossing, bicyclists may need to travel out of their way to cross a controlled access road or interstate to get to their destination. Arterials and collectors can also be challenges because they may be difficult to cross or to travel along because of roadway width, high volume motor vehicle traffic, and large multi-lane intersections that are particularly threatening for bicyclists. Other types of gaps include an incomplete bicycle facility such as a bicycle path or lane that ends at no apparent destination.

Addressing the needs of bicyclists early on in the planning stages will help identify and address these barriers and improve safety for bicyclists and other modes as well.

2-6.4 Identify Bicycle Travel Corridors

People want to go to the same places they do in cars (within the constraints imposed by distance), and the existing system of streets and highways reflects and influences the existing travel demands of the community. Identifying bicycle corridors is not the same as identifying the routes that bicyclists currently use. Instead, bicycle corridors are “desire lines” connecting neighborhoods that generate bicycling trips with other areas that also attract a significant number of bicycling trips.

A bicycle network plan identifies existing bicycle travel corridors, where connections need to be developed, and predictions of how future use may occur. This involves working collaboratively with other jurisdictions and stakeholders to identify and address locations of increased demand, problem areas, and opportunities for low-cost improvements.

Bicycle travel patterns are influenced by bicyclists’ perception of the bicycling environment. Uncomfortable or threatening bicycling conditions will cause bicyclists to depart from their most preferred route, choose a different mode (bus, car, walk), or not make the trip at all. However, bicyclists may not have a choice other than biking on a road that has minimal or no bicycle accommodation if there is not a suitable alternative route. Therefore, the task at this stage of the planning process is not just to ask, “What routes do bicyclists travel on now?” but also “What routes would they take if they could go where they preferred?”, and “how safe are these routes?”

Existing bicycle and motor vehicle traffic volume is a useful predictor of bicyclists’ preferred routes. Bicycle traffic counts can be helpful in estimating bicycling demand. However, using traffic counts can be misleading: these numbers can underestimate potential users. Instead, identifying bicycle traffic generators and areas of higher population density is a good indicator of demand, given better conditions for bicycling. Certain locations and entities generate bicycle traffic such as schools, especially colleges and universities, high-density residential areas, commercial districts, major bicycle bridge crossings, parks, beaches, libraries, greenways, rivers, lakes, and recreational facilities.

2-6.5 Evaluate and Select Specific Bicycle Routes and Design

This phase of the process of developing a bicycle network plan involves the identification of a bicycle route system and the design treatments on all roads. The first step is developing a "backbone" of bicycle facilities, or the primary bicycle routes, of the bicycle network. Next, specific routes should be selected that can be local or access routes, designed or adapted to accommodate all bicyclists. Because specific route alternatives are evaluated, input from stakeholders is important. Public involvement strategies help to involve a wide range of citizen groups.

The Bicycle Facility Network Classification System (Table 2-1) is a way to classify bicycle routes according to their purpose and intended use, primary, local, access, and tour route. A bicycle facility, whether on-road or off-road, may have more than one purpose. For example, a Mn/DOT road may be classified in more than one category depending on its function, location, roadway characteristics, and adjacent land use. A highway through a small town may serve bicyclists traveling from residential area to shopping and employment center in the downtown area. A highway near a lake, such as US 61 along the north shore of Lake Superior, may be classified as both a tour route and a primary route.

There are two ways for serving bicycling needs in an identified corridor or route, by integrating bicyclists on the arterial or collector road or using a facility parallel to the corridor. Separated paths and trails may be an option only in some cases. Paths along urban arterials generate cross traffic conflicts and transitioning from an off-road to on-road facility brings about many safety issues.

If the corridor treatment involves integrating with the road network, options include bike lanes, paved shoulders, bicycle boulevards or wide outside lanes. Context Sensitive Design approaches may provide a wider range of possibilities. A four-lane road could be converted to three lanes to add bike lanes. Travel lanes could be narrowed if conditions warrant to provide a wide outside lane or bike lanes. Chapters 4 and 5 of this manual provide bicycle facility design options.

Table 2-1 Bicycle Facility Network Classification System

Classification (Significance)	Function	Attributes
Primary Route (Regional)	This is typically a regional route that connects major employment centers, retail, commercial, industrial, residential and entertainment destinations. This route is typically multi-jurisdictional, providing service within and between cities, counties, and may even cross state borders. Primary routes serve the largest area and connect suburbs to downtown or small town to small town.	This route provides connections by the most direct route. Limited number of stops per mile to maintain momentum. Enables bicycle speeds of 20 mph or more. Relatively flat grade. Incorporate destination signing and lighting.
Local Route (Local)	This route type connects local routes to primary routes and neighborhood to neighborhood. Small to medium retail are major destinations. Provide connections between home and school and parks. Public transit service should be in close proximity to local routes.	Access to key destinations such as libraries, schools, employment centers. Relatively flat grade. Signing and lighting important.
Access Route **(Intra-neighborhood or neighborhood)**	This route type provides connections within a neighborhood or between neighborhoods.	Access to key destinations such as libraries, schools, employment centers. Relatively flat grade. They are often low motor vehicle traffic local streets with lower motor vehicle speeds. Signing and lighting important.
Tour Route **(Regional, local or neighborhood)**	This route type is to serve and connect to recreational destinations, such as paths that circulate lakes or parks, but these routes may also serve as a primary, local or access route.	Attributes may be any of the above.

Bicycle route selection factors include:

- Bicyclist and pedestrian traffic volumes
- Width of paved shoulders or wide outside lanes
- Motor vehicle traffic volume and speed
- Truck and other heavy motor vehicle traffic volume
- Motor vehicle parking
- Number and types of intersections
- Commercial entrances, vehicle turning movements, and traffic control devices
- Transit routes and stops
- Functional classification of roadway and of bikeway
- Available space
- Available right-of-way
- One-way or two-way traffic flow
- Bikeway continuity
- Road and off-road facility maintenance
- School zones
- Bicycle parking accommodations

Integrating bicycle transportation and public transit helps to increase the opportunity to travel by bicycle, provide for travel through heavy motor vehicle traffic and areas not lighted at night or maintained for bicyclists. Public transit provides an opportunity for bicyclists to make longer trips and avoid gaps in the bicycle transportation network. Most importantly, bicycle and transit connections provide a low cost way for those who cannot drive or do not have access to a motor vehicle.

Figure 2-5:
Transit routes linked to bicycle facilities provide for multimodal trip options. Bike racks on buses allow bicyclists to extend their trip distance and avoid inclement weather

2-6.6 Develop an Implementation Strategy

The bicycle component of a transportation plan or the bicycle network plan should include recommendations for implementation. The inventory of existing bicycle facilities, identification of barriers, and selection of bicycle travel corridors and treatment options provide a foundation to develop an implementation strategy.

The implementation strategy should address the issues found in the analysis of existing conditions, the barriers, and specific inefficiencies that bicyclists have shared with transportation representatives. The implementation strategy should also include the maintenance needs for selected bikeway types, the coordination of maintenance responsibilities, and the integration of bicycle parking, and the identification of funding opportunities.

Most importantly, if a bicycle project, as a part of a larger roadway improvement, has been included in a bicycle plan, then that bicycle facility will be a part of the roadway improvement plan.

The following strategies are critical in implementing a bicycle network plan:

- Prioritize capital improvements. Identify those projects that are easily implemented or those projects that address a critical need such as a high crash location.
- Identify potential funding sources, timelines, and maximum and minimum qualifying project amounts.
- Communicate progress with transportation partners to help implement plan including county, city, business owners, schools, universities, colleges, and residents.

One of the final and most useful products of a bicycle network planning process is a map showing the existence of all existing and proposed bicycle facilities. The type of facility (one-way bike lane, two-way bike lane, multi-use path, bicycle path, signed route, painted shoulder, etc.) should be identified on the map. A map can also include the location of future improvements to intersections, lighting, traffic signals, crossing treatments that are described in the bicycle network plan. Mapping bicycle routes is a way to guide bicyclists to bicycle routes and enables them to choose routes that are more suitable for their bicycling experience.

Communities and MPOs should identify bicycle projects that should receive priority for funding. Bicycle improvements that can be conducted in conjunction to a road reconstruction project should also be identified. Interim accommodation should also be identified, such as restriping bike lanes, adding lighting, or removing hazardous drainage grates, to be carried out until a larger scale project can be implemented.

Bicycle system improvements include not only infrastructure, such as bike lanes, bridges, bicycle parking, but also programs that address other barriers and problems in developing an efficient bicycle network. Education programs that stress the importance of obeying traffic laws and developing bicycling skills help to eliminate barriers and solve problems that cannot be addressed by infrastructure improvements alone.

2-6.7 Evaluate the Plan

A major goal of most bicycle networks plans is to increase bicycling while at the same time decreasing the number of crashes and fatalities. The plan should include an evaluation of these goals. An evaluation of bicycle crashes may identify locations that need attention, different design treatments, or changes in other road features, for example. Public feedback on their bicycling experiences also provides valuable insight into the progress of the bicycle network plan. Complaints, comments, and suggestions from the public help to identify problems that may be addressed by adjusting the bicycle network plan or policies. Periodic bicycle traffic counts or bicycle parking counts help to identify changes in bicycling and help to identify the degree of effectiveness of a new bicycle facility or change in design treatment.

2-6.8 Examples of Bicycle Network Plans

The following bicycle network plans provide good examples of different types of plans including a county, city, trail corridor, and metropolitan planning organization. However, for smaller communities, the bikeway network plan may be significantly less complex.

Hennepin County. Hennepin County developed a bicycle network plan, generated a bicycle map presenting both existing and proposed bicycle facilities, identified and ranked primary bicycle network barriers, or gaps, and produced a map showing the gaps in conjunction with the bike network plan. The County developed criteria to identify bike network gaps based on several characteristics: the gap appears on an existing local bike plan, it is a major river, railway, freeway crossing, or a busy intersection, or it involves a scheduled county, city or state road project. In addition, the location has a crash history of specific number of crashes per mile and the location or corridor is a specific distance from an alternative route.

The City of Minneapolis. Minneapolis developed a master bike plan based on feedback and interaction generated at neighborhood charettes. Each neighborhood selected bicycle routes in their community according to their transportation needs and plans. The City then combined the selections into a citywide 5-year plan. Minneapolis pursues funding to build the bicycle system based on this plan, and includes the projects in its Capital Improvement Program.

Gitchi-Gami Trail. The Arrowhead Regional Development Commission developed a trail plan for the Gitchi-Gami Trail, a state trail, located on Minnesota's north shore. This plan provides a vision, mission, organizational structure, technical, and funding strategy for the trail's development. The trail plan describes the collaboration of three entities, Mn/DOT, the Minnesota Department of Natural Resources (DNR), and the Gitchi-Gami Trail Association (GGTA). The GGTA worked with Mn/DOT and the DNR to develop the shared-use trail. Mn/DOT preserved right-of-way for the trail and incorporated the trail's development into Highway 61 construction plans. The trail development is set up in phases, that are coordinated with completed planning and design and funding is received.

Fargo-Moorhead. The Fargo-Moorhead Metropolitan Council of Governments bicycle and pedestrian plan (2006) includes an analysis of bicycle commuting, bicycle rack use, barriers and impediments, bicycle and pedestrian counts, and a comparison in bicycle and pedestrian traffic volumes from 2000 to 2004/5 among other analysis. The plan also identifies both short and long-term bicycle and pedestrian improvements and a financial analysis of these

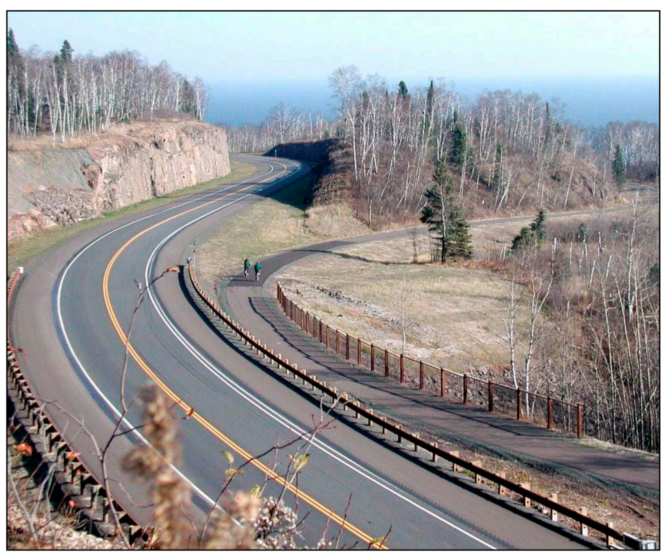


Figure 2-6:

The Gitchi-Gami Trail along the North Shore is being developed in part by incorporating the trail development into Highway 61 construction plans

improvements. The Fargo-Moorhead plan is a model for being comprehensive, informative to the community on bicycle and pedestrian issues, and citizen-based. The plan also integrates bicycle and pedestrian access with transit and safe routes to school.

2-7.0 Bicyclist and Motorist Education

Bicyclist and motorist education is a critical component of a transportation system that promotes safety and efficiency. In May, 2005, Mn/DOT and the State Bicycle Advisory Committee (SBAC) launched Minnesota's *Share the Road* bicycle safety education program. The program is based on the recognition that bicyclists and motorists are equally responsible for bicycle safety. About one-half of all collisions between bicycles and motor vehicles are attributed to various bicyclist behaviors, such as disregarding a traffic control sign or signal. The other half is attributed to motorist behaviors, such as inattention and distraction.

According to *Minnesota Crash Facts*, of all bicyclists injured in 2005, about half were less than 20 years of age, and nearly 50% of the bicyclists killed were less than 15 years of age (3 of the 7 fatalities). Crash facts from 1999 to 2004 show similar results. About 50% or more of the injuries and fatalities involved young people less than 25 years of age, and most were in the 10 - 19 year age group. But, the number one factor contributing to bicycle-motor vehicle crashes is failure to yield the right of way, both by bicyclists and motorists.

As described by the FHWA, Mn/DOT has a role in providing bike safety information to the public as well as raising awareness of traffic laws pertaining to bicycles and interactions with motorists. Other agencies, non-profits, schools, and private entities are also involved with bike safety education, bicycling skill development, and motorist defensive driving courses. It is important for all transportation practitioners to promote understanding of key traffic laws.

Motorists benefit by learning how to operate around bicyclists and to drive defensively. Children benefit from learning traffic laws and safe bicycling techniques before bicycling to school or play. Experienced bicyclists benefit from courses in bicycle safety to learn about bicycle handling skills in different traffic conditions, new crossing treatments, traffic devices, and/or bicycling equipment changes.

Programs that educate motorists, bicyclists, and pedestrians can increase the growth of bicycling in a community, encourage courteous and lawful behavior, enhance the skill levels of bicyclists, and improve safety. Transportation agencies can help by providing messages to the public that focus on the most frequent causes of crashes and injuries, informing the public about construction areas, temporary work zones, and distributing information about bicycle safety, including bicycle helmet use. See www.sharetheroadmn.org for more detailed safety and education material.

Chapter 3: General Design Factors

3-1.0 Introduction

Mn/DOT's goals include encouraging and accommodating safe bicycling. From a design perspective, these goals are achieved by first having an understanding of the dimensions of a bicycle and bicyclist and the operational characteristics. These design factors are critical in planning and designing both on-road and off-road bicycle facilities. The specific design applications are described in Chapters 4, 5 and 6 of this manual.

3-2.0 Bicycle Dimensions

To ensure the safety of bicyclists and promote efficient bicycling, the dimensions of the bicycle and bicyclist must be taken into account, along with the amount of lateral and vertical clearance needed, in the planning and design of bicycle facilities. The bicycle and bicyclist dimensions and the lateral and vertical clearance have direct bearing on the amount of right-of-way needed to accommodate bicycle traffic. See Section 3-3.0 for bicyclist dimensions and operating space.

The dimensions of a typical bicycle are a handlebar height of 0.75 - 1.10 m **(2.5 - 3.5 ft)**, handlebar width of 0.61 m **(2 ft)**, and bicycle length of 1.5 - 1.8 m **(5 - 6 ft)**. A typical bicycle with an attached trailer is 0.8 - 1.1 m **(3.7- 4.3 ft)** wide and 2.6 - 2.9 m **(8.5 - 9.5 ft)** long. See Figure 3-2 for typical bicycle dimensions and bicycle operating space.

The tires on most bicycles range in width from 20 mm to 60 mm **(0.8 to 2.4 in)** with a contact surface of approximately 3 mm **(0.12 in)** or wider. They often provide little traction. If the pavement is wet or covered with sand or leaves, the bicycle has even less traction and needs more room to brake. Stopping distance and lack of traction are two factors that influence the design of curves on bikeways.

Shared use paths, greenways, and state trails must be designed for users other than bicyclists. The design should take into account others on shared use paths such as inline skaters, adult tricycles, bicycle trailers, recumbent bicyclists, and wheelchair users. The dimensions and operational characteristics of bicyclists are important, other user types that are allowed to share the same space as bicyclists should be integrated into the initial planning stages and the design and selection of a bikeway type.

The Federal Highway Administration studied the dimensions and operational characteristics of adult tricycles, bicycles with trailers, recumbent bicycles, wheelchairs, and others and provided their average physical dimensions, eye heights, and speeds in *Characteristics of Emerging Road Users and Their Safety, (FHWA; 2004)*. See Table 3-1 for these average dimensions and speeds.

Table 3-1: Average dimension, eye height and speed of other user types

User Type	Average Width m **(ft)**	Average Length m **(ft)**	Average Eye Height m **(ft)**	Average Speed Km/h **(mph)**
Bicycle	0.61 m **(2.0 ft)**	1.68 m **(5.51 ft)**	1.57 m **(5.15 ft)**	17 km/h **(10.5 mph)**
Bicycle with trailer	0.80 m **(3.7 ft)**	2.90 m **(9.50 ft)**	1.60 m **(5.25 ft)**	17 km/h **(10.5 mph)**
Hand cycle	0.65 m **(2.1 ft)**	1.81 m **(5.94 ft)**	0.96 m **(3.15 ft)**	14 km/h **(8.7 mph)**
Inline skates	0.52 m **(1.7 ft)**	0.39 m **(1.28 ft)**	1.68 m **(5.51 ft)**	16 km/h **(9.9 mph)**
Kick scooter	0.39 m **(1.3 ft)**	0.68 m **(2.23 ft)**	1.47 m **(4.82 ft)**	12 km/h **(7.5 mph)**
Manual wheelchair	0.62 m **(2.0 ft)**	0.99 m **(3.25 ft)**	1.21 m **(3.97 ft)**	6 km/h **(3.7 mph)**
Power scooter	0.58 m **(1.9 ft)**	1.12 m **(3.67 ft)**	1.32 m **(4.33 ft)**	9 km/h **(5.6 mph)**
Power wheelchair	0.65 m **(2.1 ft)**	1.23 m **(4.04 ft)**	1.24 m **(4.07 ft)**	9 km/h **(5.6 mph)**
Power wheelchair & dog	1.30 m **(4.3 ft)**	1.19 m **(3.90 ft)**	1.17 m **(3.84 ft)**	7 km/h **(4.3 mph)**
Recumbent bicycle	0.62 m **(2.0 ft)**	1.90 m **(6.23 ft)**	1.26 m **(4.13 ft)**	23 km/h **(14.3 mph)**
Segway5	0.64 m **(2.1 ft)**	0.56 m **(1.84 ft)**	1.88 m **(6.17 ft)**	15 km/h **(9.3 mph)**
Skateboard	0.24 m **(0.8 ft)**	0.76 m **(2.49 ft)**	1.55 m **(5.09 ft)**	13 km/h **(8.1 mph)**
Stroller	0.51 m **(1.7 ft)**	1.24 m **(4.07 ft)**	1.33 m **(4.36 ft)**	5 km/h **(3.1 mph)**

3-3.0 Bicyclist Dimensions and Operating Space

A bicyclist's design vertical height is 2.4 m **(8 ft)**. Although even a tall individual will not reach this height when seated on a bicycle, it is essential to allow extra clearance for bicyclists pedaling upright or passing under an overpass. Vertical clearance should be a minimum of 3 m **(10 ft)** to allow for the clearance of maintenance and emergency vehicles in underpasses and tunnels and to allow for overhead signing.

Under normal conditions, a moving bicyclist needs a horizontal corridor at least 0.9 m **(3 ft)** wide in order to maintain balance when riding at low speeds or against crosswinds. To ride comfortably and avoid fixed objects (sidewalks, shrubs, potholes, signs signals, etc.) and other users such as pedestrians or in-line skaters, a bicyclist needs at least an additional 0.3 m **(1 ft)** of lateral clearance on each side, bringing the total operating width of a one-way corridor to 1.5 m **(5 ft)**.

If space is restricted, such as in a tunnel or bridge, a space at least 3 m **(10 ft)** wide is recommended for two opposing bicyclists to comfortably pass each other. See Figure 3-3 for bicycle operating space. More width may be needed to accommodate in-line skaters, bicycles with trailers, etc. Space is necessary for a bicyclist to react to unexpected maneuvers of another bicyclist or other user. Other users and their dimensions and operational characteristics should be considered in addition to typical bicyclists when designing facilities. See Table 3-1 for other user types and their average dimensions and speeds.

Most bicyclists can maintain a cruising speed between 20 and 30 km/h **(12 and 19 mph)** and can maintain a speed of 30 km/h **(19 mph)** or better on flat terrain and windless conditions. In descents, with a tail wind, bicyclists can reach speeds more than 50 km/h **(31 mph)**.

Generally, bicyclists prefer routes without steep climbs. Bicycle facilities should be designed with the gentlest slopes possible to encourage the use of the bikeway. However, bikeway design and bicyclists' behavior can be adjusted to compensate for steep terrain. Elevation changes may also appeal to some bicyclists.

For a variety of reasons, motorists may not see bicyclists, especially after dark or in the rain or snow. Intersections and roadsides need adequate sightlines and lighting to help increase the visibility of bicyclists.

Figure 3-1:
A bicyclist with a trailer has different dimensions and requires more operating space than a typical bicycle

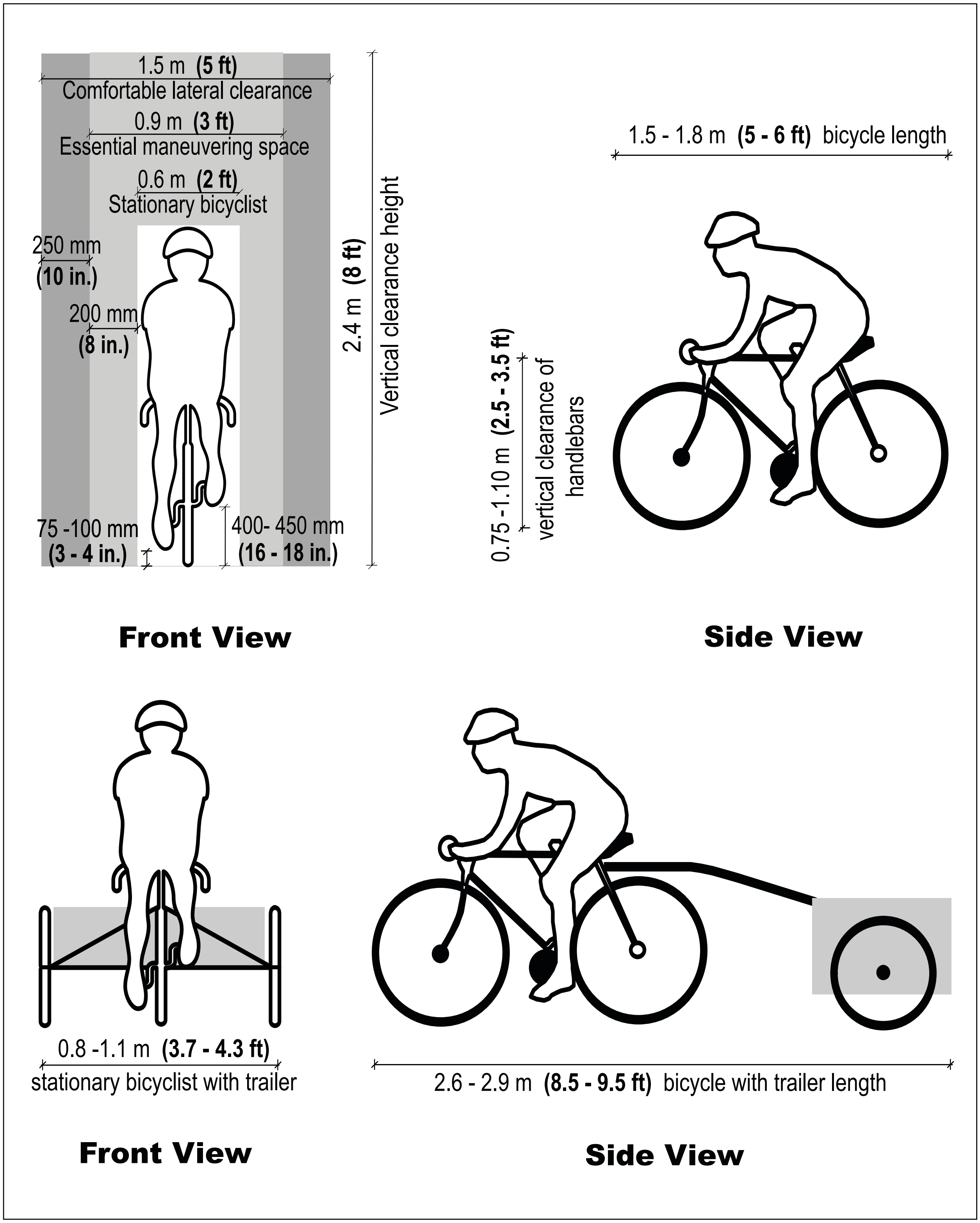


Figure 3-2:
Typical bicycle dimensions and operating space

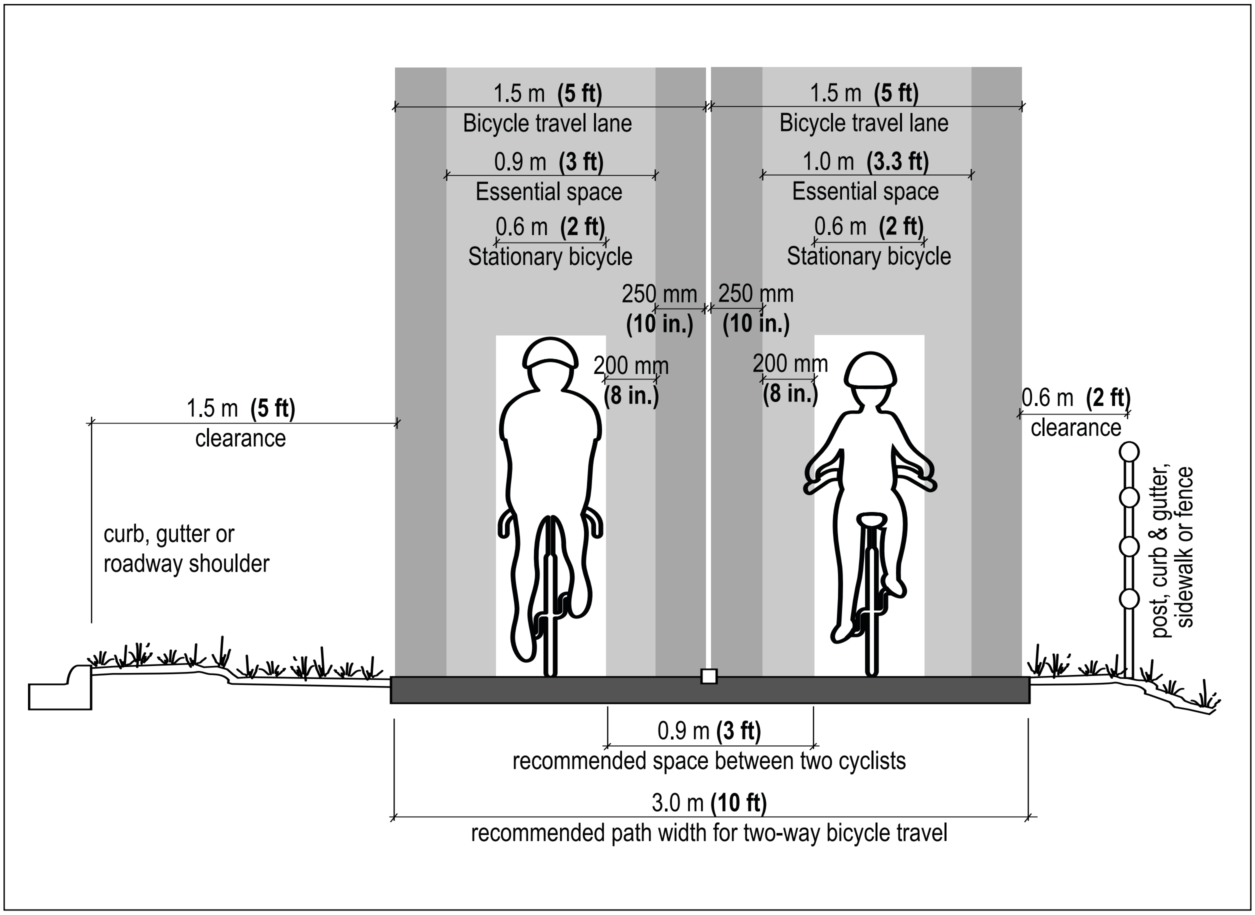


Figure 3-3:
Bicyclist operating space

3-4.0 Types of Bicyclists

Bicyclists' skills, confidence, and preferences vary significantly. Some bicyclists are comfortable riding anywhere they are legally allowed to operate, including space shared with motorized vehicles. Some bicyclists prefer to use roadways that provide space separated from motorists. Although children may be confident bicyclists and have some level of bicycle handling skills, they most often do not have the experience of adults nor the training or background in traffic laws necessary to operate safely on the road. Children need training in bicycle handling skills, education in traffic laws, and must use precaution in all traffic situations. See Chapter 2 for information about bicyclist education.

Bicycle facilities should be planned to provide continuity and consistency for all types of bicyclists. The Federal Highway Administration developed the following general categories of bicyclist types to assist planners and designers in determining the impact of different facility types and roadway conditions on bicyclists.

Advanced Bicyclists

Advanced bicyclists are experienced bicyclists who use their bicycle as they would a motor vehicle. They are biking for convenience and speed and want direct access to destinations with minimum detour or delay. They typically bike with motor vehicle traffic, biking on the roadway, but need sufficient operating space to eliminate the need for themselves or a passing motor vehicle to shift position.

Basic Bicyclists

Basic bicyclists are casual or new adult and teenage bicyclists who are less willing or able to operate in motor vehicle traffic without provisions such as bike lanes or paved shoulders or roads with lower speeds and motorized vehicle traffic volume. They prefer to avoid roads with higher speeds and motor vehicle traffic volumes unless there is ample roadway width to allow motor vehicles to pass. They prefer direct access to destinations using either low-speed, low traffic-volume streets, bike lanes, wide paved shoulders, or shared use paths.

Children

Children cicyclists are teenage or younger who bike on their own or with supervision. Their biking may be initially monitored by adults and are eventually allowed independent access to the road system. They still need access to key destinations surrounding residential areas, including schools, recreational facilities, shopping, or other recreational areas. Residential streets with low motor vehicle speeds, linked with shared use paths and streets with well-defined pavement markings between bicycles and motor vehicles can accommodate children. Children need supervision, a basic knowledge of traffic laws and bicycle operating skills before they can safely use on-road bikeways with higher motor vehicle volumes and speeds.

Planners and designers need to take into account children's lack of skill and experience when designing and planning transportation facilities. Bicycle and pedestrian accommodation on routes to schools, playgrounds, parks, libraries, and at high volume and complicated intersections is critical. Children do not have the experience or knowledge of traffic laws that adult bicyclists have. Children's' ability to perceive and respond to the road or path environment, and their ability to make quick decisions and perform multiple tasks may not be developed. A network of integrated on- and off-road bikeways with connections between the on- and off-road bikeways, are important to accommodate child bicyclists.

The following list outlines some of the ways to accommodate all bicyclist types:

- Neighborhood and residential streets functioning at appropriate operating vehicle traffic speeds and volumes.
- Providing bike lanes on streets posted for lower speeds through the key travel corridors so that bicyclists can avoid higher volume, and/or higher speed roads.
- Providing paved shoulders on roads and highways, according to volumes and speeds of motor vehicle traffic as described in Chapter 4 of this manual.
- Providing shared-use paths in independent corridors.

- Establishing and enforcing vehicle traffic speed limits to minimize speed differentials between bicycles and motor vehicles and by using traffic-calming strategies.

Advanced bicyclists prefer roadways that accommodate shared use by bicycles and motor vehicles to minimize stopping and to maintain speed. This can be accomplished by:

- Providing bike lanes or wide outside lanes on collector and arterial streets with an urban cross section design (i.e., with curb).
- Providing paved shoulders on highways with a rural cross section design (i.e., without curb).
- Establishing and enforcing speed limits to minimize speed differentials between bicycles and motor vehicles and by using traffic-calming strategies.

3-5.0 Selecting the Bikeway Type

A bicycle network plan as described in Chapter 2 helps to develop and promote a bikeway network with continuity and consistency and options for bicyclists with varying skills and experience. The desired outcome is to accommodate bicyclists, motorists, and other users with minimum travel delays and maximize safety, mobility and access.

The selection of the bikeway suited for a travel corridor depends on many factors, including bicyclists' abilities, corridor conditions, current and future land use, topography, population growth, roadway characteristics, and the cost to build and maintain the bikeway. Within any travel corridor, more than one option may be needed to serve all bicyclists. However, no one type of bikeway or road design suits every bicyclist.

Figure 3-4:

An example of a bikeway type, a paved shoulder on a rural highway

For basic bicyclists and children, key travel corridors should be identified through a planning process, and bicycle accommodation should be provided through these corridors. However, roads and shared use paths that may not be on the bicycle network plan that link residential areas to schools, libraries, shopping areas, employment centers, parks, are also critical in serving basic bicyclists and children. Adopting design standards and guidelines that include wide curb lanes and paved shoulders to accommodate bicyclists help build the continuity of the bicycle network (see Figure 3-4).

3-6.0 Bikeway Types

Bikeways include both on-road and off-road facilities, including bike lanes, paved shoulders, shared lanes, wide outside lanes, and shared use paths. Bike lanes, paved shoulders, and wide outside lanes allow bicyclists and motorists to operate parallel to each other in the roadway, maintaining a separation, without requiring motorists to change lanes to pass bicyclists.

There are many ways bicyclists can safely and conveniently be accommodated on roadways and other right-of-way. During the development of a transportation plan, planners and designers should recognize that the choice of road design will affect the level of bicycling, the types of bicyclists that will use the road, and the level of access and mobility that is provided to the bicyclist.

Shared use paths and greenways offer opportunities not provided by the road system and can serve as direct commute routes. Shared use paths may also help to close gaps in the bicycle network caused by cul de sacs, railroads, freeways, and interstates or to navigate around natural barriers. Other users that are allowed to use shared use paths should be integrated into the design as well.

The overriding goals in selecting and designing a bikeway type are:

- The bikeway allows for bicyclists to operate in a manner that is consistent with traffic laws.
- The needs of motorists, pedestrians, and bicyclists are integrated in the design of the bikeway.
- Road crossings and connections are provided that provide access to other bikeways.

The design and applications of on-road bikeways, including shoulders, bike lanes, shared lanes and wide outside lanes, are described in Chapter 4 of this manual. The design and applications of off-road bikeways, including shared-used paths are described in Chapter 5.

3-7.0 Accessible Design

Most bicycle facilities are required to comply with ADA so that they are functional for all users, both with and without disabilities. Americans with Disabilities Act of 1990 (ADA) is a law that protects the civil rights of persons with disabilities. It prohibits discrimination on the basis of disability in employment, State and local government services, transportation, public accommodations, commercial facilities, and telecommunications. Accessible design benefits everyone.

Transportation facilities such as paths and sidewalks and bicycle facilities shared with pedestrians shall comply with existing ADA standards (ADA Accessibility Guidelines for Buildings and Facilities (ADAAG)) and use the pending design guidelines for public rights-of-way that will be incorporated into ADAAG as best practices. All new construction that has bicycle and/or pedestrian facilities must incorporate accessible pedestrian features to the extent technically feasible, without regard to cost.

To optimize design for persons with disabilities, planners and designers must address surface cross slope, surface material treatment, minimum path width, maximum running slope of 5%, curb ramp locations and design, and other elements that may create localized obstructions affecting use. Removal of all accessibility barriers will maximize opportunities for the largest number of people.

The Access Board, the federal body responsible for drafting accessibility guidelines is working to supplement those guidelines that the Access Board has issued for the built environment and will address unique constraints specific to public rights-of-way. When finalized, they will become a part of the ADAAG. The provisions being developed include surface treatment, minimum path width, passing space, and changes in the level surface.

Chapter 4: On-Road Bikeways

4-1.0 Introduction

This chapter provides guidelines to help select and design safe on-road bikeways. On-road bikeways include bicycle lanes, shared lanes, shoulders, and wide outside lanes (bikeways that are off the roadway are not covered in this chapter; for off-road bikeways see Chapter 5, Shared-Use Paths).

Section 4-2 provides a framework for considering factors that affect bikeway selection and design, and Section 4-2.2 includes Bikeway Design Selection Tables to assist designers in selecting an appropriate type of on-road bikeway. Section 4-3 provides detailed information about design and construction of specific on-road bikeway configurations, while Section 4-4 provides information for design of bikeways at intersections. Section 4-5 and 4-6 cover retrofitting existing roadways to better accommodate bicycles, and other considerations for on-road bikeways.

Figure 4-1:
Children in a Bicycle Lane

On-road bikeways must be considered at the same time as other elements of the roadway in all projects during scoping, preliminary design and final design.

Many of the same factors that are used to determine appropriate roadway design in new construction, reconstruction and rehabilitation are also used to determine appropriate bikeway design. Decisions regarding bikeways will potentially affect major project elements including roadway cross section, grading, drainage, right-of-way requirements, signs, striping, traffic barriers, lighting and signals, as well as operation and maintenance.

Existing roadways that are not being reconstructed provide many opportunities to improve safety for bicyclists and other users. Bikeways should be considered in all projects, including pavement surface overlay projects, signal replacement, re-striping or pavement maintenance. Bikeways can be retrofitted onto existing streets and roads without construction by making reasonable changes with signs, striping, lighting, traffic signals, operation, and maintenance.

The following four basic types of on-road bikeways are discussed in this chapter:

Bicycle Lane (Bike Lane):

A bike lane is a portion of the roadway or shoulder designated for exclusive or preferential use by people using bicycles. Bicycle lanes are distinguished from the portion of the roadway or shoulder used for motor vehicle traffic by striping, marking, or other similar techniques.

Paved Shoulder:

The shoulder is the edge or border of a roadway that is contiguous with, and on the same level as, the regularly traveled lanes. Bicyclists require a paved surface for operation. Any unpaved shoulder width does not accommodate bicycles. The width of a shoulder bikeway and separation from the travel lane depend primarily on roadway motor vehicle speed and traffic volume.

Shared Lane:

On any roadway where a bicycle may legally be operated, bicycles may need to share a travel lane with motor vehicles if the road does not have a bike lane, a paved shoulder or a separate shared-use path. A shared travel lane may be an appropriate bikeway on some low-speed, low-volume streets or roads. Where a shared lane is intended to be part of a bike route, it should be signed as a bikeway to direct bicyclists and inform motorists. Travel lanes are typically 3.6 m **(12 ft)** wide, or less.

Wide Outside Lane:

A wide outside lane (the right-most through traffic lane) is shared by bicyclists and motorists but designed with extra width to accommodate bicycles. A wide outside lane should be no less than 4.2 m **(14 ft)** and no more than 4.8 m **(16 ft)** wide.

4-2.0 Selecting a Bikeway Design

For new designs as well as retrofitting, there are a few key factors that are used to determine appropriate bikeway design.

For a given type of roadway cross section, motor vehicle speed and average daily traffic volume are the first factors to look at in the process of selecting a bikeway design treatment. However, bikeway design is influenced by other geometric and operational factors including the following:

- On-street parking
- Intersections and driveways
- Right-of-way constraints
- Vehicle turn lane configuration
- Number of traffic lanes
- Topography, grades, sight distances and sight lines
- Traffic composition, especially volume of large trucks

- Bus routes
- Peak-hour vehicle traffic volume
- Average daily and peak-hour bicycle traffic volume
- Bicyclist characteristics

Answers to the following questions will assist in developing the appropriate design:

- What current and anticipated traffic operations will affect the choice of a bicycle design treatment? Accurate traffic data will assist designers in selecting appropriate on-road design treatments.
- Are there right-of-way limitations?
- What kind of bicyclist is the route intended to serve? Bicyclists have different needs based on their skill and comfort in riding a bicycle. (Refer to Chapter 3 for definitions and specific needs of different types of cyclists.)

4-2.1 Consideration of Geometric and Operation Factors

The factors that affect bikeway selection and design are discussed below along with the ranges of values used to differentiate levels of need.

Traffic Volume

Average daily traffic (ADT) volume is the most readily available measure of motor vehicle traffic volume. Peak-hour volume is another commonly reported measure. These are reported from observed counts, automated counts or computer modeling. Higher motor vehicle traffic volume increases risk for bicyclists and increases the required width and separation of the bikeway. The values in Tables 4-1 and 4-2 refer to motor vehicle ADT in terms of two-way ADT.

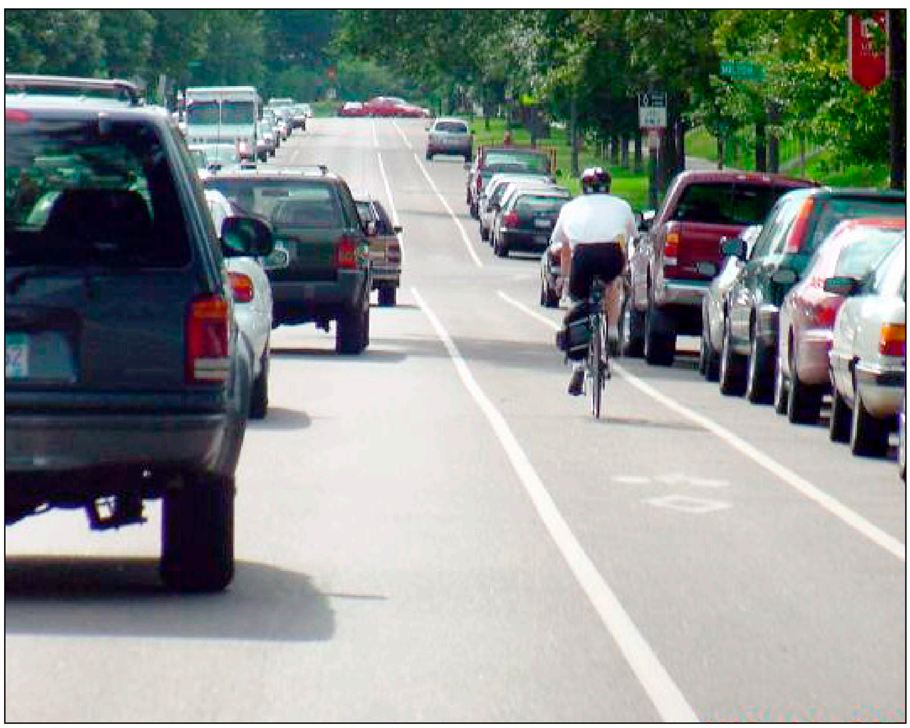


Figure 4-2:
Mixing of Bicycle and Vehicular Traffic

Motor Vehicle Speed

Higher motor vehicle speed has a negative impact on bicyclist risk and comfort unless mitigated by design treatments. Posted speed is recommended as the motor vehicle speed to use when selecting a bikeway design treatment, but consideration may be given to operating speed and design speed where they are known.

A note on motor vehicle speed

Posted speed is the maximum legal operating speed. Actual operating speed is measured by observation of traffic and is generally reported as a statistic, such as average operating speed or 85th percentile operating speed (85 percent of motorists drive at or below this speed). Design speed is defined by AASHTO as "a selected speed used to determine the various geometric design features of the roadway." Designers are accustomed to thinking in terms of the design speed selected to determine geometric characteristics of the facility, including allowable curvature and sight distances. Posted speed and operating speed after construction may or may not be the same as the selected design speed. Posted speed in many situations is determined by policy, statute or ordinance, rather than by design speed. Observation in many settings indicates that traffic often operates at a speed greater than posted, and these observations have been confirmed by data. However, observation also indicates that many motorists reduce their speed when they see that bicyclists are present on the roadway. All roads have a posted speed, but operating speed and design speed may not be readily known. On existing roads the posted advisory speeds may be based on sight lines and other geometric factors that were achievable, given the topography and construction practices used. These considerations lead to the conclusion that posted speed should be the primary factor when selecting a bikeway design treatment, but consideration may be given to operating speed and design speed where they are known.

Roadway Cross Section

The two basic types of roadway cross section for selecting a bikeway design in this chapter are urban (curb and gutter) cross section and rural (shoulder and ditch) cross section. The rural and urban cross section highway terminology are a convention based on the presence or absence of curbing, and have nothing to do with the land use adjacent to the road. The roadway cross section, in general, includes travel lanes, turn lanes, bikeways, sidewalks, shared-use paths, drainage features (curb and gutter or shoulder and drainage ditch), medians, traffic barriers, frontage roads and other features.

Road Functional Classifications

The two major considerations in classifying the functions of highway and street networks are mobility and access. Mobility refers to the ability to travel at higher speeds over longer distances, while access refers to connections between the transportation system and adjacent land uses. There are three major functional classes: *Arterial roads* provide good mobility but have limited access to adjacent property, *local roads* provide access to each property but may have restricted mobility, and *collector roads* connect local roads with arterial roads, providing both mobility and access. Functional classification is based upon traffic volume, speed, traffic composition and access. However, Mn/DOT classifies roads on the State Trunk Highway System as principal arterials, minor arterials and collectors, with local roads in that context meaning all roads of any size or function that are operated and maintained by a city or county. Therefore the *Mn/DOT Road Design Manual* provides design guidelines only for arterial and collector roads, but arterials and collectors are divided into *low speed roads*, which have a posted speed less than or equal to 70 km/h **(40 mph)**, and *high speed roads*, which have a posted speed greater than or equal to 75 km/h **(45 mph)**.

On-Street Parking

The presence of on-street parking increases the width needed in an adjacent bike lane for cyclists to maneuver around motorists entering and exiting cars in the bicycle travel path, thus bike lane width should be increased by 0.3 m **(1 ft)** over the width listed in Table 4-1. This is primarily a concern on streets and highways with an urban (curb and gutter) cross section. On-street parking is not allowed on high speed streets or roads (i.e. those with a posted speed 75 km/h **(45 mph)** or greater) on the State Trunk Highway System.

Intersections and Driveways

Intersections and driveways are roadway features that require extra consideration and care as they relate to bikeways, and provide opportunities as well as potential difficulties for designers of bikeways. Since bicyclists generally want to reach the same destinations as motorists, these features provide access to those destinations. They also present potential locations for conflicts between motor vehicles and bicycles. Most bicycle crashes with motor vehicles occur at intersections.

Right-of-Way Constraints

Right-of-way needs and constraints related to bikeways should be considered throughout project planning and design. Where limited right-of-way does not accommodate a standard bikeway treatment, creative bikeway design solutions may be worked out in consultation with the Mn/DOT Bikeways and Pedestrians Section or other appropriate resource. On alignments where bicycles cannot be safely accommodated due to right-of-way constraints, the project may need to include funding of a bikeway on a parallel road or other alignment in order to meet the project purpose and need pertaining to the bicycle transportation mode.

Vehicle Turn Lane Configuration

Since bicyclists typically operate to the right of motorized traffic, vehicle right turn lanes are roadway features that require extra consideration and care as they relate to bikeways. Traffic flow and safety can be improved by signing and striping bike lanes as well as providing informational signs for motorists stating the rules of interaction at points where vehicle right-turn lanes cross bike lanes.

Number of Traffic Lanes

Intersection design treatment may depend on the number of lanes that a bicyclist or pedestrian must cross.

Topography, Grades, Sight Distance And Sight Lines

Additional bikeway width or separation from the roadway is needed on roads with hills or curves, as determined through a case-by-case analysis. A higher level of bicycle accommodation than indicated in Tables 4-1 and 4-2 is necessary in most cases in rough terrain, and should be considered in rolling terrain. Adequate sight distance is required when a motorist overtaking a bicycle needs to either change lane positions or slow to the bicyclist's speed. Motorists tend to encroach on the shoulder on the inside of curves where the curve advisory speed is less than the main route speed. Inadequate sight distance and obstructed sight lines may be due to restrictive roadway geometry and/or visual obstructions such as vegetation. Bicyclist speed is strongly influenced by topography and grades. On long, steep downhills, bicyclists may approach motor vehicle speeds and may have reduced ability to stop. On uphill sections, bicyclists may need to stand up to pedal, leading to a wider bicycle track in the bikeway.

Traffic Composition

The regular presence of heavy vehicles (trucks, buses, and/or recreation vehicles) may decrease safety and comfort for bicyclists unless special design treatments are provided. If the percentage of trucks or other large vehicles is greater than 10 percent or greater than 250 per peak-hour, a higher level of bikeway accommodation should be used on designated bike routes by increasing the bike lane width, providing an off-road bikeway (shared-use path) or increasing the separation between the roadway and bikeway.

Figure 4-3:
Example of Comfortable Spacing from Bus Traffic

At speeds greater than 75 km/h **(45 mph)** the windblast from large vehicles may create a serious risk for bicyclists. Even at lower operating speeds, they are not compatible with bicyclists using a shared lane. All types of bicyclists prefer extra roadway width or separate facilities to allow greater separation from large vehicles. Many bicyclists will choose a different route or not ride at all where there is a regular presence of large-vehicle traffic unless they are able to move several meters away from them.

Bus Routes

Bus routes may be compatible with bikeways, or they may present unsafe conditions for bicyclists, depending on bus operation and lane configuration. On streets where buses make frequent stops, they may operate at a similar average speed as bicycles, but because the bicyclist's speed is relatively constant while the bus makes frequent stops at the curb, they may have to pass each other many times, creating a potentially unsafe condition. Dedicated busways or transitways may provide good opportunities for bikeways.

Peak-hour Traffic Volume

Peak-hour volume of motor vehicles should be considered in addition to ADT, especially in regard to high-volume turning movements and at intersections where queuing of vehicles may obstruct bikeways.

Average Daily Bicycle Volume and Peak-Hour Bicycle Volume

These measures are not routinely reported, in part because they are difficult to obtain using automated equipment and because they are likely to be significantly higher after a bikeway is added to a street or road that does not currently have appropriate bicycle accommodations. Estimates of bicycle traffic volume may be determined by video recording a road or intersection, or a facility that is similar to the one under design, observing the tape and manually logging the data. Qualitative data may be obtained by simply observing similar facilities.

Bicyclist Characteristics

The types of bicyclists expected to use the bikeway may be an important consideration in some cases (see Chapter 3 for additional information). Most bikeways are designed to accommodate basic bicyclists, but advanced bicyclists and children bicyclists may have additional needs. Advanced bicyclists and bicycle commuters may have low tolerance for bikeways that require frequent stops or detours away from the road, and may choose to occupy a traffic lane instead of an inconvenient bikeway. Children bicyclists are likely to have limited bicycling ability and limited understanding of traffic rules and drivers' perception, and they may need additional accommodation near schools and playgrounds, and at busy intersections or other locations.

4-2.2 On-Road Bikeway Design Selection Tables

Use Table 4-1 or Table 4-2 to select an appropriate bikeway type and width for roadways with either an urban (curb and gutter) cross section or rural (shoulder and ditch) cross section, based on expected motor vehicle speed and traffic volume. The bikeway widths and types determined from the tables should be modified by consideration of the additional geometric and operation factors discussed in Section 4-2.1.

Table 4-1: Bikeway Design Selection for Urban (Curb and Gutter) Cross Section – English Units							
Motor Vehicle ADT (2 Lane)		<500	500-1,000	1,000-2,000	2,000-5,000	5,000-10,000	>10,000
Motor Vehicle ADT (4 Lane)		N/A	N/A	2,000-4,000	4,000-10,000	10,000-20,000	>20,000
Motor Vehicle Speed	25 mph	SL	WOL	WOL	WOL	BL = 5 ft	Not Applicable
	30 mph	SL with sign	WOL	BL = 5 ft	BL = 5 ft	BL = 6 ft	BL = 6 ft
	35 - 40 mph	WOL	BL = 5 ft	BL = 5 ft	BL = 6 ft	BL = 6 ft	BL = 6 ft or PS = 8 ft
	45 mph and greater	BL = 5 ft	BL = 5 ft	BL = 6 ft	BL = 6 ft	BL = 6 ft or PS = 8 ft	SUP or PS= 10 ft
BL = Bicycle Lane, SL = Shared Lane, WOL = Wide Outside Lane, SUP = Shared-Use Path, PS = Paved Shoulder							

Table 4-2: Bikeway Design Selection for Rural (Shoulder and Ditch) Cross Section – English Units							
Motor Vehicle ADT (2 Lane)		<500	500-1,000	1,000-2,000	2,000-5,000	5,000-10,000	>10,000
Motor Vehicle ADT (4 Lane)		N/A	N/A	2,000-4,000	4,000-10,000	10,000-20,000	>20,000
Motor Vehicle Speed	25 mph	PS = 4 ft* or SL	PS = 4 ft* or SL	PS = 4 ft* or WOL	PS = 4 ft*	PS = 4 ft*	Not Applicable
	30 mph	PS = 4 ft* or SL	PS = 4 ft* or WOL	PS = 4 ft*	PS = 4 ft*	PS = 6 ft	PS = 6 ft
	35 - 40 mph	PS = 4 ft* or SL	PS = 4 ft* or WOL	PS = 6 ft	PS = 6 ft	PS = 6 ft	PS = 8 ft
	45 mph and greater	PS = 4 ft*	PS = 4 ft*	PS = 6 ft	PS = 8 ft	PS = 8 ft	SUP or PS= 10 ft
* See discussion in Section 4-3.1 regarding rumble strips on 4-foot shoulders. PS = Paved Shoulder, SL = Shared Lane, SUP = Shared-Use Path, WOL = Wide Outside Lane							

Refer to Section 4-2.1 for additional geometric and operation factors.

4-3.0 On-Road Bikeway Design Guidelines

Several types of bikeway treatments can be used to accommodate bicycles on roadways, including the following:

- Shoulders
- Traffic barrier-protected shoulders
- Standard bicycle lanes
- Combination bus/bicycle lanes
- Wide outside lanes
- Shared lanes

These and other design treatments are discussed in the following sections.

4-3.1 Shoulders

The shoulder is the edge or border of a roadway that is contiguous with, and on the same level as, the regularly traveled lanes. Bicycles can be accommodated on paved shoulders of appropriate width, but unpaved shoulders do not accommodate bicycles. By law, bicyclists may use roadway shoulders, with the exception that bicycles are not permitted on shoulders or travel lanes of the Interstate freeway system and certain other restricted-access expressways. The appropriate width of the shoulder is determined by design speed, ADT, bicyclist needs, and other factors. Bicyclists need at least 4 feet of smooth, rideable paved shoulder width.

Shoulder Rumble Strips

Shoulder rumble strips are typically 0.3 m **(1 ft)** wide and are typically located on the right shoulder beginning 0.15 to 0.3 m **(0.5 ft to 1 ft)** from the edge of the travel lane, but sometimes are wider and/or farther from the edge of travel lane. For compatibility with bicycle transportation, rumble strips should be no wider than 0.4 m **(1.33 ft)**, and should be installed in an alternating on/off pattern within 0.15 m **(0.5 ft)** of the edge of travel lane or fog line, with a minimum 1.2 m **(4 ft)** width of smooth pavement for bicycles on the shoulder.

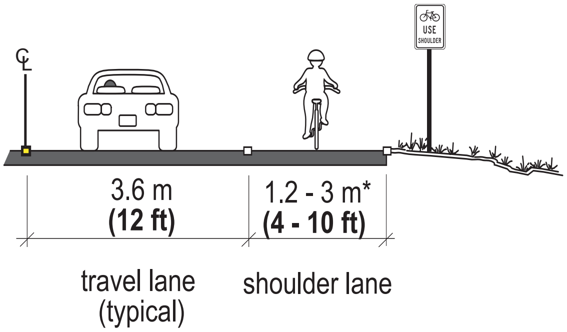
Figure 4-4:
Shoulders as a Bikeway Facility

Shoulder widths of 1.2 m **(4 ft)** or less with standard rumble strips will not adequately accommodate bicycles. Therefore, in accordance with the *Mn/DOT Road Design Manual*, rumble strips should not be placed on these roadway sections unless there is a documented serious ROR (run-off-the-road) crash history, and little or no bicycle traffic is expected. Where a rumble strip is necessary on a 4 ft shoulder, designers can consider the option of placing a 0.3 m **(1 ft)** wide rumble strip on the edge line of the roadway with the edge stripe painted over the rumble strip. See Figures 4-4 and 4-5. For more information on rumble strips, see Section 4-6.1 of this manual, and Chapter 4 of the *Mn/DOT Road Design Manual*.

Shoulder as a Bikeway Facility

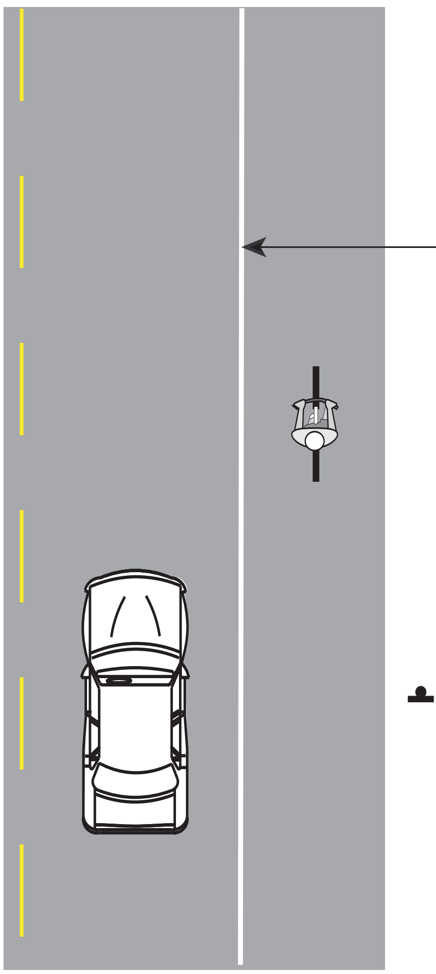
Figure 4-5 illustrates signing and striping of the roadway shoulder as a bikeway. The appropriate shoulder width ranges from 1.2 m to 3 m **(4 ft to 10 ft)** as provided in Table 4-2.

The minimum paved shoulder width to accommodate bicyclists is 1.2 m **(4 ft)**, with a minimum 1.5 m **(5 ft)** distance from the right edge of the rumble strip to any guardrail, curb or other roadside barrier.



Design Requirements:

- * Shoulder width ranges from 1.2 m - 3 m **(4 ft - 10 ft)** (See Table 4-2)
- Minimum 1.5 m **(5 ft)** from right edge of rumble strip to the face of a guardrail, curb or other roadside barrier.
- Shoulders should be wider where higher volumes of bicyclists are expected.



Shoulder Lane Stripe

Pavement marking line
100 mm **(4 in)** wide solid white

#R9-X1

Optional:
Sign shoulders as a bikeway on designated bicycle routes and/or popular bicycling roadways when ADT > 2,000, average vehicle speeds > 56 km/h **(35 mph)**, and when there is inadequate sight distance (e.g. corners and hills)

**** Not to Scale ****

Note: Check current MN MUCTD for any changes to signs and striping configurations.

Figure 4-5:
Shoulder as a Bikeway Facility

4-3.2 Traffic Barrier-Protected Shoulders

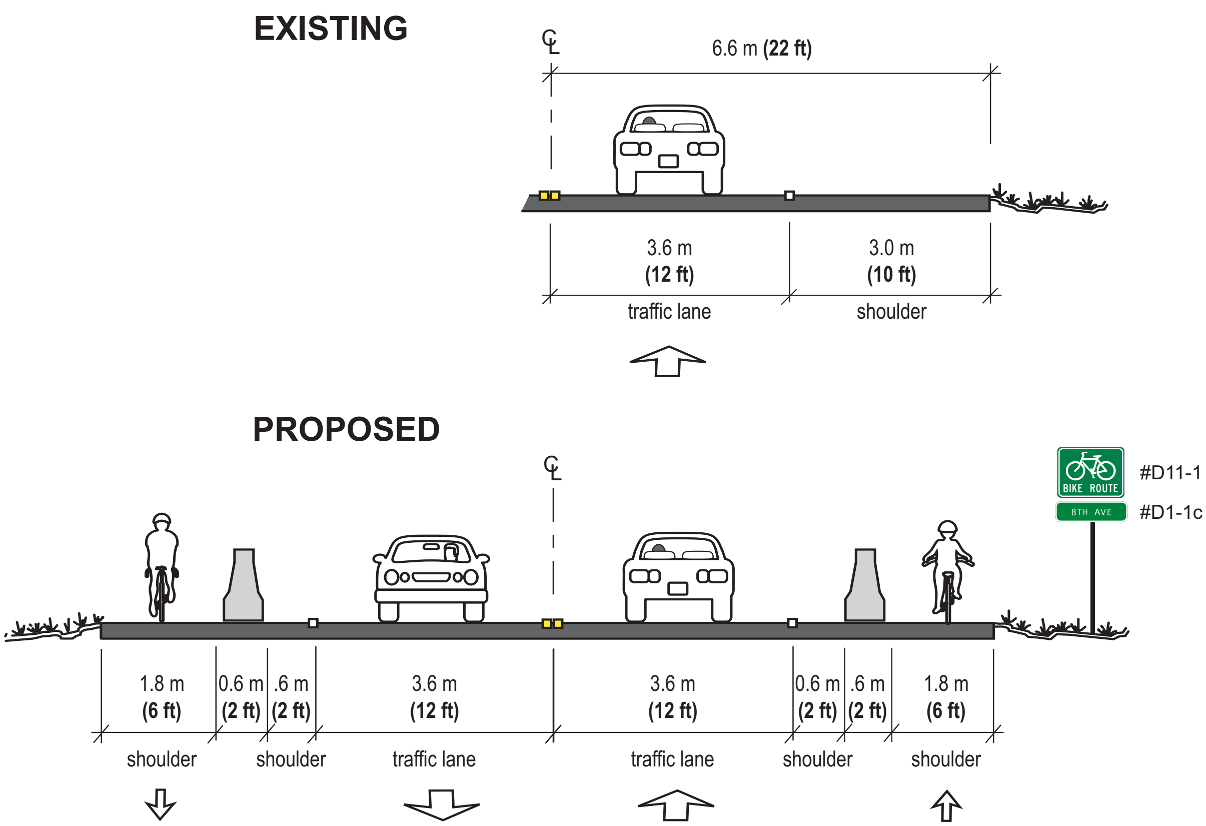
Although additional shoulder width can accommodate bicyclists on roads with relatively high traffic speeds and/or volumes, not all types of riders will feel safe. Some high-volume, high-speed roadways may warrant a physical separation of bikes from traffic lanes. This can be accomplished by partitioning shoulders with a concrete traffic barrier.

Traffic barrier-protected shoulders are also recommended in highway construction zones where vehicle travel lanes and shoulders have been shifted or eliminated. Connections should be well marked with signage, especially in construction/detour zones.

A bikeway created through the construction of a concrete barrier-protected shoulder is pictured in Figure 4-6 and illustrated in Figure 4-7.

When concrete barriers are installed on a shoulder, 0.6 m **(2 ft)** should be left for emergency or distressed vehicles on the motor vehicle side and 1.8 m **(6 ft)** on the other side for one-way bicycle travel. Any two-way bicycle facility along a roadway must be designed in accordance with the guidelines of Chapter 5 of the manual.

Figure 4-6:
Bikeway with a Jersey Barrier-Protected Shoulder, Seattle
Picture courtesy of www.pedbikeimages.org / Dan Burden



Note: Check current MN MUCTD for any changes to signs and striping configurations.

Figure 4-7:
Traffic Barrier-Protected Shoulders

4-3.3 Standard Bicycle Lanes

The designs in this section are presented in a continuum from most preferable to least preferable to provide designers with flexibility in a variety of conditions; including limited right of way. Designs that specifically address accommodating bicycles where there is constrained right of way include share the road options and reducing lane widths and parking lane widths to accommodate a bike lane. When looking at these options designers must pay particular attention to site specific factors such as vehicle speed and traffic volume while balancing the needs of maintaining network continuity for bicyclists and safety for all road users. It is also important for the designer to choose a solution that maintains the proper design standards for the roadway's classification.

A bicycle lane is a portion of a roadway designated by striping, signing, and pavement markings for the preferential or exclusive use of bicycles. These one-way bicycle facilities are appropriate for roads with an urban (curb and gutter) cross section. Bicycle lanes carry bicycle traffic in the same direction as adjacent motor vehicle traffic.

Bicycle lanes provide increased separation from traffic and accommodate bicycles better than shared lanes or wide outside lanes. Research indicates that bicycle lanes have a strong channelizing effect on motor vehicles and bicycles. Bicycle lane stripes remind motorists to expect bicycles and can increase bicyclists' confidence that motorists will not stray into their path of travel. Designers should refer to Chapter 9 of the *MN MUTCD*, which provides standards for bike lane signs, striping and pavement markings.

Bicycle lanes usually have a width of 1.5 m **(5 ft)** or 1.8 m (6 ft) as provided in Table 4-1, depending on the factors discussed in Section 4-2.1. Bicycle lanes wider than 1.8 m **(6 ft)** may be misinterpreted by some drivers as a travel lane or right-turn lane. Where additional width is available on the roadway, additional clearance between vehicles and the bike lane can be provided by increasing the widths of the parking lane and/or travel lane. Where the roadway width is restrictive, striping and marking a non-standard 1.2 m **(4 ft)** bike lane may provide safer channelization than a wide curb lane.

Figure 4-8 illustrates recommended standard bike lane widths for several typical roadway conditions. Additional bike lane design guidelines are provided in Sections 4-3.3.1, 4-3.3.2, 4-3.3.3 and 4-3.3.4.

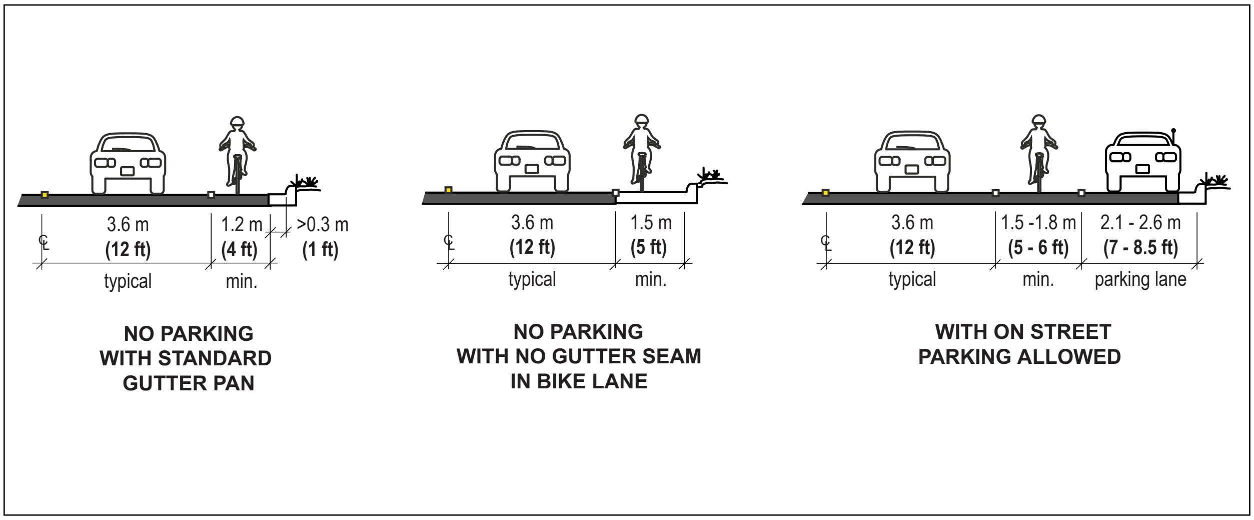


Figure 4-8:
Typical Roadways with Bike Lanes

4-3.3.1 Bicycle Lanes, Road with Gutter Pan

The longitudinal joint between the gutter pan (the curb and gutter) and roadway surface can be hazardous to a cyclist. Where a standard gutter pan is present, and the longitudinal seam or joint is within the bike lane, the minimum bicycle lane width should be 1.5 m **(5 ft)** from the face of the curb to the bike lane stripe, with a minimum continuous width of 0.9 m **(3 ft)**, and preferably 1.2 m **(4 ft)** or greater, of smooth rideable surface provided. In locations with greater than 10 percent truck traffic, and at higher traffic speeds and traffic volumes as indicated in Table 4-1, a minimum bicycle lane width of 1.8 m **(6 ft)** is preferred, with a minimum width 1.5 m **(5 ft)** of smooth, rideable surface provided.

Figure 4-10 illustrates design of a bike lane on a roadway with a standard gutter pan, where parking is prohibited.

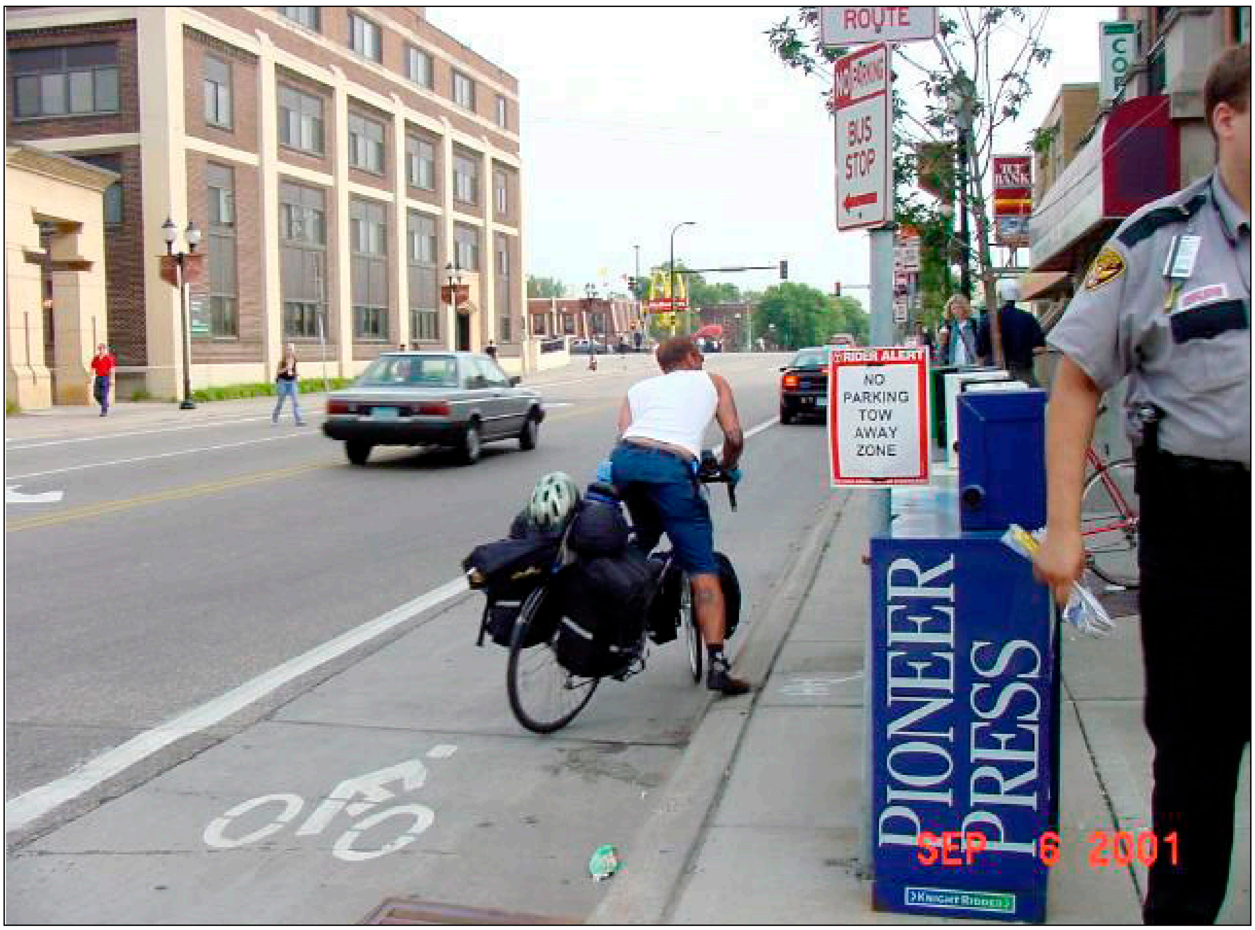
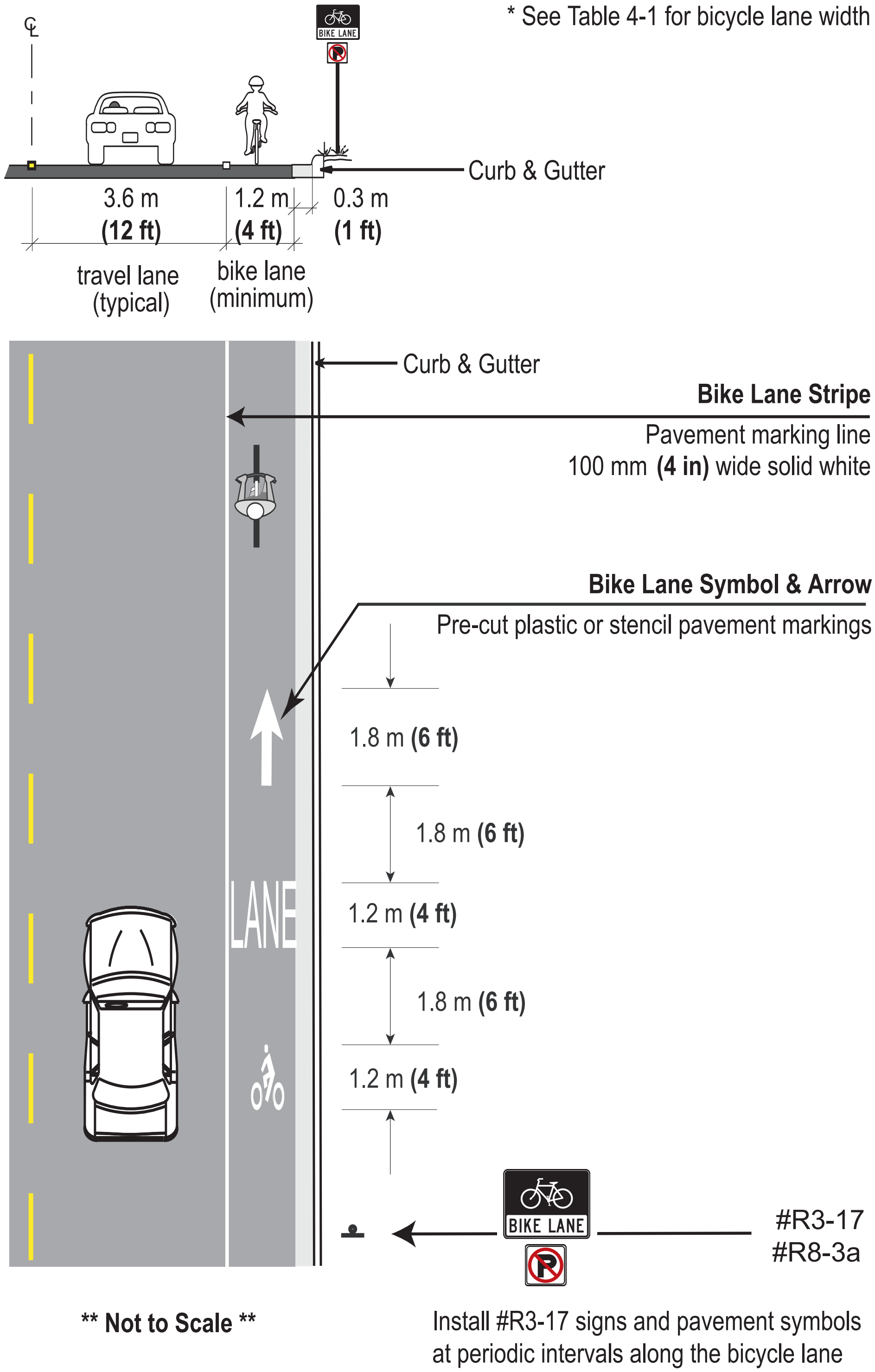


Figure 4-9:
Bicycle Lane on a Roadway with Curb and Gutter



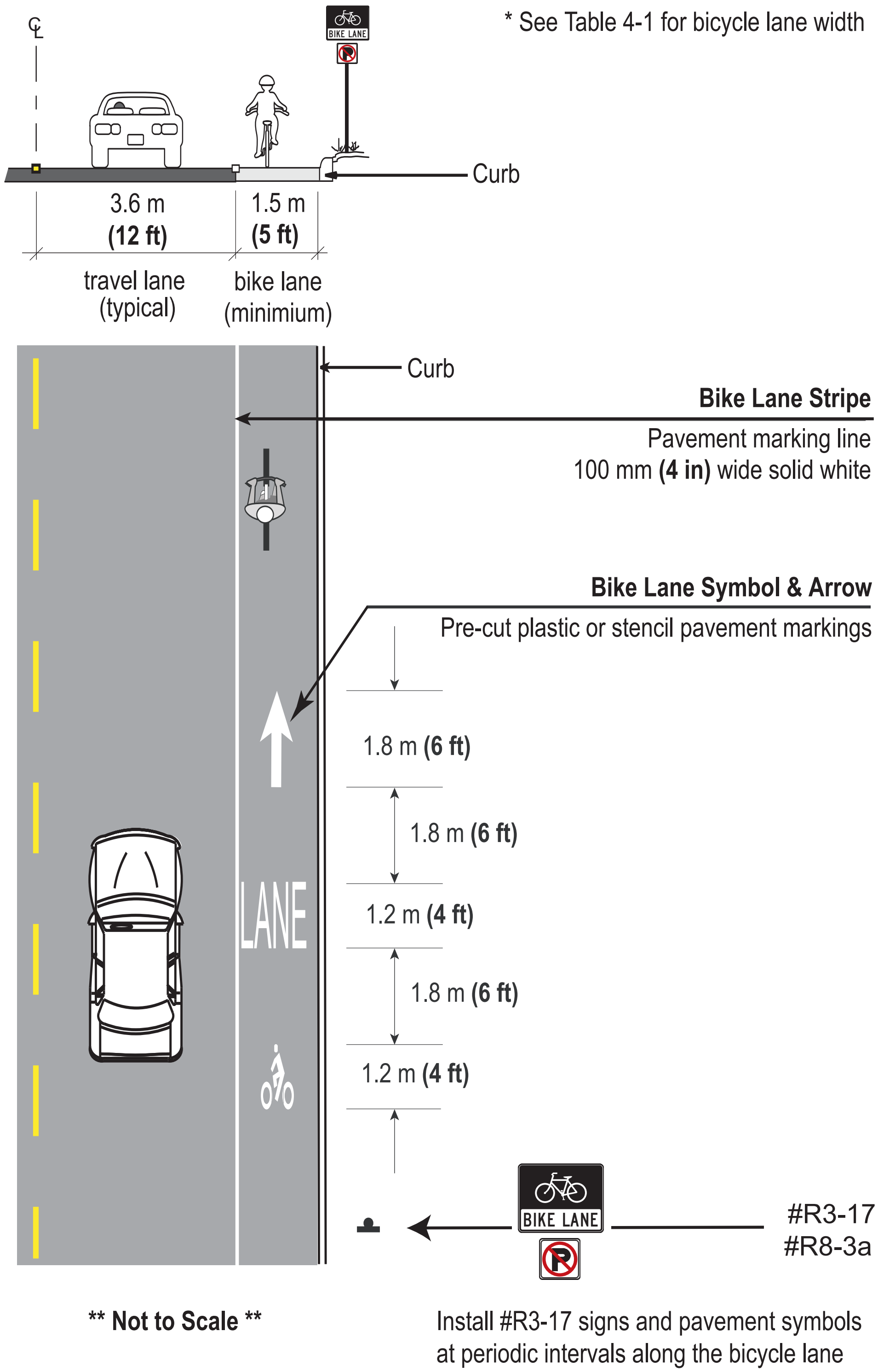
Note:
Application of MN MUTCD Series R7-9 or R7-9a "NO PARKING BIKE LANE" signage may be used. Check current MN MUCTD for any changes to signs and striping configurations.

Figure 4-10:
Bicycle Lane with No Parking and Standard Gutter Pan

4-3.3.2 Bicycle Lanes, Road with Curb but No Gutter Pan

For a curbed section that has pavement to the curb, with no longitudinal gutter seam, the minimum width for a bicycle lane is 1.5 m **(5 ft)** from the face of the curb to the bike lane stripe, with a minimum width 1.2 m **(4 ft)** of smooth, rideable surface. In locations with greater than 10 percent truck traffic, and at higher traffic speeds and traffic volumes as indicated in Table 4-1, a minimum bicycle lane width of 1.8 m **(6 ft)** is preferred, with a minimum width 1.5 m **(5 ft)** of smooth, rideable surface provided. See Figure 4-11. Bicycle lanes on roadways with no gutter pan seams are illustrated in Figure 4-12.

Figure 4-11:
Bicycle Lane on a Roadway with Curb but No Gutter



Note:
Application of MN MUTCD Series R7-9 or R7-9a "NO PARKING BIKE LANE" signage may also be used. Check current MN MUCTD for any changes to signs and striping configurations.

Figure 4-12:
Bicycle Lane with No Gutter Pan Seam within the Bicycle Lane

4-3.3.3 Bicycle Lanes with On-Street Parking Allowed

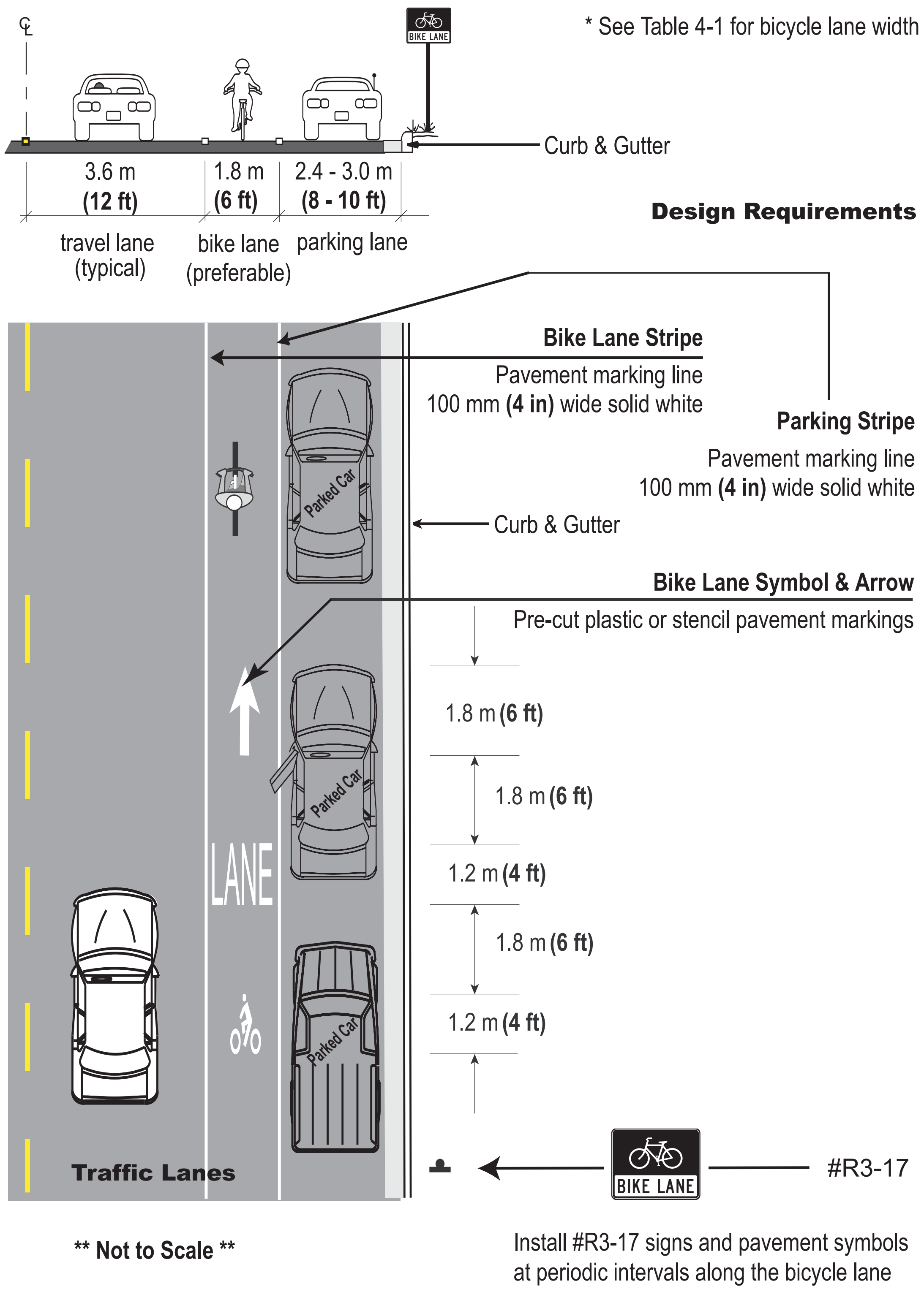
On streets with a parking lane, the bicycle lane shall be located between the vehicle travel lane and the parking lane. Parking movements and car doors opening potentially cause bicycle crashes. Design bicycle lanes and parking lanes to minimize these conflicts. A 1.8 m **(6 ft)** bicycle lane is preferred adjacent to a parking lane. The right side of the bike lane should be marked with a parking lane stripe, especially where there is high parking turnover. Where space is available, additional clearance from opening car doors can be provided by increasing the width of the parking lane, and additional emergency maneuvering space can be provided by increasing the width of the travel lane.

Figure 4-13:
Bicycle Lane with On-Street Parking Allowed

It is important for bicyclist safety to periodically maintain and repaint the bike lane stripes and pavement markings.

Bicycle lanes on a roadway with on-street parking is pictured in Figure 4-13 and the design is illustrated in Figure 4-14. See also Section 4-2.1 for additional discussion of on-street parking.

Decisions to designate bicycle lanes adjacent to angled parking should be accompanied by a full engineering review. In these cases, current practice recommends angled parking spaces with a "back in" configuration in order to increase the visibility of bicyclists to motorists. Width of the parking lane depends on parking angle.



Note: Check current MN MUCTD for any changes to signs and striping configurations.

Figure 4-14:
Bicycle Lane with On-Street Parking Allowed

4-3.3.4 Left-Side Bicycle Lane on a One-Way Street

Bike lanes on the left side of one-way streets are unfamiliar and unexpected for most motorists. They should only be considered when they would substantially decrease the number of conflicts, such as those caused by parked cars, bus traffic, or unusually heavy vehicle turning movements to the right, or where there are a significant number of left-turning bicyclists. See Figure 4-16 for an illustration of left-side bike lane design.

Figure 4-15:
Left Side Bike Lane on a One-Way Street

A bicycle lane on the left side of the street is designed according to the same guidelines as standard right side bicycle lanes. It is best if there is no on-street parking on the left side of the roadway, and a full engineering review should accompany any planning or decision making process for this configuration.

Contra-flow bike lanes (those in the opposite direction of the normal traffic flow) are not recommended. Since they route bicyclists in a direction motorists do not expect, these facilities create an unpredictable environment that may create conflict.

Application of Series R7-9 and/or R7-9a “No Parking Bike Lane” signage, in accordance with *Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD)*, may also be appropriate.

4-3.4 Combination Bus/Bike Lanes

Bus/bicycle lanes are usually intended for the exclusive use of buses, bicycles, and right-turning vehicles. Because bicycles generally travel at slow speeds and buses make frequent stops, these lanes can often function without impeding traffic flow. Generally, the bicyclist should overtake a stopped bus on the left, since passing on the right invites conflict with boarding and exiting bus passengers. Depending on traffic conditions, bus/bicycle lanes are sometimes closed to other traffic during peak hours and opened in those hours when fewer bicyclists and buses are present. Right-turning vehicles are often allowed in the lane only within 25 m **(82 ft**) of an intersection.

Mixing bicycle and bus traffic in a designated lane is most acceptable if bus speeds are low, preferably less than 30 km/h **(20 mph)**. Where the speed limit is greater than 50 km/h **(30 mph)**, employing combination bus/bicycle lanes is not desirable. A bike route may not be safe on streets with high peak hour traffic volume where buses make frequent stops. In this case, buses and bicycles may have similar average speeds, but have to pass each other repeatedly, with bicyclists required to share a busy adjacent travel lane to pass.

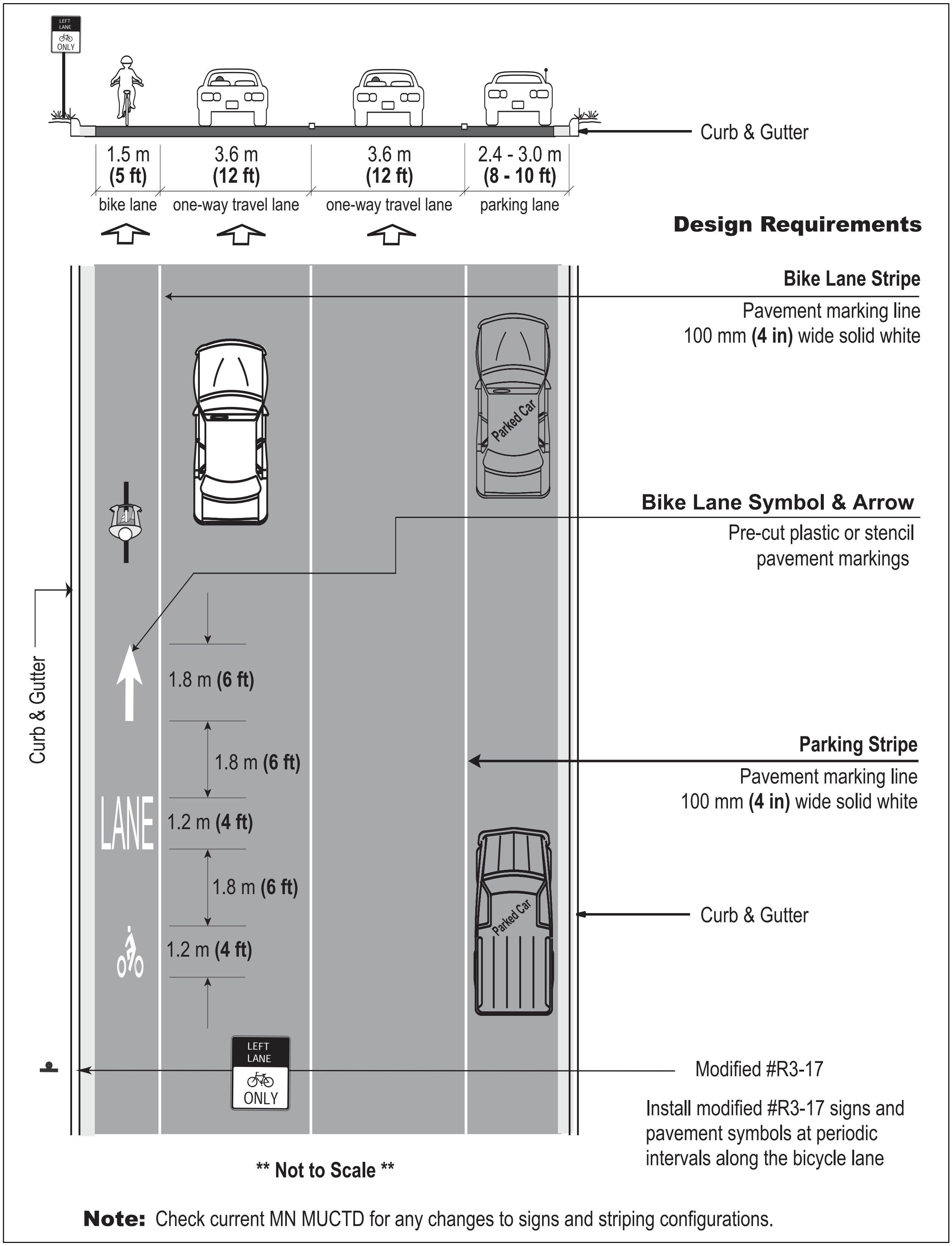


Figure 4-16:
Left Side Bike Lane on a One-Way Street

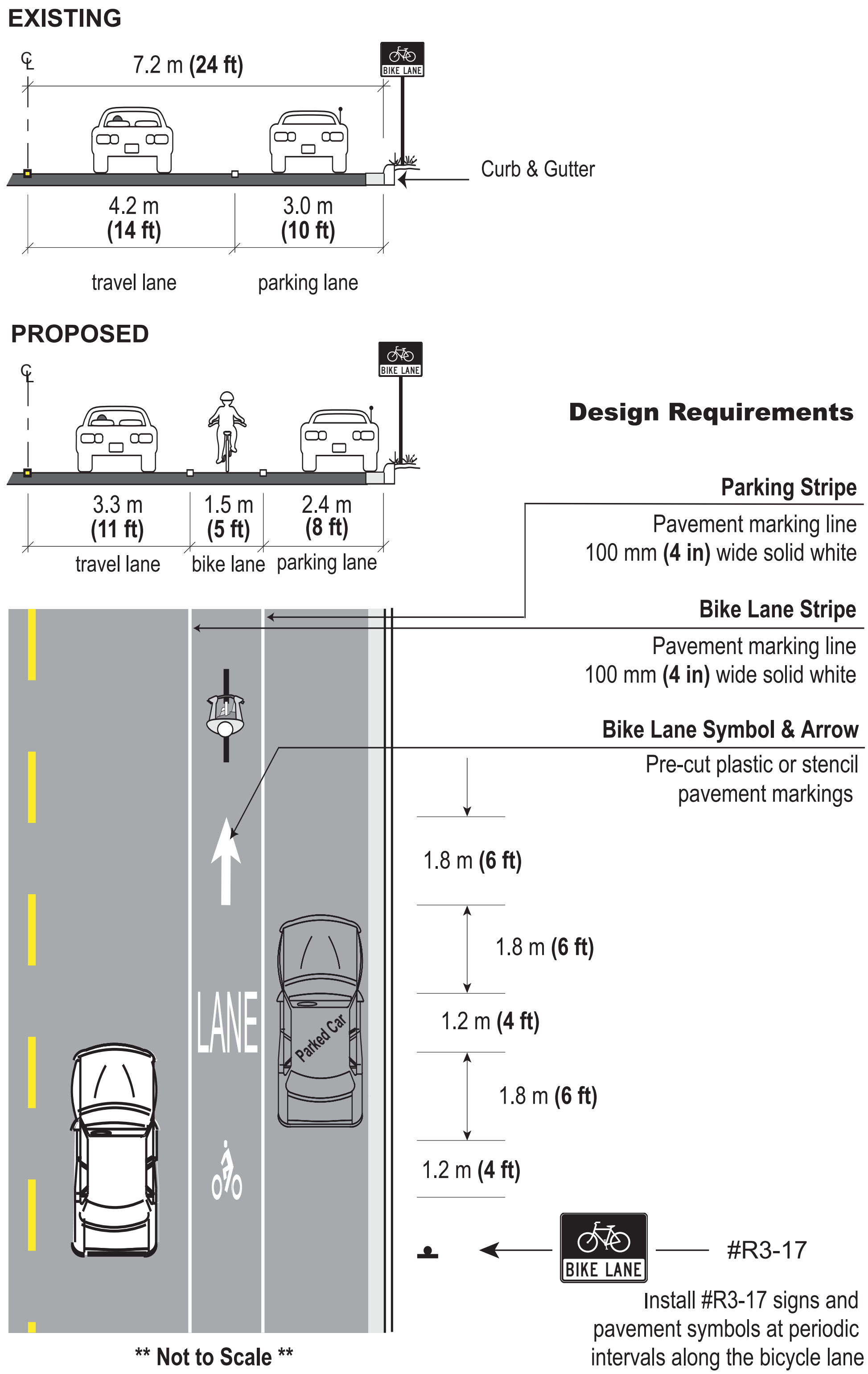
4-3.5 Bike Lane on Constrained Right-of-Way with Parking

Creating a bicycle lane on a constrained-width roadway that includes parking is an design that can be accomplished by narrowing parking and travel lanes, and designating a portion of the roadway for bicycle use by striping, signing, and using pavement markings. The recommended reduced widths of the travel and parking lanes are described below for the case where the existing right-of-way in one direction of travel is 24 feet, and for the case where it is 22 feet.

Case A (24-foot Right-of-Way)

Creating a constrained bike lane via striping, signing, and pavement marking as illustrated in Figure 4-17 is appropriate when the following conditions exist:

- Traffic lane plus parking lane = 7.2 m **(24 ft)** wide
- Traffic lane = 4.5 m **(15 ft)** wide
- Posted vehicle speeds = 48 km/h **(30 mph)** or less



Note: Check current MN MUCTD for any changes to signs and striping configurations.

Figure 4-17:
Constrained R.O.W. with Parking Case A (24-Foot Right-of-Way)

Bike Lane on Constrained Right-of-Way with Parking

Case B (22-foot Right-of-Way)

Creating a constrained bike lane via striping, signing, and pavement marking as illustrated in Figure 4-18 is appropriate when the following conditions exist:

- Traffic lane plus parking lane = 6.7 m **(22 ft)** wide
- Traffic lane = 4.2 m **(14 ft)** wide
- Posted vehicle speeds = 48 km/h **(30 mph)** or less

Designating a 1.5 m **(5 ft)** bicycle lane in this narrow right-of-way is possible because in low-speed residential areas, the combination of narrow parallel parking and travel lanes [2.1 to 2.4 m **(7 to 8 ft)** parking and 3.0 m **(10 ft)** travel] are acceptable. For additional information on minimum lane widths, see *A Policy on the Geometric Design of Highways and Streets (AASHTO*; *2004)* or *Local State-Aid Route Standards (Minnesota Rules Chapter 8820).*

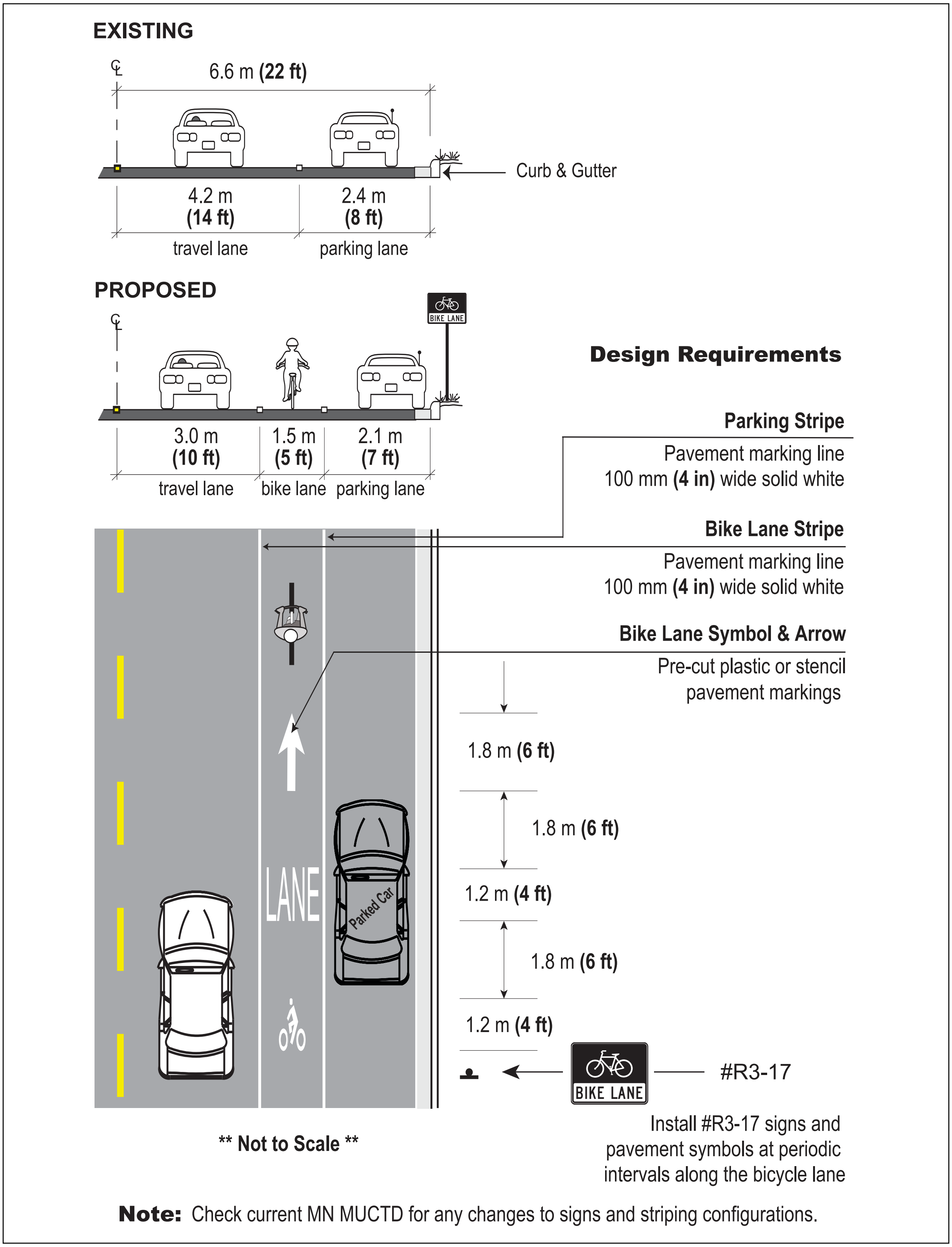


Figure 4-18:
Constrained R.O.W. with Parking Case B (22-Foot Right-of-Way)

4-3.6 Wide Outside Lanes

Wide outside lanes accommodate bicycles and motorists in the same lane with a lane width of 4.2 – 4.8 m **(14 – 16 ft)**. In most cases, motorists will not need to change lanes to pass a bicyclist, minimizing conflicts. Wide outside lanes also provide bicyclists more maneuvering room at driveways, in places with limited sight lines, and on steep grades. Wide outside lanes can accommodate advanced bicyclists who ride comfortably and safely in areas with high traffic volumes. However, for basic bicyclists, wide outside lanes generally do not provide the same degree of comfort and safety as designated bicycle lanes.

Wide outside lanes may be considered where there is insufficient width to provide striped bicycle lanes. The following wide outside lane widths are recommended:

- A wide outside lane with 4.2 m **(14 ft)** width is appropriate where vehicle speeds are 56 km/h **(35 mph)** or less.
- A wide outside lane with 4.5 – 4.8 m **(15 – 16 ft)** width is appropriate where vehicle speeds are 64 km/h **(40 mph)** or greater, or where bicyclists need extra maneuvering room.
- Wide outside lanes greater than 4.8 m **(16 ft)** are not recommended, because drivers may try to form two travel lanes, where striping a bike lane may provide better channelization of vehicles and bicycles.

Caution should be used when designating wide outside lanes because they may encourage increased traffic speeds, contrary to the goals of traffic calming and pedestrian safety. On popular bicycling streets, it may be appropriate to mark wide outside lanes with shared-lane marking. Pavement marking should be placed at least 0.9 m **(3 ft)** from the edge of the rideable surface. Figure 4-19 illustrates urban roadway cross sections with a wide outside lane, which are discussed further in Sections 4-3.6.1 and 4-3.6.2. Wide outside lanes may also be appropriate on roadways without curbs (see Table 4-2).

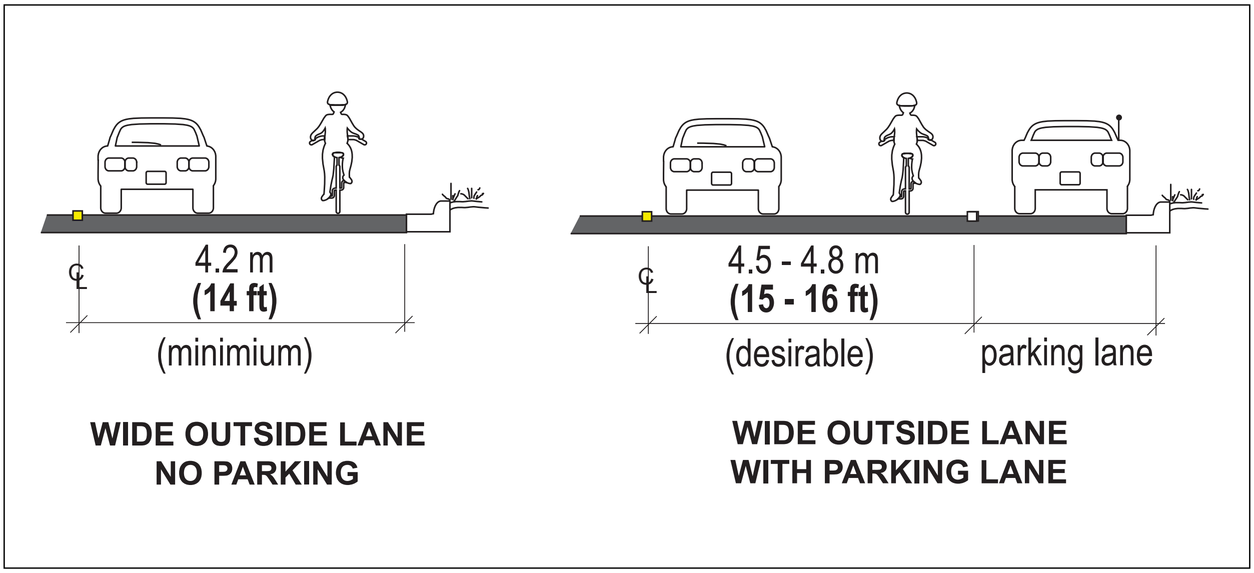
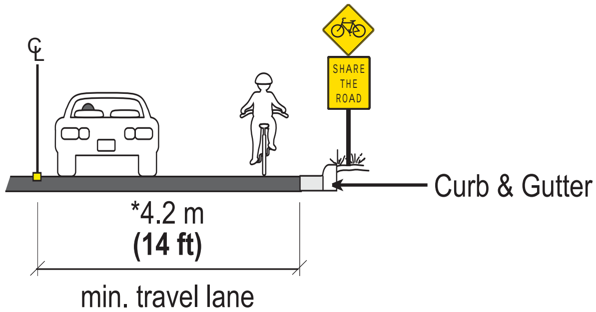


Figure 4-19:
Typical Roadways with Wide Outside Lanes

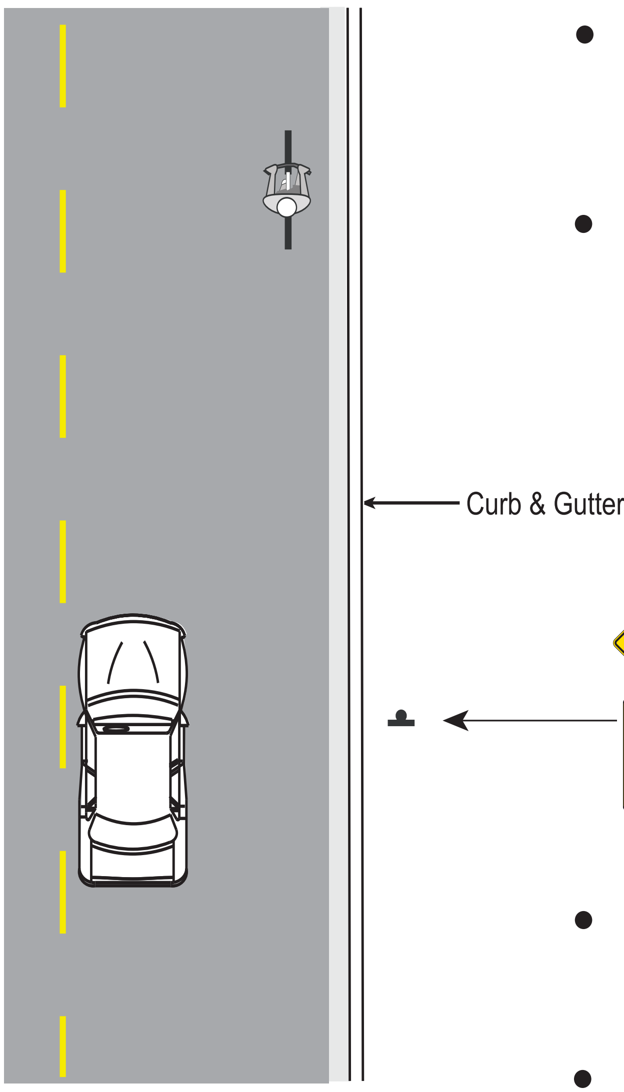
4-3.6.1 Wide Outside Lane with No Parking

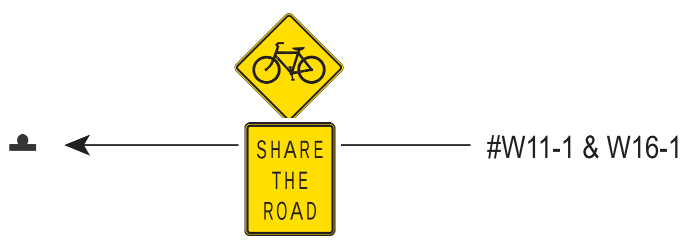
Most practitioners agree that on urban streets without parking, the minimum space necessary to allow a bicyclist and motorist to share the same lane, is 4.2 m **(14 ft)**, measured from the lane stripe to the edge of the gutter pan, rather than to the curb face. This width allows a shared lane without creating conflicts, necessitating lane changes, or reducing the motor vehicle capacity of the lane. See Figure 4-20. Application of *MN MUTCD* Series R7-9 or R7-9a “NO PARKING BIKE LANE” signs may be appropriate.



Design Requirements

- * 4.5 m **(15 ft)** of usable width is desirable on sections of roadway where bicyclists need more maneuvering room (e.g., steep grades, limited sight distance)
- If traffic speeds exceed 64 km/h **(40 mph)** 4.5 - 4.8 m **(15 - 16 ft)** wide curb lanes are desirable





Optional:

- Install Share the Road signs to warn drivers to watch for bicyclists traveling along urban streets with wide outside lanes of 4.2 m **(14 ft)** or greater, but no bicycle lane.
- Space signs approximately every 0.8 km **(0.5 mi)** on urban routes frequently used by bicyclists.

**** Not to Scale ****

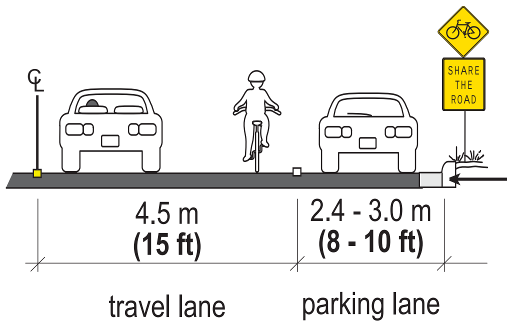
Note: Check current MN MUCTD for any changes to signs and striping configurations.

Figure 4-20:
Wide Outside Lane with No Parking

4-3.6.2 Wide Outside Lane with On-Street Parking

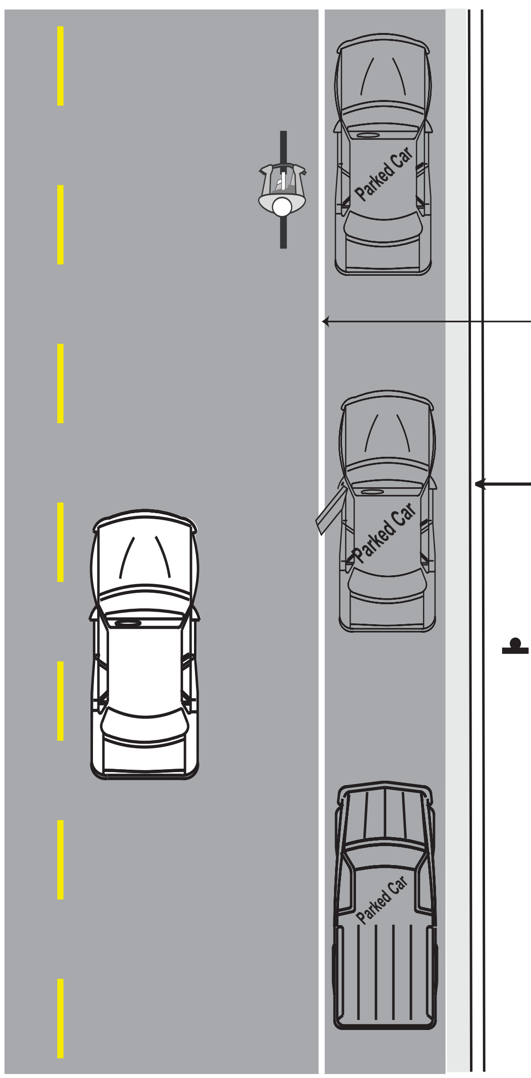
Since an open car door takes up extra space, a wide outside lane of 4.5 m **(15 ft)** minimum width is recommended adjacent to the parking lane to allow bikes extra space for maneuvering to keep clear of on-street parking. See Figure 4-21.

If on-street parking is provided along with the wide outside travel lane, the parking lane should be at least standard width. Narrowing a parking lane to provide the space for bicyclists may or may not encourage motorists to park closer to the curb.



Design Requirements

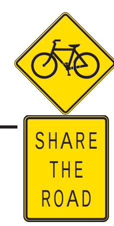
- * 4.8 m **(16 ft)** of usable width is desirable on sections of roadway where bicyclists need more maneuvering room (e.g., steep grades, limited sight distance)
- If traffic speeds exceed 64 km/h **(40 mph)** 4.8 m **(16 ft)** wide outside lanes are desirable



Bike Lane Stripe

Pavement marking line
100 mm **(4 in)** wide solid white

Curb & Gutter



#W11-1 & W16-1

Optional:

- Install Share the Road signs to warn drivers to watch for bicyclists traveling along urban streets with wide outside lanes of 4.2 m **(14 ft)** or greater, but no bicycle lane.
- Space signs approximately every 0.8 km **(0.5 mi)** on urban routes frequently used by bicyclists.

Note: Check current MN MUCTD for any changes to signs and striping configurations.

Figure 4-21:
Wide Outside Lane with On-Street Parking

4-3.7 Shared Lanes

Shared lanes are streets and highways with no special provision on the roadway for bicyclists, as shown in Figure 4-22. Shared lanes often feature 3.6 m **(12 ft)** lane widths or less with no shoulders, allowing cars to pass bicyclists only by crossing the centerline or moving into another traffic lane. In residential areas with low motor vehicle traffic volumes and average speeds of less than 48 km/h **(30 mph)**, shared lanes are normally adequate for bicyclists to use. With higher speeds and traffic volumes, shared lanes become less attractive to basic bicyclists.

Figure 4-22:
Non-Marked Shared Lane

Shared lanes are not typically signed as bicycle routes. Signage may be needed when specific destinations or potential alternate routes for bicyclists need to be shown, or on roads that bridge a gap between two designated bike routes. Application of *MN MUTCD* Series R7 and/or R8 "No Parking" signage may also be appropriate. Figure 4-23 illustrates shared lanes on three typical roadway types. Figure 4-24 illustrates a shared lane on an urban (curb and gutter) cross section roadway with no on-street parking.

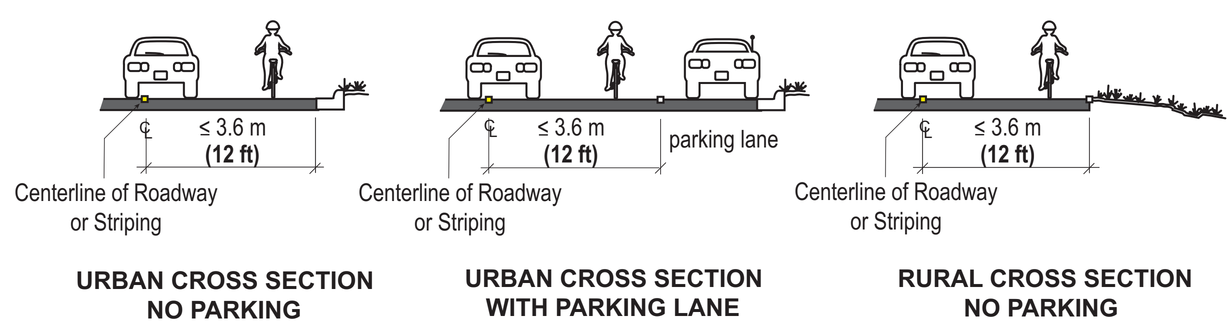
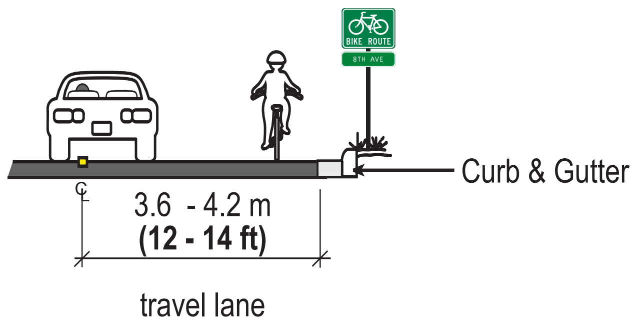
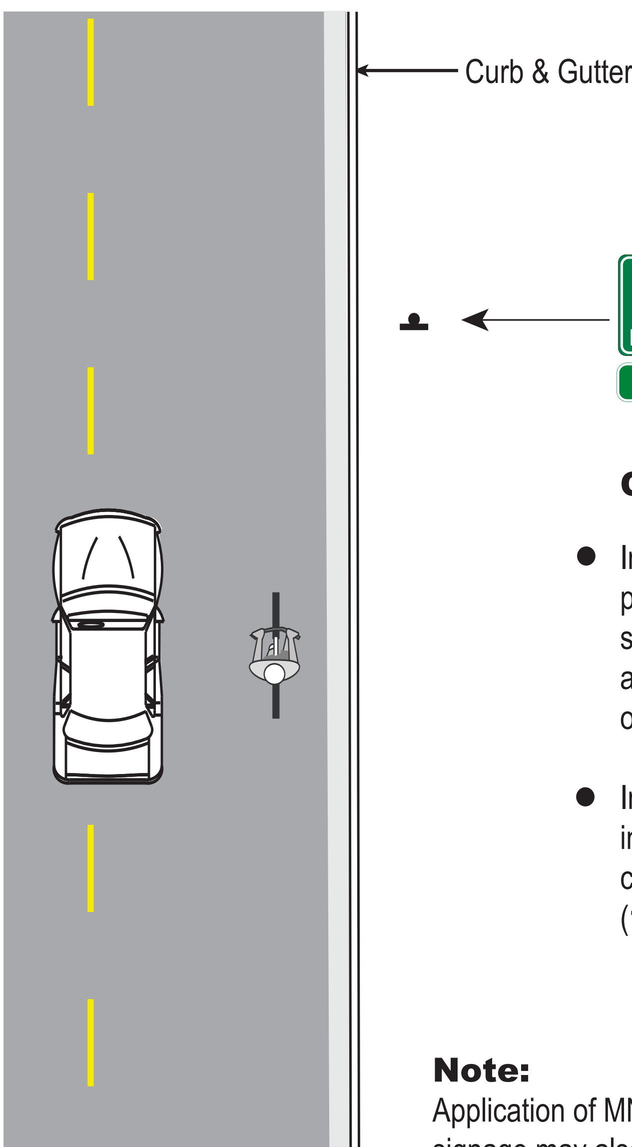
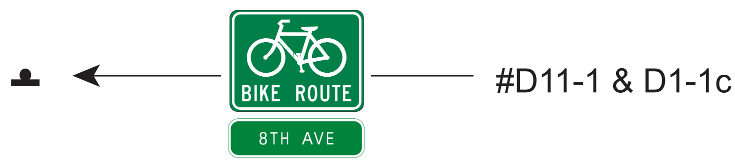


Figure 4-23:
Typical Roadways with Shared Lanes







Optional:

- Install Bike Route signs with destination plaques if street is needed to connect specific destinations, establish a potential alternate route, or provide a link between other bicycle facilities.
- Install signs at every major intersection, intersections with other bicycle routes, confusing junctions, or every 300 m (**1000 ft**).

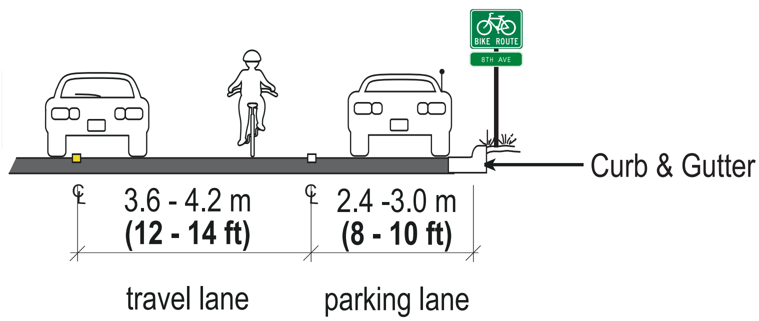
** Not to Scale **

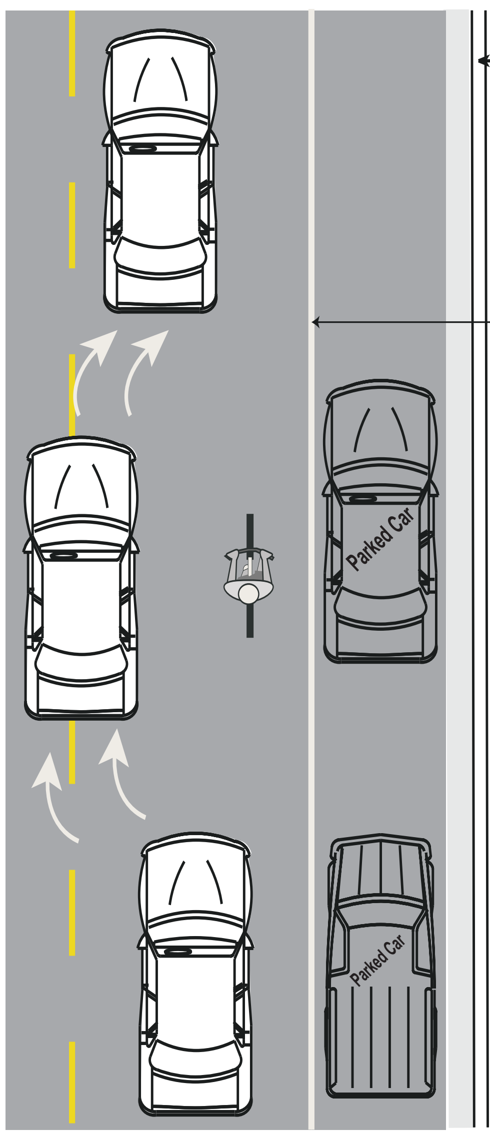
Note:
Application of MN MUTCD Series R7 and/or R8 “NO PARKING” signage may also be appropriate. Check current MN MUCTD for any changes to signs and striping configurations.

Figure 4-24:
Shared Lane, Urban Cross Section with No Parking

4-3.7.1 Shared Lane, Urban (Curb and Gutter) Cross Section with Parking

Where a shared lane is used adjacent to a parking lane, striping the parking lane to indicate a 4.2 m **(14 ft)** shared lane is recommended. This provides some extra clearance and allow bicyclists to avoid potential collisions in the “open door zone” of parked vehicles. In addition, signage can clarify bicyclists’ right to share the road and alert motorists to bicyclists. See Figure 4-25.

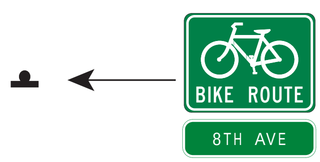




Design Requirements

Parking Lane Stripe

Pavement marking line
100 mm **(4 in)** wide solid white



#D11-1 & D1-1c

Optional:

- Install Bike Route signs with destination plaques if street is needed to connect specific destinations, establish a potential alternate route, or provide a link between other bicycle facilities.
- Install signs at every major intersection, intersections with other bicycle routes, confusing junctions, or every 300 m **(1000 ft)**.

** Not to Scale **

Note: Check current MN MUCTD for any changes to signs and striping configurations.

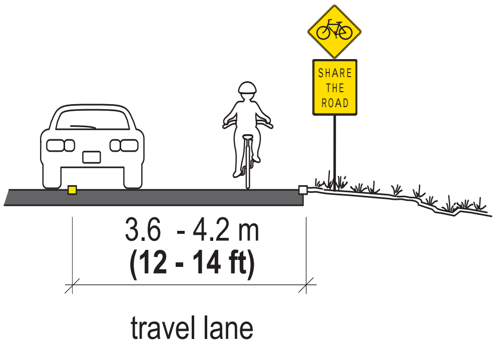
Figure 4-25:
Shared Lane, Urban Cross Section with Parking Lane

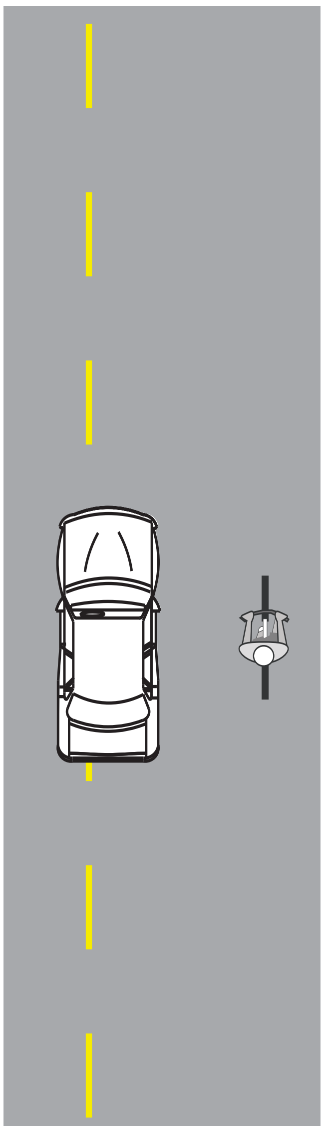
4-3.7.2 Shared Lane, Rural (Shoulder and Ditch) Cross Section with No Parking

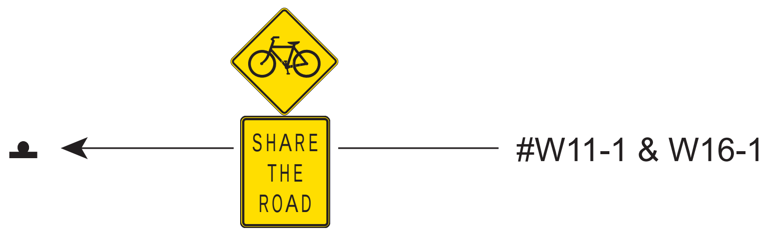
On a road with no curb and no parking, the width for a shared lane should be 3.6 - 4.2 m **(12 - 14 ft)** wide. Motorists may have to cross the centerline of the road to pass bicyclists, which is acceptable on low-volume roads.

Installing “Share the Road” signage to increase driver awareness of bicyclists is optional.

Figure 4-26 illustrates shared lane design on a rural (shoulder and ditch) cross section roadway with no parking.







Optional:

- Install Share the Road signs to warn drivers to watch for bicyclists traveling along the road in rural situations where there is no paved shoulder and a large number of bicycles use the roadway.
- Space signs every 1.6 - 3.2 km **(1 - 2 mi)** and/or on corners, hills, or other places with limited sight distances.

** Not to Scale **

Note:
Application of MN MUTCD Series R7-9 or R7-9a "NO PARKING BIKE LANE" signage may also be used. Check current MN MUCTD for any changes to signs and striping configurations.

Figure 4-26:
Shared Lane, Rural Cross Section (No Parking, No Curb & Gutter)

4-4.0 On-Road Bikeways at Intersections

In urban areas, more than three-fourths of all car/bike crashes occur at intersections. The causes of these crashes are numerous; no single measure will provide a solution to the intersection problem. Almost one-fifth of all car/bike collisions are caused when a bicyclist runs a stop sign or red light. In addition, motor vehicle drivers in both left and right turning situations have a tendency to overlook bicyclists riding (improperly) against the normal flow of traffic. Safety at intersections depends on the functions of the roads and bikeways, motor vehicle and bicycle traffic volumes and speeds, crossing distances, and the amount of space available at the crossing.

The following guidelines will help achieve safe, workable intersections.

Safety

- Ensure that bicyclists and motor vehicles are able to easily see each other
- Create intersection designs that avoid the need for complex maneuvers
- Use the design guidelines in this section and Section 5-4
- Allow sufficient maneuvering or waiting space

Bicycle Delay

- Minimize bicyclist waiting times at crossings on bike routes
- Maximize the possibility to cross without delay
- Give main bicycle routes priority over local motor vehicle routes

Convenience

- Provide bicyclists clearly marked routes across the intersection
- Make curb cuts and transitions flush with the road and as wide as the approaching facility
- Pay special attention to bicyclist turning movements (primarily left-turning bicycles)

4-4.1 Intersection Crossing Distance

More than three lanes to cross at a time may be difficult for bicyclists. A raised pedestrian refuge island should be installed where the crossing distance is greater than 23 m **(75 ft)**. See Section 5-4.3 of this manual for guidance on the design of pedestrian refuge islands.

4-4.2 Signalized Intersections

At intersections with traffic signals, detection loops should be adjusted, when possible, to detect bicycles. Installation of bicycle-sensitive loops within the bicycle lane is desirable, and is particularly important where signals are vehicle-actuated and may not change for a bicycle unless a car is present, or unless the bicyclist leaves the lane to trip the signal within the traffic lane. If push button activators are used, they should be installed in a location to allow the bicyclist to remain mounted and in the designated bike lane.

Where bicycle lanes are heavily used, a separate bikes-only green phase may be included. This allows bicyclists to cross the street and make turns without having to contend with motor-vehicle traffic. Where bicyclists tend to become “stranded” while crossing multi-lane streets, consideration should be given to the clearance intervals. A common solution is an all-red clearance interval.

4-4.3 Bikeways at Right-Turn-Only Lanes

Minnesota law requires the bicyclist to keep as close as practicable to the right edge of the roadway. Therefore, many bicyclists tend to move to the right edge of the right-turn lane, which is not a desirable position if the bicyclist is intending to go straight through the intersection. On roadways with right turn lanes, providing a through bicycle lane to the left of the right-turn lane at the intersection can minimize conflicts, as shown in Figure 4-27. The designer should review traffic volumes and speeds in determining appropriate actions. It should be recognized that if the roadway carries enough traffic to warrant a right-turn lane, bicycle lanes are likely to be appropriate for the entire section of the roadway.

In some cases it will be desirable to replace the standard *“Right-Turn Lane*” sign (R3-X1) with *“Begin Right-Turn Lane; Yield to Bikes”* (R4-4).

Right Turn on Red

On-road bikeways can complicate turning movements at intersections. Where right turn on red is permitted, right-turning motorists focus more intently on cross traffic approaching from the left. Bicyclists stopped for the red light may find that vehicles turning right on red infringe on the area where the bicyclist is waiting, unless the bike lane is located to the left of the right turn lane.

While right-turning motor vehicles may infringe less if the intersection curve radius is relatively small, designers should consider prohibiting “right turn on red” on some bikeways where there is not a right-turn-only lane.

Bicyclist and Right-Turning Motorist Positioning

Conflicts with right-turning cars account for about one tenth of all car/bike collisions in urban settings. Right-turning motorists approaching an intersection often infringe on the bike lane . Operating space and expected behavior near intersections can be communicated to bicyclists and motorists by using clear pavement symbol markings, striping and signs.

Right turns on green by motorists may be hazardous because both the driver and the through-bicyclist may perceive they have the right of way. Every effort should be made to encourage right-turning motorists to slow down and observe bicycle traffic, before reaching the intersection and turning right. The most effective solution is to place a through bicycle lane to the left of the right turn lane, with dashed lines indicating where right-turning vehicles may cross the bike lane. This will ensure that vehicles can move to the right of bicycles in advance of the intersection, and both bicyclist and motorists are correctly positioned to proceed without conflict. Weaving of motor vehicles and bicycles is not desirable if the intersection approach or exit is on a curve.

Some bicyclists use right-turn-only lanes when traveling straight through an intersection. This causes difficulties because motorists expect the bicyclist to turn right. At right-turn only lanes, bicyclists traveling straight through an intersection should be encouraged to merge to the left side of the lane to complete the weave maneuver. However, this is often difficult for bicyclists to do. In lanes that allow both through traffic and right-turns, it may be difficult for the motorist and bicyclist to recognize each other's intent. At intersections where there is a history of bicycle crashes, designers should specify signage and pavement markings that clarify who is responsible for yielding. As an additional safety measure, parking may be prohibited for a minimum of 30 m **(100 ft)** or more from the intersection, depending on the design speed of the turn lane.

4-4.3.1 Bicycle Lane Parallel to Right-Turn-Only Lane

Right-turn lanes have always posed a challenge for bike lane designers. Moving the bicycle lane to the left of the right-turn lane, however, allows designers to create a merging area ahead of the intersection. This gives bicyclists and right-turning motorists the opportunity to negotiate to the proper position before reaching the intersection.

At the point where a right-turn only lane starts, the bike lane left stripe should continue across with a dashed line. The length of the dashed line will be determined by the length of the right-turn storage area and the taper. A second dashed line may be used to delineate the right side of the bicycle lane. See Figure 4-27.

For more information on standard design of right-turn lanes, see Chapter 5 of the *Mn/DOT Road Design Manual.*

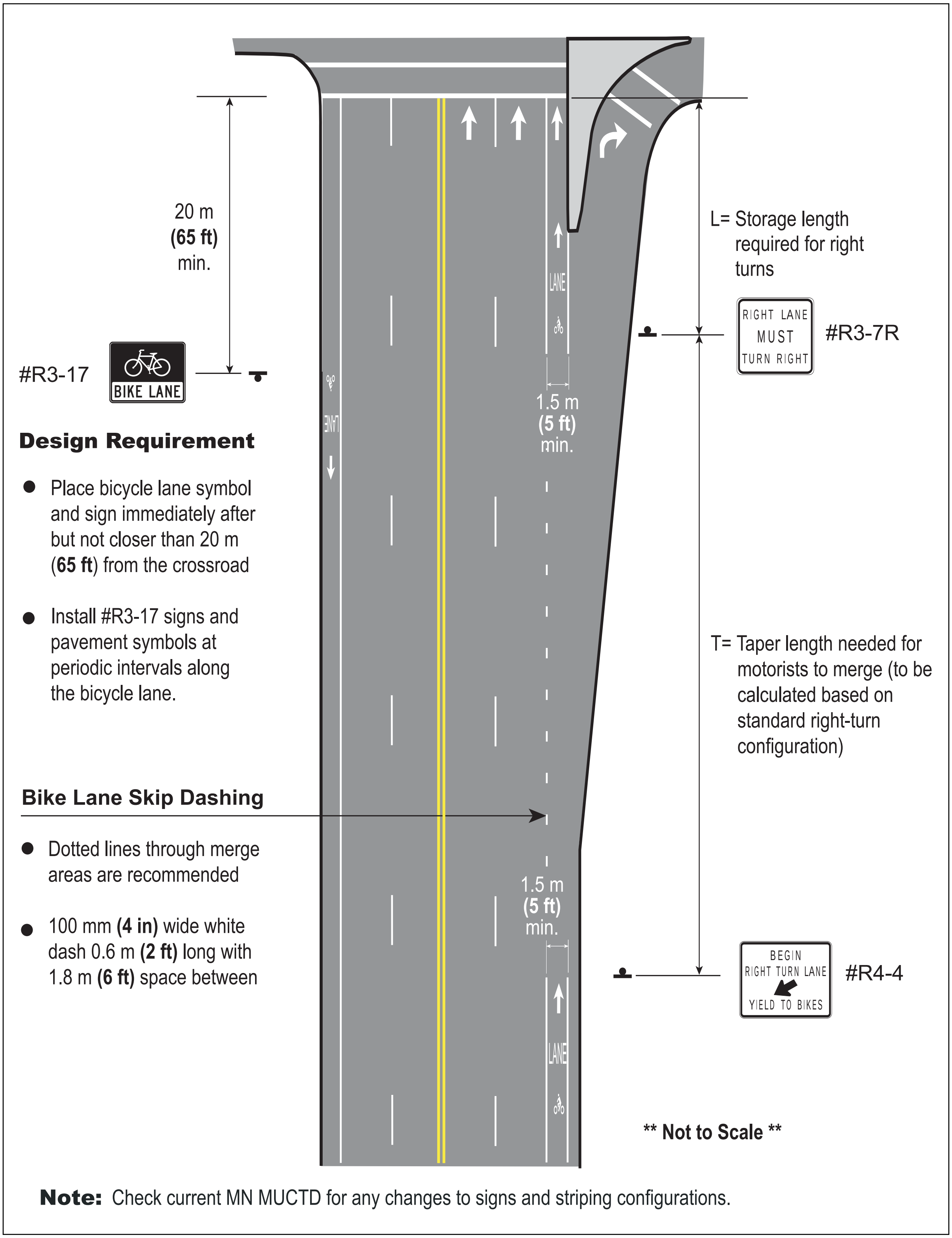


Figure 4-27:
Bike Lane Parallel to Right-Turn Only Lane

4-4.3.2 Bicycle Lane Parallel to Double Right-Turn Lane

Where a double right-turn lane starts, it may be necessary to discontinue the bicycle lane through the intersection. However, safe bicyclist movements can be accommodated via a wide outside lane with extra width carried thorough the intersection in the right-most through lane and the rights of bicyclists clearly delineated through signage. MN MUTCD sign #R4-4 indicates that motorists must yield to bicyclists approaching the intersection. The bicyclist-motorist merging area is based on standard right-turn lane designs detailed in the Mn/DOT Road Design Manual.

A bike lane at a double right-turn lane is illustrated in Figure 4-28.

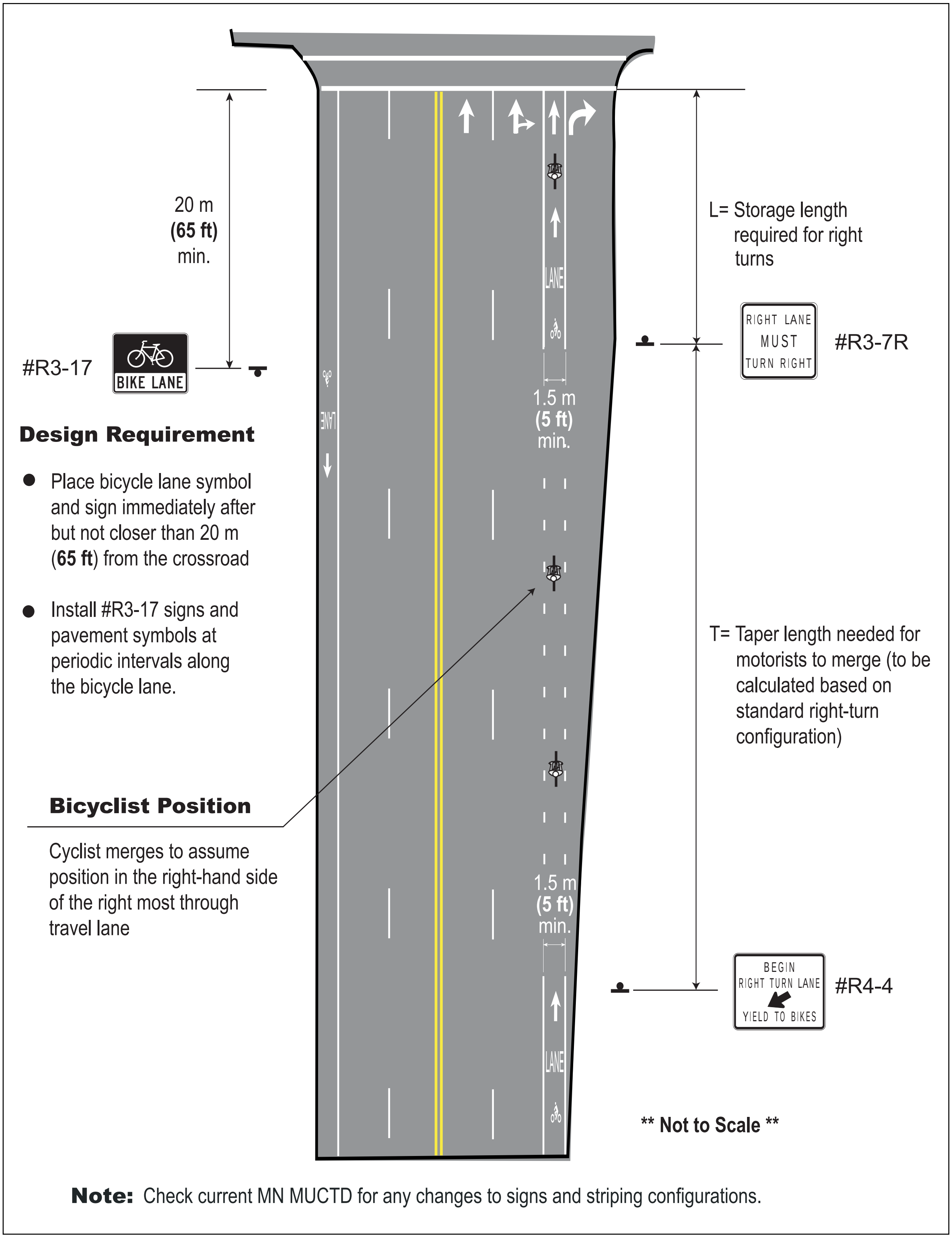
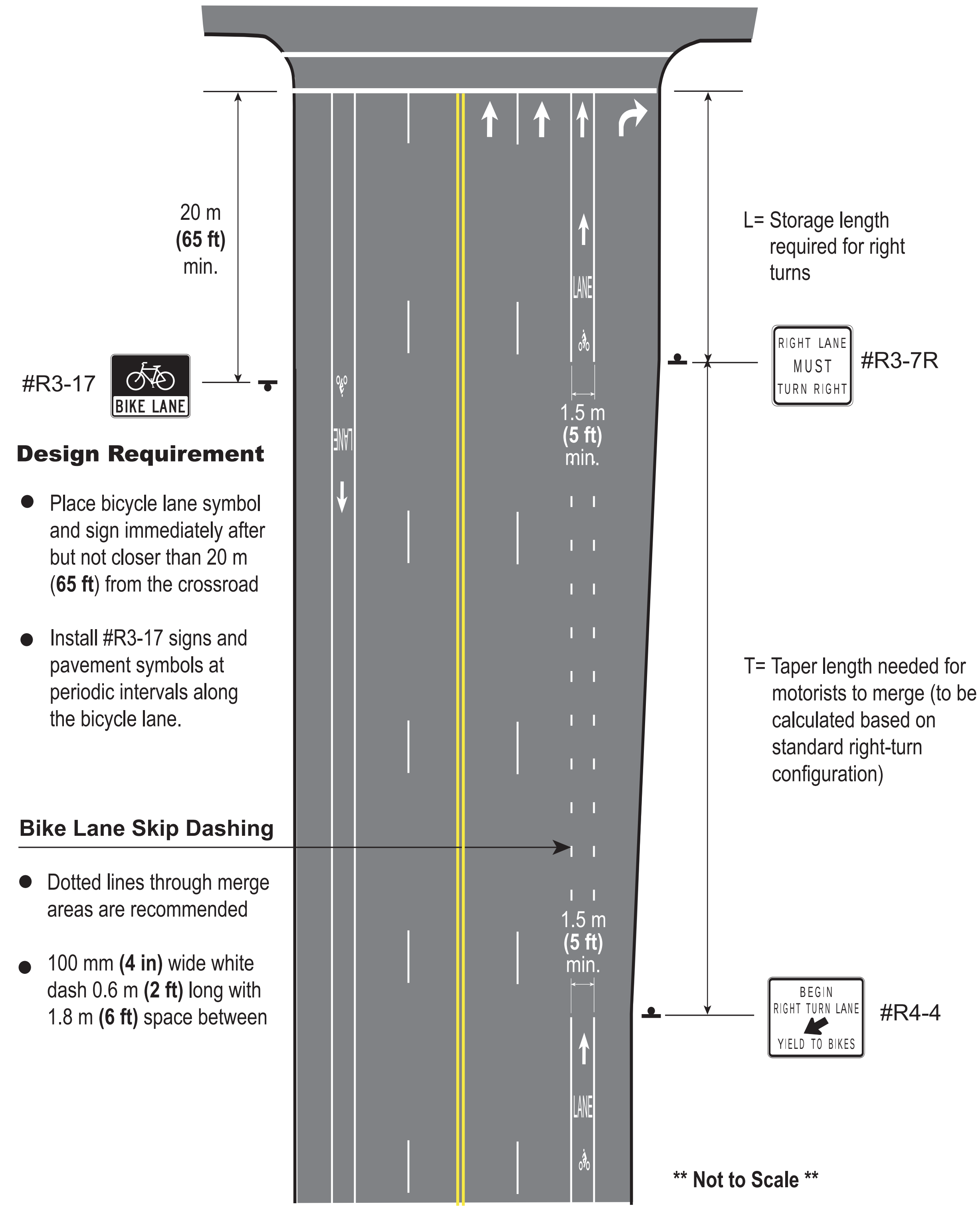


Figure 4-28:
Bike Lane Parallel to Double Right-Turn Lane

4-4.3.3 Parking Lane Becomes Right-Turn-Only Lane with Bicycle Lane

On a street with a bike lane, if a parking lane becomes a right-turn-only lane, the bicycle lane left edge stripe should be continued to the crosswalk or to the extension of adjacent property line if there is no crosswalk. The parking lane markings should be dropped at an appropriate distance from the intersection to allow proper sight distances, and a dashed line may be used to delineate the right edge of the bicycle lane continuing to the crosswalk. This type of intersection is illustrated in Figure 4-29.



Note: Check current MN MUCTD for any changes to signs and striping configurations.

Figure 4-29:
Parking Lane Becomes Right-Turn Only Lane with Bicycle Lanes

4-4.4 Bikeways and Left-Turn Movements

On-road bikeways encourage bicyclists to keep right and motorists to keep left, regardless of their turning intentions. Bicyclists changing lanes to the left from a bicycle lane or shared lane to make a left turn are maneuvering contrary to the usual rules of the road. Operating space and expected behavior near intersections can be communicated to bicyclists and motorists by using clear pavement symbol markings, striping and signs.

Bicyclists use a variety of maneuvers to make left turns, depending on road conditions, traffic and bicyclist skill level. These bicyclist maneuvers include a 2-stage left turn by staying to the right in the crosswalks, left turn from a vehicle left turn-only lane, left turn from left through lane, left turn from right through lane, or left turn stopping at a pedestrian refuge or median island.

Bicyclists may follow the same maneuver that motor vehicles use, and make the necessary lane-changing movements to make a left turn from the left lane. The tendency for bicyclists to ride alongside turning vehicles, rather than follow them, may create opportunity for sideswipes.

4-4.4.1 Left-Turning Motorist and Oncoming Bicyclist

Conflicts with left-turning motorists account for almost one-fourth of all crashes involving a motor vehicle and a bicycle in urban settings. This type of collision typically occurs because the left-turning motorist either does not see oncoming bicyclists or the motorist underestimates the bicyclist's speed. While a bicycle traveling in the roadway is usually within a motorist's field of view, the pressure on the motorist to clear the intersection in the face of oncoming traffic may cause the left-turning motorist to fail to yield to the oncoming bicycle. This type of "panic" turn by motorists can be eliminated by installing a protected left-turn phase at signalized intersections. Bicycle lanes located farther from the curb at the intersection can also make bicyclists easier to see.

4-4.4.2 Bicycle Lanes and Left-Turning Bicycle Traffic

At busy intersections, pavement marking options may improve safety and comfort for left-turning bicyclists. When left-turn bicycle volumes are significant, a left-turn bicycle lane painted next to the right edge of a left-turn lane may be appropriate. This option is recommended at signalized intersections and stop-controlled intersections without right turn on red. Double left turns lanes are discouraged on streets with bikeways.

4-4.5 Bikeways at Roundabouts

Bicycles can be accommodated through roundabouts either in mixed flow with vehicular traffic or on a separate path outside the roundabout. On roundabouts with two or more lanes in the circulatory roadway, mixing bicycles and vehicles is not recommended due to potentially higher vehicle speeds, and a separate off-road path must be provided. These concepts are discussed below. For additional information, see *Roundabouts: An Informational Guide (FHWA; 2000)*, Publication No. FHWA-RD-00-067.

Bicyclists are vulnerable users of roundabouts and consideration should be given for their accommodation. A majority of bike crashes at roundabouts involve entering vehicles and circulating bicycles, reinforcing the need to reduce entering speeds by providing ample deflection, to maintain good visibility for entering traffic and to enforce yield conditions for entering traffic. All crosswalks must be designed as accessible pedestrian crossings, with the splitter island cut to allow pedestrians, wheelchairs, strollers and bicycles to pass through. Pedestrian access is allowed only across the legs of the roundabout, and not to the central island.

Where a road with a bicycle lane approaches a roundabout, the bike lane striping shall not be carried on the roadway through the roundabout, and bike lanes within the circulatory roadway should never be used. Bicycle lanes should be terminated before the splitter island, and bicyclists should either be accommodated in mixed traffic in the roundabout or on a separate pathway outside the roundabout.

Urban compact roundabouts and mini-roundabouts are characterized by vehicle approach speeds less than 60 km/h **(35 mph)** and low speed on the circulatory roadway. At these types of roundabouts, bicycle traffic may proceed through the roundabout in a shared lane with motor vehicles after termination of the bicycle lane. However, child bicyclists may need to be accommodated as pedestrians.

Urban single-lane roundabouts and urban double-lane roundabouts are characterized by slightly higher approach speeds than compact roundabouts, with circulatory speeds 35 - 40 km/h **(20 - 25 mph)**. Alternative bicycle pathways should be provided and must be clearly delineated with path construction and landscaping to direct bicyclists to the appropriate crossing locations and alignment. On the approach to these roundabouts, dashed white 200 mm **(8 in)** striping is used to indicate that the bicycle lane ends, and pavement markings should route bicycle traffic onto an off-road bike path or shared-use path via a curb-cut ramp. The ramp up and ramp down for bicycles is in addition to the curb-cut ramp at the crosswalk, and the designer should exercise care in locating and designing the bicycle ramps so that they are not misinterpreted by pedestrians as an unmarked pedestrian crossing. See Chapter 5 for description of curb-cut ramp requirements. The off-road path continues to the roundabout crosswalk and also to a continuation of the bicycle lane on departing legs of the roundabout, or to a shared-use path adjacent to the departing legs.

Rural single-lane roundabouts and rural double-lane roundabouts are characterized by high average approach speeds in the range of 80 – 100 km/h **(50 – 60 mph)**, with circulatory speeds of 40 – 50 km/h **(25 – 30 mph)**. Mixing bicycle and vehicle traffic on these types of roundabouts is not recommended. The approach roads will typically have paved shoulders, but the highway shoulder is eliminated from the cross section in advance of the roundabout and the shoulder is not carried through the roundabout circulatory roadway. To accommodate bicyclists, an off-road shared-use path should be included in the design from the point where the shoulder is terminated. This must be identified early in project planning and scoping because it may require acquisition of additional right-of-way beyond the limits of an existing intersection.

4-4.6 Bikeways at Interchanges

Bikeway treatments at interchanges and on bridges are discussed in Chapter 6, *Bridges and Grade Separations.*

4-4.7 Painted Refuge Islands for Bicyclists

Where traffic is relatively light, painting a refuge island on the corner provides a comfort zone for bicyclists. Allowing right turn on red is not recommended with painted refuge islands. Where traffic volumes are relatively high, refuge space can be provided by a raised free right turn island that is easily reached by left-turning bicyclists who are using a two-step left turn maneuver.

4-4.8 Advanced Stop Lines

Creating an advanced stop line (ASL) makes it possible for bicyclists to position themselves in front of waiting motorized traffic and cross the intersection first on the green light or, when turning left, on a separate green phase. Twenty-five bicycles or more per peak hour and good enforcement of stopping behavior are needed for effective use of ASLs. The ASL helps bicyclists turning left where there is one lane for motorized traffic. ASLs may also be applied on approaching road sections with no more than two lanes.

A separate ASL, inclusive of an approaching bicycle lane, is best introduced when there is a left-turn lane. If traffic turning left has a separate green phase, a separate ASL is necessary. If this is not the case, one ASL may suffice, however, bicyclists may choose to weave to the left turn lane anyway. For increased visibility and recognition, complete the ASL and a part of the approaching bicycle lane in a different color pavement, preferably red. Bicycle sensitive vehicle detectors (pavement loops or other devices) are desirable when using ASLs.

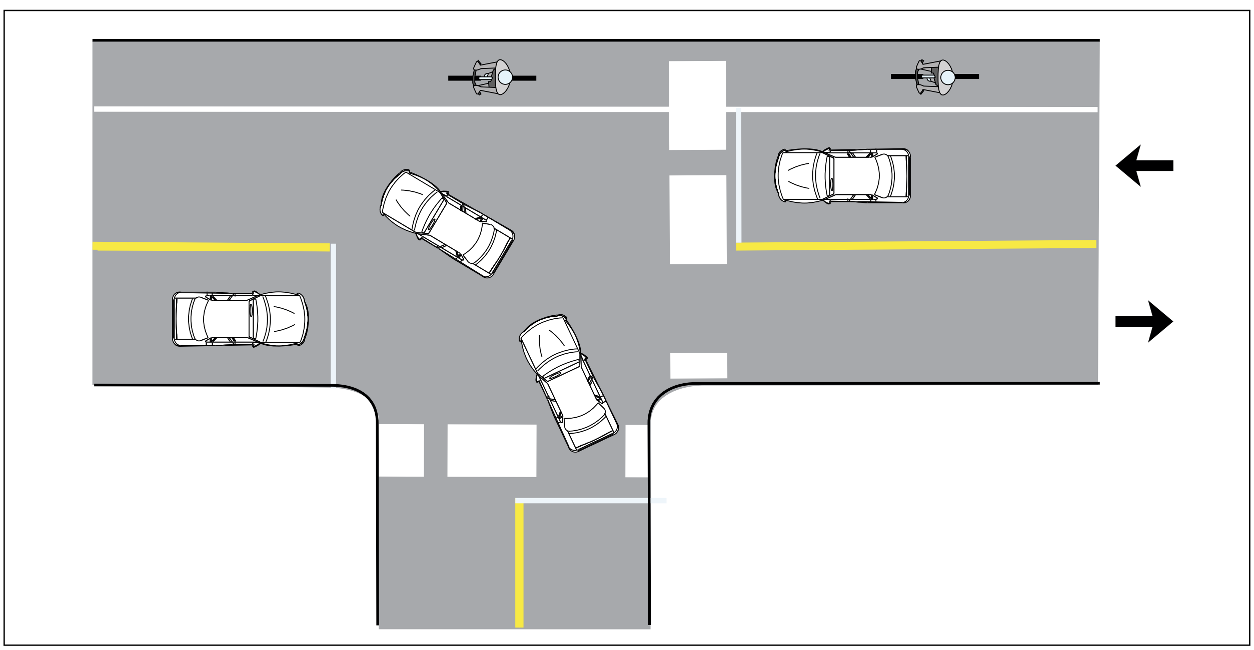


Figure 4-30:
Bicycle Lane Continuation at T-Intersection

4-4.9 Bicycle Lane Continuation at T-Intersections

It is preferred that bicycle traffic be allowed uninterrupted through-movement at T-intersections. Continuing the bicycle lane through the intersection as shown in Figure 4-30 is recommended. Even where there are no bicycle lanes, lane continuation could be added to the intersection if it is stop-sign controlled.

4-4.10 Railroad Crossing Intersections

Special care should be taken wherever a bikeway crosses railroad tracks at grade. The bicyclist should be able to approach the tracks at an angle of 60 to 90 degrees. Wherever practical, the bicyclist traveling straight ahead should be allowed a level crossing at right angles to the rails. If the road does not cross the tracks at a right angle, the bikeway may swing away from the roadway to allow the bicyclist to approach the tracks at 60 to 90 degrees, or the shoulder, bike lane or wide curb lane may be widened in the approach area to allow the bicyclist to swing wide

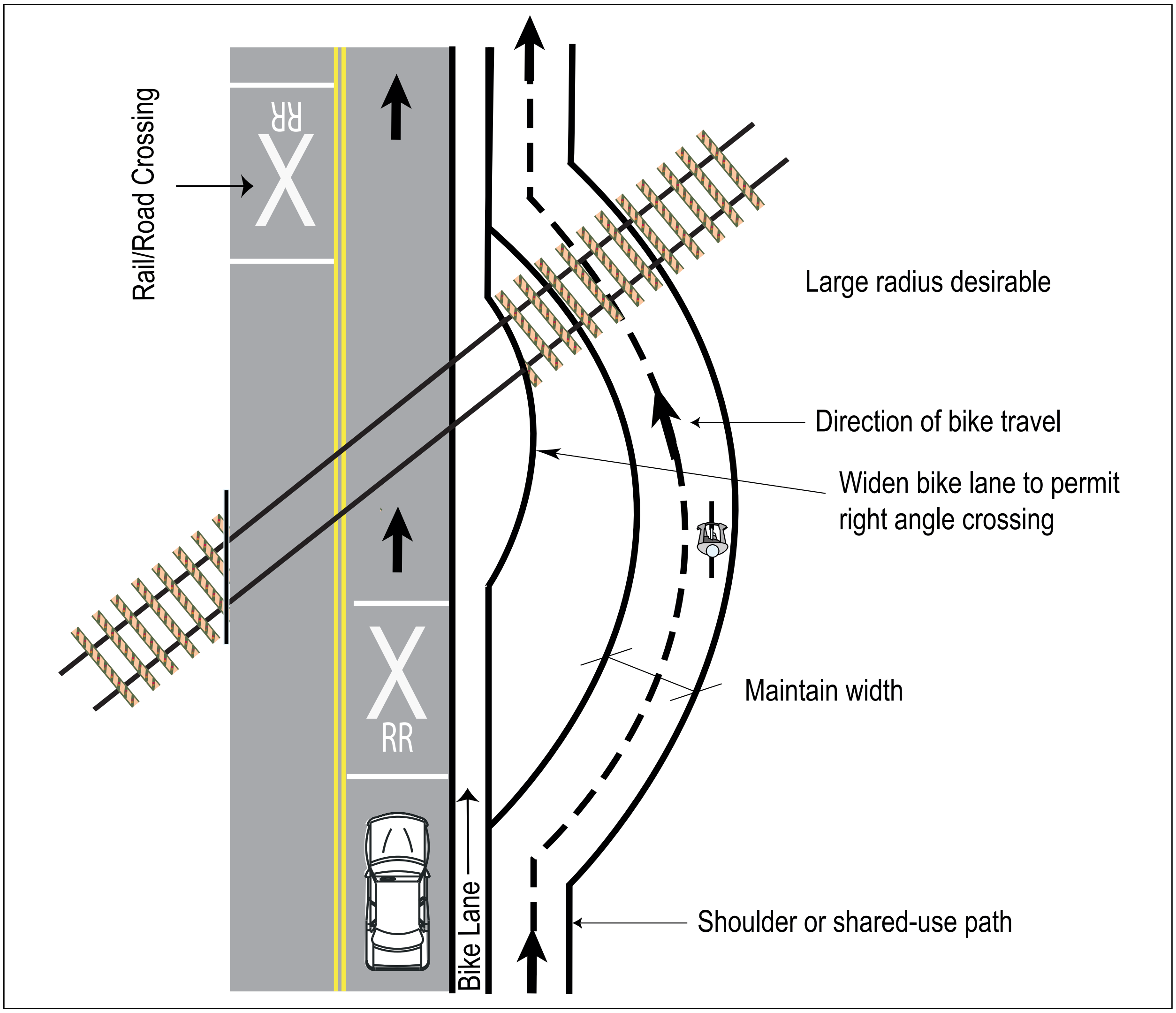


Figure 4-31:
Bicycle-Safe Railroad Crossings

for a better approach. The more the crossing deviates from 90 degrees, the greater is the potential for a bicyclist's front wheel to be diverted by the flangeway (the gap on either side of the rail) or even by the rail, particularly when wet. Crossing rails at angles of 30 degrees or less is considered hazardous. See Figure 4-31, which illustrates bicycle-safe rail crossings.

The crossing should be at least as wide as the bikeway approach. The surface between rails should be based on the planned uses of the roadway. Hot mix asphalt and rubber surfaces are generally acceptable for at-grade crossings. Wood surfaces are suited to limited use; they are very slippery when wet and tend to wear faster than other surfaces. Abandoned tracks should be removed, but only as authorized by the owner of the track.

Most tracks and rail crossings are governed by Federal Railroad Administration (FRAG) rules, but tracks and crossings on light rail transit (LRT) lines such as the Hiawatha LRT line and proposed Central Corridor LRT line are governed by Federal Transit Administration (FTA) rules. The proposed Northstar Corridor Commuter Rail would run on existing freight railroad tracks and may be regulated by both FTA and FRAG. Designers should refer to the applicable agencies and rules for guidance.

The flangeway poses potential hazards to all non-motorized users, but particularly those who rely on wheeled forms of mobility. A 90-degree crossing angle reduces the risk, but flangeways at any angle can be a safety concern and should be minimized. The gap on the outside of the rail, or the "field flangeway," is easy to reduce. Fillers made of rubber or polymer can be installed to eliminate the field flangeway almost entirely and provide a level surface. The "gauge flangeway," the gap on the inside of the rails where the train wheel's flange must travel, must be kept open. Federal regulations require public crossings to have at least a 65 mm **(2.5 in)** gauge flangeway. Products are available to fill the gauge flangeway, but these may only be used in low-speed applications, such as on freight yard or manufacturing plant track, with authorization from the owner of the tracks. At higher speeds, the filler will not compress and can derail the train.

Special construction and materials should be considered to keep the flangeway depth and width to a minimum. Currently there are no design treatments that can completely eliminate the flangeway gap for high-speed freight trains. Where train speeds are low, commercially available compressible flangeway fillers may be used, and additional treatments may be allowable for light-rail trains.

- Approaches to the track and the area between the tracks should be at the same elevation as the top of the rail. Approaches to the track should be ramped with minimal grades and should be flat for a distance of 5 feet on either side of the tracks, free from obstacles, and have a firm and stable surface
- A surface material that will not buckle, expand or contract significantly should be used.
- Pavement should be maintained so ridge buildup, a potential hazard to bicyclists, does not occur next to the rails.
- Timber plank crossings may be used, but tend to be slippery when wet.
- Signs and pavement markings should be installed in accordance with Section 9B of the *MN MUTCD* to inform and warn bicyclists of tracks
- Signals with flashers, bells and/or gates should be considered

It should be noted that the design of crossings and other facilities in the railroad right-of-way are generally subject to review and approval by the owner of the tracks.

Roadways, paths, and bicycle lanes should have signage and pavement markings installed in accordance with *MN MUTCD*. Consider sign and signal visibility and installation when widening the approach bikeway. “Pedestrian arms” and signals with bells may also be appropriate.

4-5.0 Design of Retrofits for Bicycle Accommodation

There are a number of ways to efficiently use an existing road right-of-way to upgrade bicycle accommodation as discussed in the following paragraphs. Finding the best alternative requires careful consideration of the operating characteristics of the road space, the context of the area, and types of cyclists using the bicycle facility.

4-5.1 Changing Vehicular Travel Lane Widths

In lower speed zones, motor vehicle lane widths can be reduced to create space for a bikeway within the existing roadway. This treatment is often used in urban settings where the right-of-way cannot be widened. Refer to AASTHO guidelines, State Aid rules and other applicable standards to determine acceptable minimum travel lane width based on vehicle speed and ADT. The following lane widths may be acceptable:

- Where the posted speed is 40 km/h **(25 mph)**, a travel lane width of 3.0 m **(10 ft)** may be acceptable.
- Where the posted speed is 50 – 60 km/h **(30 – 40 mph)**, a travel lane width of 3.2 m **(10.5 ft)** and center turn lane width of 3.6 m **(12 ft)** may be acceptable.
- Where posted speed is 70 km/h **(45 mph)** or greater, a travel lane width of 3.6 m **(12 ft)** and center turn lane width of 4.2 m **(14 ft)** are desirable.

4-5.2 Changing the Number of Travel Lanes

There are opportunities to create or improve bicycle accommodations on streets and roads by changing two-way streets to one-way couplets, or changing four-lane undivided roadways to a 3-lane configuration that includes a center two-way turn lane.

4-5.2.1 Two-Way Streets to One-Way Couplet

The conversion of parallel two-way streets to one-way couplets may result in greater motor vehicle capacity and more travel lanes than are needed. For example, a pair of two-way streets with parking on each side may be changed to a couplet of one-way streets. These one-way streets provide better opportunities for a bike lane or wide curb lane than the original two-way streets because there are fewer vehicle turning movements to contend with.

4-5.2.2 Four-Lane Road Converted to Three-Lane Road with Two-Way Left-Turn Lane

Four-lane undivided roads with urban (curb and gutter) cross section can be converted to a three-lane configuration that includes one travel lane in each direction and a center two-way left-turn lane. This is a common treatment that creates space for bike lanes or wide curb lanes in each direction on the roadway. Safety and traffic flow may be improved for motorists as well as bicyclists, especially if there is a significant number of vehicle left-turn movements. In many cases, this approach can implemented by striping and pavement markings without significant changes to signals.

4-5.3 Removing Obstructions

Paved or landscaped traffic islands often reduce available roadway space. If not needed for access control, traffic calming, or as refuges, raised islands may be eliminated, narrowed, or replaced with pavement markings, to increase usable width. Relocating utility poles and light standards, parking meters, signs, guardrails, and other obstructions away from the edge of the roadway may also increase usable width.

4-5.4 Changing Parking Amounts or Arrangements

Parking should be closely evaluated prior to designating bicycle facilities, as parking may be rearranged, reduced, or eliminated on one or both sides of the street to allow space for bicycle facilities. Shared parking between businesses and residences may alleviate the need for on-street parking. Removing parking does not always improve safety, however, and in some locations doing so may actually decrease safety. Conduct a careful study of existing businesses and residences and associated parking before making changes.

When it is determined unacceptable to remove all on-street parking, other options may be pursued. These include narrowing parking lanes to a minimum of 2.1 m **(7 ft)** in areas with low truck parking and low parking turnover. Changing the parking direction from diagonal to parallel parking requires less pavement width to accommodate a parking stall, and allows for additional space for bicycle facilities. Removing parking from one side of the roadway to provide space for bicycle facilities is appropriate when businesses and residences only need parking on one side. Prohibiting parking by employees can also increase the number of available spaces for customers and allow parking spaces to be reduced.

4-5.5 Traffic Calming

Traffic calming is a series of design tools to increase overall traffic safety and improve the quality of the street environment by employing methods that cause vehicular traffic to slow down. On streets with restricted space and appropriate traffic operation factors, traffic calming techniques by themselves or combined with other alternatives may be an effective option to improve safety for bicyclists and pedestrians. See Section 4-6.6 for a discussion of traffic calming techniques.

4-6.0 Other Design Considerations

To promote a consistent and safe bicycling environment, the following additional factors may be considered in the design phase of on-street bikeway facilities:

- Rumble strips
- Drainage and drainage grates
- Bypass lanes
- Climbing lanes
- Lighting
- Traffic calming
- Alternate bike routes

4-6.1 Rumble Strips

Rumble strips are bands of raised material or indentations formed or grooved in the pavement that transmit sound and vibration through the vehicle, alerting inattentive drivers. Research has documented that use of rumble strips along the shoulders of rural freeways and expressways has reduced the number of run-off-the-road (ROR) accidents by 40 to 70 percent. In-lane rumble strips across the travel lane are sometimes used to provide advanced audible warning of a stop sign at an intersection.

Provisions should be made for bicyclists to safely traverse through or around rumble strips, regardless of their location. Rumble strips are a rough surface that causes instability and unsafe operating conditions for bicyclists. Potential for mishap arises when the bicyclist contacts rumble strips or attempts to avoid them by weaving. Care must be taken to ensure a stable riding surface. Sand and debris tend to gather along the outside edge of the shoulder, effectively reducing the available bicycling space. Brooming of shoulders may become necessary to remove debris.

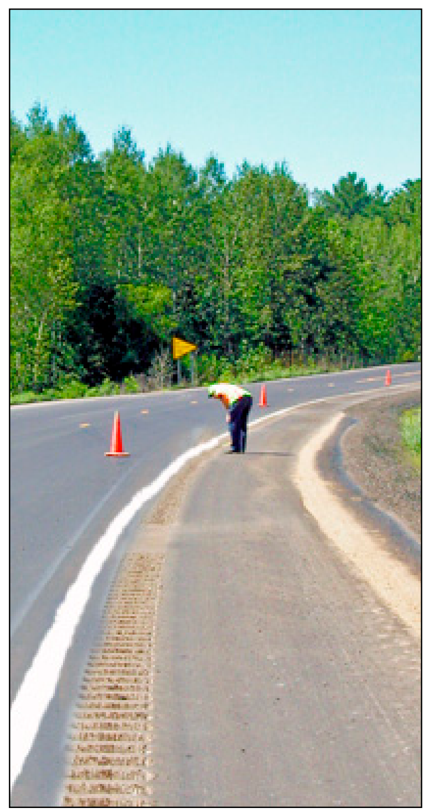


Figure 4-32: Bicycle-Safe Rumble Strips

Where shoulder rumble strips are used on the right shoulder, there shall be 1.2 m **(4 ft)** minimum width of smooth pavement between the outside edge of the rumble strip and the outside edge of the paved shoulder, and a minimum distance of 1.5 m **(5 ft)** from the outside edge of the rumble strip to a guardrail, curb or other obstacle adjacent to the shoulder. See Section 4-3.1 of this manual for a discussion of rumble strips on 4-foot shoulders. All rumble strips should be placed using an intermittent pattern, alternating on and off in 3 m **(10 ft)** lengths, which allows maneuverability of bicyclists onto the shoulder area. See Chapter 4 of the *Mn/DOT Road Design Manual* for additional design specifications for rumble strips.

4-6.2 Drainage and Drainage Grates

For bicycle travel, existing roadway drainage is normally adequate. However, on curb and gutter sections, ponding depths should be checked when a problem is identified and corrective action taken if depths are significant. This may entail improved drainage grates or wider lanes. Pavement overlays are troublesome where the surface material tapers into drainage outlets and manhole covers. In the years following the overlay, these tapers often loosen around inlets and manholes, leaving an unacceptable ridge that can be hazardous for cyclists. The existing pavement should be scarified or the inlets and manholes raised prior to the overlay.

When a new roadway is designed, all drainage grates and manhole covers should be kept out of the bicyclists' expected path. Curb inlets are preferable to surface type inlets.

Drainage inlet grates on roadways shall have openings narrow enough and short enough to prevent bicycle tires from dropping into the grates, regardless of the direction of bicycle travel. Grates with bars parallel to the direction of bicycle travel should be replaced with bicycle-safe, hydraulically efficient grates. Vane type grates are preferable surface type grates. Pavement marking to identify and warn cyclists about unsafe grates may be a temporary solution in some situations. However, parallel bar grates should be replaced or physically corrected as soon as practicable. See Mn/DOT Standard Plates 4151 and 4152 for acceptable designs of grates. Where it is not immediately feasible to replace existing grates with standard grates designed for bicycles, 25 mm by 6 mm **(1 in by 1/4 in)** steel cross straps should be welded to the grates at a spacing of 150 mm to 200 mm **(6 in to 8 in)** on center to reduce the size of the opening. This should be considered a temporary correction, as snowplows can often scrape off such straps.

See the *Mn/DOT Drainage Manual* and Chapter 8 of the *Mn/DOT Road Design Manua*l for further design information.

4-6.3 Left-Turn Bypass Lanes

A bypass lane allows a vehicle to move to the right on the roadway and pass another vehicle that has slowed or stopped in the travel lane to make a left turn. They are typically found at "T" intersections on two-lane roads where there is no left-turn lane. A combination right-turn and bypass lane may be used at four-legged intersections. Cars overtaking left-turning vehicles move to their right, often without slowing, traveling in the shoulder area typically used by bicycles. At least 1.2 m **(4 ft)** of smooth paved shoulder should be added to the right of the bypass lane to provide space for bicyclists, and even greater additional shoulder width is desirable if the percentage of heavy vehicles (trucks, buses and recreational vehicles) is high.

The bypass lane should be clearly striped so that the motorist does not drift into the bicyclist's path. Refer to Chapter 5 of the *Mn/DOT Road Design Manual* for left-turn bypass lane design information.

4-6.4 Truck-Climbing Lanes and Passing Lanes

A truck-climbing lane is an additional uphill lane that allows vehicles to pass those that are unable to maintain satisfactory speeds. Passing lanes are an additional lane added on a two-lane road for a limited distance to allow slow-moving vehicles to move to the right and be passed. To accommodate bicycle travel, the shoulder should include a minimum 1.2 m **(4 ft)** smooth paved width adjacent to the truck-climbing lane or passing lane and through the lane drop area. Chapter 3 of the *Mn/DOT Road Design Manua*l contains design information for truck-climbing lanes and passing lanes.

Climbing lanes should be indicated with appropriate signage. The shoulder edge as well as the climbing lane must be clearly marked to ensure that motorists do not move into the bicycle path.

4-6.5 Lighting

On shared roadways and those with bicycle lanes, the area normally reserved for bicyclists may be illuminated in accordance with recommended design values in AASHTO's *An International Guide for Roadway Lighting and ANSI/IES Recommended Practices*. The lighting system as a whole should provide adequate illumination along the entire length and width of the bikeway, without variations in luminous intensity (bright and dark spots) to which bicyclists and motor vehicle drivers might experience difficulty adjusting.

All preliminary roadway lighting designs should be checked for conformance with luminance requirements prescribed for walkways adjacent to roadways and bicycle lanes. Additional information regarding bikeway lighting can be found in Section 5-8 of this manual.

4-6.6 Traffic-Calmed Roadways

Traffic calming employs a variety of techniques, including grade changes, curb extensions, and pedestrian refuges, to reduce the dominance and speed of motor vehicles. In areas of traffic calming, it is rare to see special facilities for bicyclists because many of the benefits of traffic calming (slower vehicle speeds, better driver discipline, less traffic, and environmental improvements) directly benefit bicyclists. For these reasons, traffic-calmed roadways are often used as routes in bicycle and pedestrian networks.

Benefits attributed to traffic calming include an average one-third reduction in crashes, a greater feeling of security among vulnerable road users, and aesthetic improvements through landscaping and reduced presence of motor vehicles. In addition to making traffic-calmed roads safer, slower vehicle speeds may create better driver discipline and reduce fuel consumption, vehicle emissions, and noise levels.

Traffic calming is typically used on residential streets, but may apply to other roads depending on their functional classification and use. Techniques applicable to main urban thoroughfares generally differ from those employed in minor residential streets. A greater variety of traffic calming features has been developed for minor roads where stricter speed controls and reduced capacity will not create undue delay.

Some traffic calming treatments may be detrimental to bicyclists, who are susceptible to changes in surface height and texture or unexpected road narrowing. A design balance should be maintained so that bicyclists traveling through traffic-calmed areas are able to maintain their momentum without endangering other users.

General design guidelines to accommodate bicycles on roadways with traffic calming are listed below:

- Provide bicyclists with alternative paths [minimum width 1.2 m **(4 ft)**] around physical obstacles such as ramps and through barriers such as cul-de-sacs.
- Where roads are narrowed as a speed control measure, consider how bicyclists and motorists can share the remaining space.
- Surface materials should have good skid resistance. Textured areas should not be so rough as to create instability for bicyclists.
- Smooth transitions on entry and exit slopes adjacent to raised surfaces, with clear indication and transition gradients of no more than 6:1.
- Consider overall gradients, noting that bicyclists are likely to approach grade changes at different speeds uphill and downhill.
- Combine appropriate signing with public awareness campaigns to remind drivers about traffic-calmed areas.

4-6.6.1 Curb Extensions

Narrowing the roadway by extending the curb reduces the crossing distance for pedestrians. When placed near an intersection, curb extensions tend to tighten the vehicle turning radius and reduce vehicle speeds, and prevent vehicles from parking too close to the intersection. They also help shelter parked vehicles and ensure that a pedestrian's view of approaching vehicles and bicyclists is not obstructed. To prevent curb extensions from causing a safety hazard by protruding into the bicyclists' path they should not extend beyond the width of the parking lane.

4-6.6.2 Pedestrian Refuge Islands

Refuge islands allow pedestrians to cross fewer lanes at a time and assess conflicts differently. Pedestrian refuge islands should be 2.4 m **(8 ft)** wide, where practical, to allow bicycles with trailers to use the island to cross the street. There are no impacts to on-street bicycle facilities unless the lanes are narrowed to provide space for the island.

4-6.7 Alternate Bicycle Route

Whenever possible, bike facilities should be constructed to accommodate the entire range of cyclists with one facility. However, in some instances, it may be necessary to create an alternate, parallel bicycle route, as when a route along an arterial roadway may be acceptable to advanced bicyclists, but inappropriate for basic bicyclists and children bicyclists. A lower-volume roadway that parallels a high-volume arterial can provide a pleasant alternative for "through" bicyclists, as well as a higher level of mobility and safety. Figure 4-33 illustrates an alternative bicycle route.

Alternate routes are most appropriate under the following conditions:

- The alternate route is within 400 m **(0.25 mi)** of the arterial
- The arterial has on-street parking and/or multiple driveways and/or turning conflicts
- Average daily traffic on the arterial road is greater than 10,000;
- Average vehicle speeds exceed 50 km/h **(30 mph)**
- The arterial lacks sufficient right-of-way to allow a striped bicycle lane

Designating an alternate bicycle route does not remove the need to improve the safety of the primary route for those bicyclists who still need to use the arterial, especially when commercial or other public destinations exist along that arterial. However, the alternate route should decrease bicycle traffic on the arterial substantially.

To succeed, an alternate bicycle route needs to be very convenient and legible. That is, creating a strong mental image in the minds of the bicyclists expected to use it. Alternate routes are most successful when they connect destination points, such as trails, schools, parks, churches, historical sites, downtown areas, and other points of interest.

To implement alternate routes, AASHTO recommends that directional and informational signs should be posted every 500 m **(0.31 mi)** and at every turn to both mark upcoming turns and confirm that riders have made the correct turns. Limit stop signs and signals to the greatest extent practical, except where they are needed to cross busy streets. Traffic-calming techniques should be used to enhance attractiveness and safety for bicyclists.

It is inappropriate to designate a sidewalk as an alternate route or designated bike route. To do so would prohibit bicyclists from using an alternate facility that might better serve their needs and prevent conflicts with pedestrians or motorists.

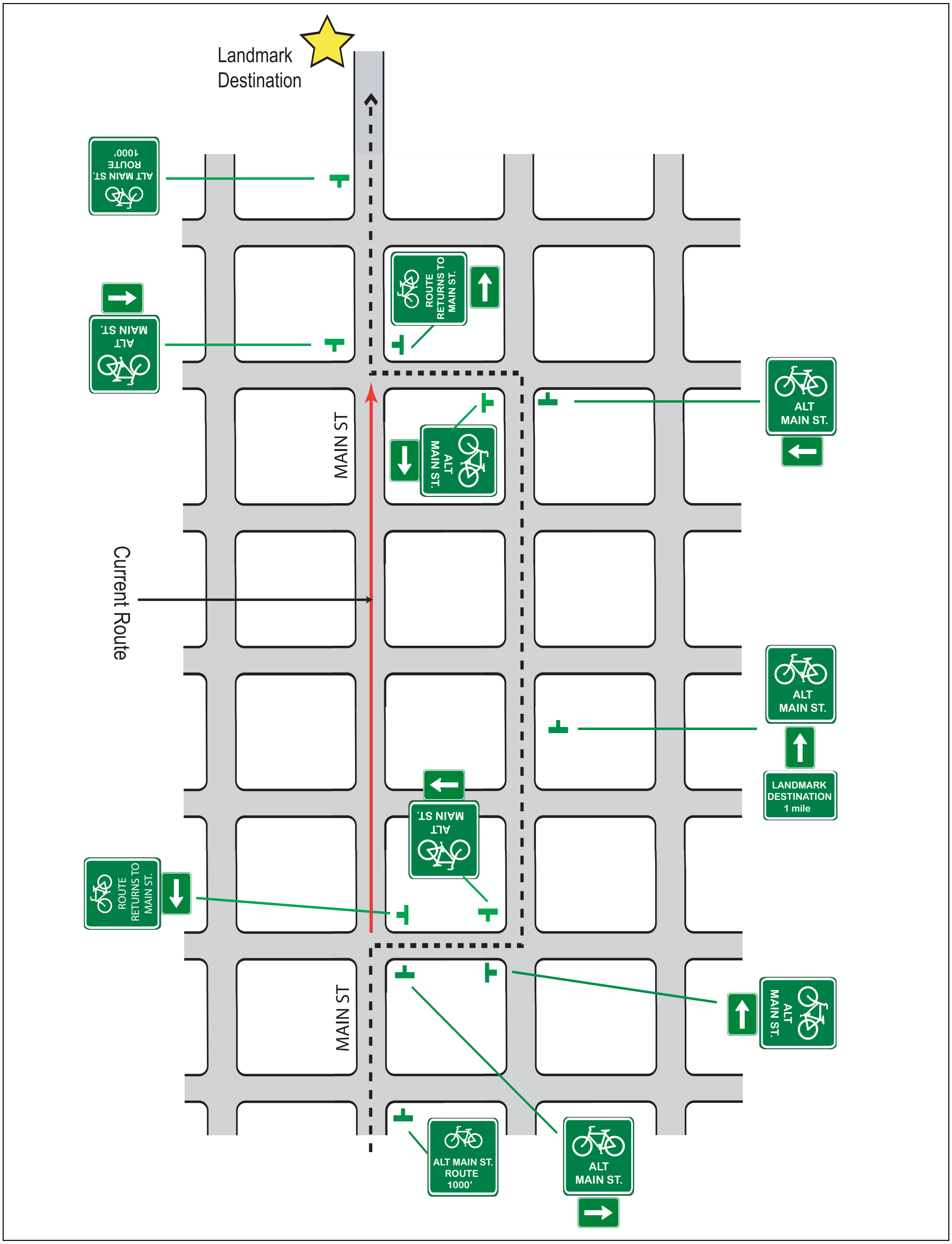


Figure 4-33:
Alternate Bicycle Route

Chapter 5: Shared-Use Paths

5-1.0 Introduction

This chapter provides guidelines for design of bicycle transportation facilities that are separated from the roadway. In most cases, a path separated from the roadway may be used by bicyclists, pedestrians, roller skaters, and individuals in wheel chairs, as well as other users, and the path must be designed for shared use. This manual does not provide guidance on design or construction of recreational off-road mountain biking paths. The 2006 Department of Natural Resources, *Trail Planning Design, and Development Guidelines*, provides detailed guidance on shared use paved trails, natural surface trails, winter use trails and bikeways.

5-1.1 Types of Off-Roadway Bicycle Facilities

In addition to shared-use paths, several other types of off-roadway facilities may meet the needs of various users, as described below.

5-1.1.1 Shared-Use Paths

Shared-use path is a term adopted by the 1999 AASHTO Guide for the Development of Bicycle Facilities in recognition that paths are seldom, if ever, used only by bicycles. As shown in Figure 5-1, a shared-use path is typically located on exclusive right-of-way, with no fixed objects in the pathway and minimal cross flow by motor vehicles. Portions of a shared-use path may be within the road right-of-way but physically separated from the roadway by a barrier or landscaping. Users typically include bicyclists, in-line skaters, wheelchair users (both non-motorized and motorized) and pedestrians, including walkers, runners, people with baby strollers or dogs with people.

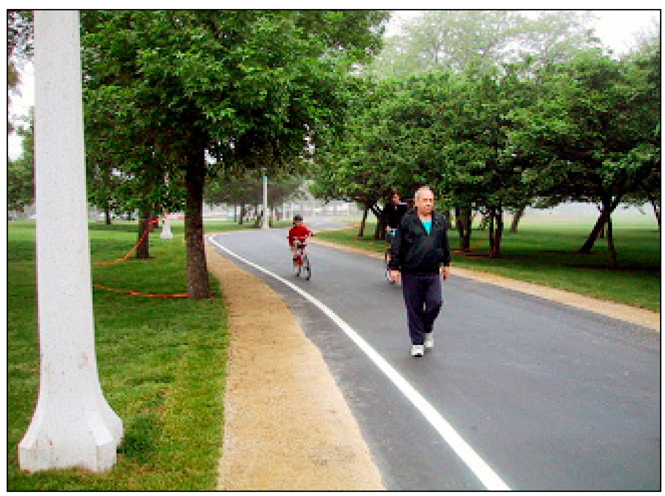


Figure 5-1:
Example of typical shared-use path

Shared-use paths are a valuable element of bicycle networks and serve both a transportation and recreation function, providing route continuity for commuting and recreation trips, access to destinations not otherwise available to bicyclists on the street and road system, and access between buildings and other discontinuities in the street network. Where shared-use paths have been added to the transportation network, they have proven to be significant

Chapter 5 Shared-Use Paths

generators of bicycle use and other non-motorized use. Shared-use paths are a necessary extension of the roadway system to accommodate bicycle transportation, supplementing the network of on-road bicycle facilities.

Shared-use paths are usually designed for two-way travel except under special conditions. The guidance in this manual is for a two-way facility unless otherwise stated. One-way shared-use paths, located on both sides of a road, have some application, and may increase the visibility of bicyclists to motorists at properly designed intersections. However, paths intended for one-way travel are often used as two-way facilities unless effective measures are taken to ensure one-way operation, including clear one-way designation, convenient access to a separate facility in the other direction, and enforcement. Without such measures, any shared-use path is likely be used as a two-way facility by both pedestrians and bicyclists, and should be designed accordingly.

In some cases it is desirable to separate bicyclists from pedestrians. This separation of users can be accomplished by signing and striping or by providing separate paths. If a path is intended for bicycle use only, the bike path should be located parallel to a nearby sidewalk or walking path.

5-1.1.2 Trails

The term “trail” may have different meanings depending on the context, but generally does not have the same meaning as the term “shared-use path.” There are many types of trails and each type provides different experiences for different users. Trails may be used for a variety of reasons including exercise, transportation, recreation, or education. Trail users may include hikers, cyclists, skaters, equestrians, snowmobilers, pedestrians, and others. Trails that are designed to provide a bicycle transportation function while supporting multiple users are called shared-use paths. Where a trail is designated as a bicycle facility, all design criteria for shared-use paths should be met. Trails that are designed primarily for a recreational experience are recreation trails. Unimproved or unpaved recreational facilities are often referred to as trails. In general usage, but not in this manual, shared-use paths or bike paths are sometimes referred to as multi-use trails or bike trails. Some multi-use trails are open to snowmobilers or cross-country skiers in winter.

In another context, a trail may consist of several on-road and off-road segments along a designated, signed and marked route providing access to thematically-tied resources, such as historic, scenic, cultural, recreational, natural or archeological places. The Minnesota Department of Natural Resources and certain local park authorities have developed trails of this type throughout the state. Some of those trails include bicycle facilities, while other designated trail systems may not accommodate bicycles.

5-1.1.3 Greenways

A greenway is a linear space established along a corridor, such as a riverfront, stream valley, or other natural or landscaped system. Greenways may connect open spaces, parks, nature reserves, cultural features, or historic sites with populated areas and with one another. Greenways may or may not include a bikeway, shared-use path or multi-use trail.

5-1.1.4 Sidewalks

Sidewalks typically have the following characteristics that make them not suitable for bicycling:

- Designed primarily for walking pedestrians
- Bicycle use of sidewalks is prohibited by local ordinance in some areas
- Sidewalk geometrics are not intended to safely accommodate bicycles
- Typically contain sign posts, parking meters, hydrants, benches, trees and other fixed objects
- Direct access from doorways, gates and parked cars causes conflicts with bicycling
- May have frequent intersections with driveways, alleys, roadways and other sidewalks.

Designating a sidewalk as a shared facility for bicycle travel is not recommended. Developing extremely wide sidewalks does not necessarily increase safety, because wide sidewalks may encourage higher-speed bicycle use and thus increased potential for conflicts with pedestrians. Sidewalks are typically designed for pedestrian speeds and maneuverability, and are generally not safe for higher-speed bicycle use.

It is usually inappropriate to sign sidewalks that do not meet AASHTO shared-use path design criteria as bicycle routes. However, short segments of sidewalk may be signed for bicycle use if users are appropriately warned of substandard conditions, but this should be considered only under limited circumstances where there are no better alternatives, such as:

- To provide bikeway continuity along high-speed or heavily traveled roadways that offer inadequate space for bicyclists on the roadway.
- On long, narrow bridges. In such cases, ramps should be installed at the sidewalk approaches to allow bicycle traffic to enter from the sidewalk as well as the roadway. If approach bikeways are two-way, sidewalk facilities also should be two-way.

In residential areas, sidewalk bicycle riding by young children is common. With lower bicycle speeds and lower cross-street auto speeds, potential conflicts are lessened, but not eliminated. Nevertheless, this type of sidewalk bicycle use is accepted.

5-2.0 Planning and Locating Shared-Use Paths

Shared-use paths serve a variety of important purposes, such as providing an alternative to a busy thoroughfare or controlled-access corridor. They serve an important transportation function by providing a through-route for bicycle commuters where existing street and road configurations make longer distance biking difficult. Shared-use paths can provide an enjoyable non-motorized travel opportunity for individuals and families or a place to exercise, recreate, or rehabilitate from injury. Shared-use paths play an important role in providing continuity for the overall bicycle network by creating connections where there are missing links, or creating a route through a neighborhood to a nearby destination.

A shared-use path can be located on exclusive right-of-way, or within the road right-of-way but physically separated from the road. Some typical locations for paths on exclusive right-of-way include the following:

- Along a linear feature, as shown in Figure 5-2, such as a river, creek, lake shore, railroad grade, freeway, or utility easement
- Within college campuses
- Within or between parks
- Between cul-de-sac streets.

Locate shared-use paths for longer distance pedestrian and bicycle mobility along a main road to serve land use as effectively as possible and to connect with the rest of the bikeway network. The quality of the route, available space, and interchange arrangements also affect the choice of the location. The following general principles apply when locating shared-use paths next to main roads:

- Arrange shared-use paths so that pedestrians or bicyclists do not need to venture onto the traveled way.
- Create a distinct and continuous main route for long-distance walking and bicycling alongside main roads or parallel to them in other corridors.
- For roadway projects that intersect, or run close to, existing or planned shared-use paths, use careful analysis and design measures to ensure the continued access and safety of bicyclists and other path users.
- As an alternative to the main road, a shared-use path can be located along a nearby parallel roadway if connections can be provided to destinations located on the main road and to longer distance bike routes.

Locating a shared-use path parallel to a high-speed roadway or in a developed commercial area requires careful consideration of many factors including the following:

- Driver expectations and behavior
- Location and frequency of driveways and other access points crossing the shared-use path
- Access for bicyclists and pedestrians to destinations along the route
- Mobility for longer distance bicycle travel
- Safety of bicyclists and pedestrians crossing the road
- Availability of suitable right-of-way for the shared-use path.

Figure 5-2:

Shared-use path adjacent to a road, with separate facilities for bicyclists and pedestrians

If land use on both sides of a road attracts pedestrians and bicyclists, shared-use paths should occur along both sides. However, if the land use along one side of the road generates little pedestrian and bicycle traffic, a one-side solution may be practical. In a situation where there are numerous businesses and other destinations on both sides of a road, a good solution may be to choose the side with fewer driveways for a shared-use path to provide bicycle mobility for longer distance travel, while providing pedestrian access on both sides of the road.

Avoid crossing a shared-use path from one side of the roadway to the other, especially over short distances [less than approximately 450 m **(1,500 ft)**]. Requiring bicyclists to make frequent road crossings interrupts bikeway continuity and mobility, presents an inconvenience, creates a serious potential hazard for crossing bicyclists, and users may have difficulty following the designated route.

5-3.0 Geometric Design of Shared-Use Paths

The following sections provide guidelines for geometric design of shared-use paths. These guidelines are intended to be applied using a flexible design approach. Where recommended minimum design standards cannot be met due to right-of-way limits or other constraints, a detailed safety analysis should be conducted to determine the best compromise design solution.

5-3.1 Separation Between Path and Roadway

When a two-way shared-use path is located adjacent to a roadway, wide separation between the shared-use path and adjacent highway is desirable, demonstrating to both the bicyclist and the motorist that the path functions as an independent facility. The factors in determining how far away a shared-use path should be separated from the roadway include the posted speed of the road, the type of signs between the path and roadway, the amount of space available, and whether the roadway has a rural (shoulder and ditch) cross section or urban (curb and gutter) cross section.

The separation distance between a path and a roadway depends primarily on the posted speed limit of the road. Recommended separations for rural (shoulder and ditch) and urban (curb and gutter) road cross sections are illustrated in Figures 5-3 and 5-4 and detailed in Tables 5-1 and 5-2. Figure 5-5 shows a well-designed separation of a shared-use path from an adjacent roadway.

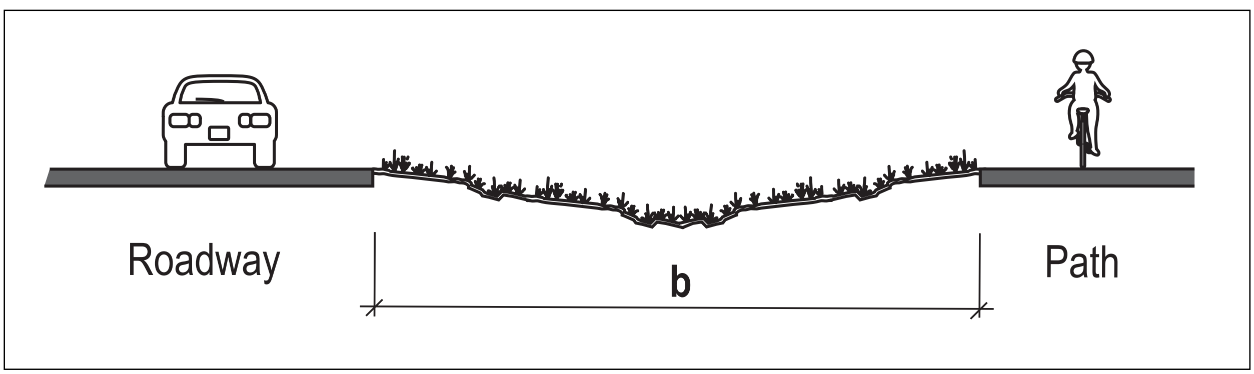


Figure 5-3:
Path Separation from Roadway with No Curb (See Table 5-1)

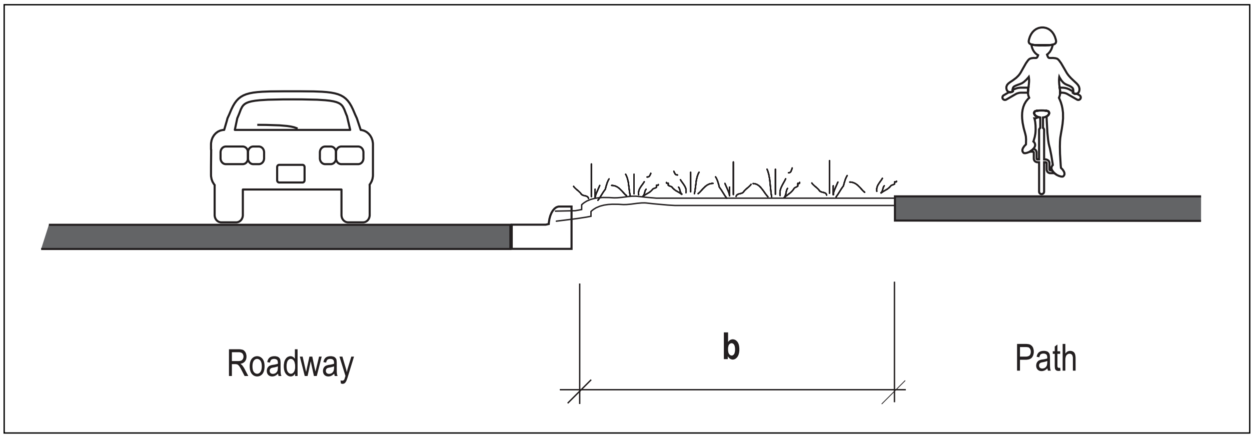


Figure 5-4:
Path Separation from Roadway with Curb (See Table 5-2)

Table 5-1 Recommended Path Separation from Roadway with No Curb

(English)		(Metric)	
Speed Limit - mph	**Separation (b)**	**Speed Limit - km/h**	**Separation (b)**
40 mph or less	20 ft (desirable) 10 ft (minimum)	65 or less	6 m (desirable) 3 m (minimum)
45 mph or greater	24 ft - 35 ft	70 or greater	7.2 m-10.7 m
Freeway	50 ft (minimum)	Freeway	15.2 m (minimum)

Table 5-2 Recommended Path Separation from Roadway with Curb

(English)		(Metric)	
Speed Limit - mph	**Separation (b)**	**Speed Limit - km/h**	**Separation (b)**
30 or less	5 ft (minimum) 3 ft (minimum, if parking allowed)	50 or less	1.5 m (minimum) 0.9 m (minimum, if parking allowed)
35 - 40	5 ft (minimum)	55 - 70	1.5 m (minimum)
45 or greater	10 ft (desirable) 5 ft (minimum)	75 or greater	3 m (desirable) 2 m (minimum)
Freeway	50 ft (minimum)	Freeway	15.2 m (minimum)

A traffic barrier may be desirable for bicyclist safety if the distance between the edge of the roadway and the shared-use path is less than indicated in Table 5-1 or Table 5-2. The type of traffic barrier that is appropriate will depend primarily upon motor vehicle speed. Where a concrete traffic barrier is adjacent to a shared-use path, provide clearance or extra pavement width of 0.3 m **(1 ft)** (minimum) to 0.9 m **(3 ft)** (desirable). For guardrail supported on posts, 0.9 m **(3 ft)** or greater clearance from the edge of the shared-use path pavement is recommended because of the greater risk of injury to a bicyclist striking a post. Railings on bridges must meet the design guidelines provided in Chapter 6 of this manual, or as otherwise required.

Figure 5-5:
This shared-use path is separated by at least 3 m (10 ft) from the roadway

Traffic noise along high-speed, high-volume roadways can detract from the bicycling experience. Earth berms or embankments constructed between the roadway and path can improve this situation.

Snow Storage in Separation Area

The separation area between a road and a shared-use path may be used to store snow removed from both the roadway and the path. A separation area width of 5.5 m **(18 ft)** is usually enough to store plowed snow. Where space is limited, overall road cross-section design must consider the likely amount of removed snow, the space needed to store it, and how snow will be managed. When snow is stored in the separation area between the road and shared-use path, at least three-fourths of the path should remain usable. Where snow storage is a design issue, the designer should consult with the maintenance supervisor.

5-3.2 Design Speed

For general design of shared-use paths, a bicycle design speed of 30 km/h **(20 mph)** is desirable. For long downgrades or other conditions where high speeds may occur, a bicycle design speed of 50 km/h **(30 mph)** is desirable. On unpaved paths, where bicyclists tend to ride more slowly, a bicycle design speed of 25 km/h **(15 mph)** may be used. However, since skidding is more common on unpaved surfaces, horizontal curvature design should take into account lower coefficients of friction.

The major geometric features that affect the speed at which a bicyclist can travel safely and comfortably are curvature, superelevation, gradient, and width of the traveled way. In addition, factors such as traffic, intersections, type of bicycle, physical condition of the rider, wind, and surface condition also affect the bicyclist's speed.

Where local State-Aid Route Standards apply, a design speed of 20 mph is required, except a design speed of 30 mph shall be used for longer than 500 feet and steeper than 4 percent *(Minn. Rules 8820.9995).*

5-3.3 Horizontal Curvature and Superelevation

Superelevation (transverse sloping of path down toward the inside of the curve) of 2 percent to 3 percent should be provided on all curves. For most conditions, the minimum superelevation rate of 2 percent will be adequate. The ADA allows a maximum superelevation rate of 3 percent for accessibility. When transitioning a 3 percent superelevation, a minimum 7.5 m (25 ft) transition distance should be provided between the end and beginning of consecutive and reversing horizontal curves. A cross slope of 2 percent is recommended for drainage on tangent (straight) sections of a shared-use path.

The minimum radius of horizontal curvature depends on design speed, rate of superelevation, coefficient of friction and the allowable lean angle of the bicyclist. By ignoring the coefficient of friction and the superelevation rate, the equation shown in Figure 5-6A can be used to find the approximate bicyclist lean angle for a given curve radius and bicyclist speed. The desirable minimum radius of horizontal curvature for varied design speeds, based on a 15 degree lean angle, is provided in Table 5-4A.

For Metric Units:	For English Units:
$\theta = \text{Tan}^{-1}\left(\frac{0.0079\,V^2}{R}\right)$	$\theta = \text{Tan}^{-1}\left(\frac{0.067\,V^2}{R}\right)$
Where: R = Radius of curvature (m) V = Design speed (km/h) θ = Lean angle from the vertical (degrees)	Where: R = Radius of curvature (ft) V = Design speed (mph) θ = Lean angle from the vertical (degrees)

Figure 5-6A:
Bicyclist Lean Angle Equation

Table 5-4A:
Desirable Minimum Radius of Horizontal Curvature for Paved Shared-Use Paths

Design Speed (mph)	Radius (ft)
12	36
20	100
25	156
30	225
Design Speed (km/h)	**Radius (m)**
20	12
30	27
40	47
50	74

A lean angle of 20 degrees is considered maximum for average bicyclists, and the pedal may strike the ground at a lean angle of approximately 25 degrees. When the lean angle approaches 20 degrees, the minimum radius of curvature negotiable by a bicycle is a function of the superelevation rate, the coefficient of friction between the bicycle tires and the path surface, and the speed of the bicycle. For this situation, the minimum design radius of curvature can be determined from the equation shown in Figure 5-6B.

For Metric Units:

$$R = \frac{V^2}{127\left(\frac{e}{100} + f\right)}$$

Where:
R = Minimum radius of curvature (m)
V = Design speed (km/h)
f = Coefficient of friction
e = Superelevation rate (%)

For English Units:

$$R = \frac{V^2}{15\left(\frac{e}{100} + f\right)}$$

Where:
R = Minimum radius of curvature (ft)
V = Design speed (mph)
f = Coefficient of friction
e = Superelevation rate (%)

Figure 5-6B:
Minimum Radius of Curvature for 20 Degree Lean Angle

Coefficient of friction factors used for design should be selected based upon the point at which centrifugal force causes the bicyclist to recognize a feeling of discomfort and instinctively act to avoid higher speed. The coefficient of friction depends on speed, surface type, roughness and condition of pavement, tire type and condition, and whether the surface is wet or dry. Although no data exists for unpaved surfaces, it is suggested that friction factors be reduced by 50 percent to allow a sufficient margin of safety.

The minimum radius of horizontal curvature, based upon a 2 percent superelevation rate and a 20 percent lean angle, is shown in Table 5-4B. Extra paved width should be provided for curves designed for a 20 degree lean angle, because the bicyclist will require more space while leaning on the curve. When a curve radius smaller than shown in Table 5-4B is used (because of limited right of way or other considerations) standard curve warning signs and supplemental pavement markings may be needed. The negative effects of a sharper curve can also be partially offset by widening the pavement through the curve.

Table 5-4B:
Minimum Radius for Paved Shared-Use Paths (Based on 2 Percent Superelevation Rates and 20 Degree Lean Angle)

Design Speed (v) (mph)	Coefficient Friction (f)	Minimum Radius (R) ft
12	0.31	30
16	0.29	55
20	0.28	90
25	0.25	155
30	0.21	260
Design Speed (v) (km/h)	**Coefficient Friction (f)**	**Minimum Radius (R) m**
20	0.31	10
25	0.29	16
30	0.28	24
40	0.25	47
50	0.21	86

5-3.4 Grades

The grade that a bicyclist can be expected to negotiate depends on the length of the grade, wind velocity, and surface condition. Generally speaking, the amount of energy required to use a bicycle route will affect the usage of the route, and bicyclists will tend to avoid routes that have steep hills. Some bicyclists will find themselves walking on long, steep uphill grades. On downhill grades, bicyclists may exceed the speed at which they can safely control their bicycles. Therefore, grades should be kept to a minimum, even at the expense of providing added curvature or travel distance, within the practical limits for the site.

The maximum grade recommended for shared-use paths is 5 percent and sustained grades should be limited to 3 percent, as much as practical. However, steeper grades are allowable. Grades on paths parallel to a roadway should be equal to or flatter than the roadway grade, with grades of 5 percent or less preferred.

Grades in excess of 8.3 percent (12:1) exceed ADA Accessibility Guidelines for pedestrian facilities and should be avoided on shared-use paths unless significant physical constraints exist. Where local State-Aid Route Standards apply, the maximum allowable grade is 8.3 percent (*Minn. Rules 8820.9995*).

The AASHTO Guide for the Development of Bicycle Facilities acknowledges that on recreational routes, designers may need to exceed a 5 percent grade for short sections. It recommends several methods to mitigate excessive grades:

- Eliminate hazards to the bicyclists and pedestrians near the end of a ramp
- Warn bicyclists and pedestrians with signage ahead of steep downgrade hazards
- Provide signage stating recommended descent speed
- Exceed minimum stopping sight-distances
- When practical, widen the path by 1.2 - 1.8 m **(4 - 6 ft)** to provide space for slower speed bicyclists to dismount and walk
- Provide a series of short switchbacks near the top to contain the speed of descending bicyclists.

For paths with crushed stone surfaces, grades less than 3 percent are preferred due to the risk of skidding, as well as for erosion control. A paved section is recommended to allow for stopping ahead of an intersection at the bottom of an unpaved downgrade section. Path surfaces should be paved for the distance that grades exceed 3 percent, if practical.

The maximum recommended values for grade restrictions and grade lengths are shown in Table 5-5.

Table 5-5 Recommended Grade Restrictions for Paved Paths

Grade Value (%)	Maximum Length of Grade Segment
5-6	240 m **(800 ft)**
7	120 m **(400 ft)**
8	90 m **(300 ft)**
9	60 m **(200 ft)**

5-3.5 Sight-Distance

Figure 5-7:
Example of unacceptable sight distance on a curve

To provide users an opportunity to see and react to other users and unexpected conditions, a shared-use path should be designed with adequate stopping sight-distance on vertical curves, horizontal curves, and at intersections. Stopping sight-distance at intersections is provided in Section 5-8.

5-3.5.1 Stopping Sight-Distance

Stopping sight-distance for bicyclists is typically calculated as a function of brake reaction time and ability of a bicyclist to come to a complete stop. Due to differences in brake type and quality, rider skill, and surface condition, stopping distances for bicyclists traveling at the same speed may vary dramatically. The distance a bicyclist requires to come to a complete stop is a function of the bicyclist's perception and reaction time, temperature and moisture conditions, the tire/surface coefficient of friction, the grade, and the bicyclist's weight, speed and equipment.

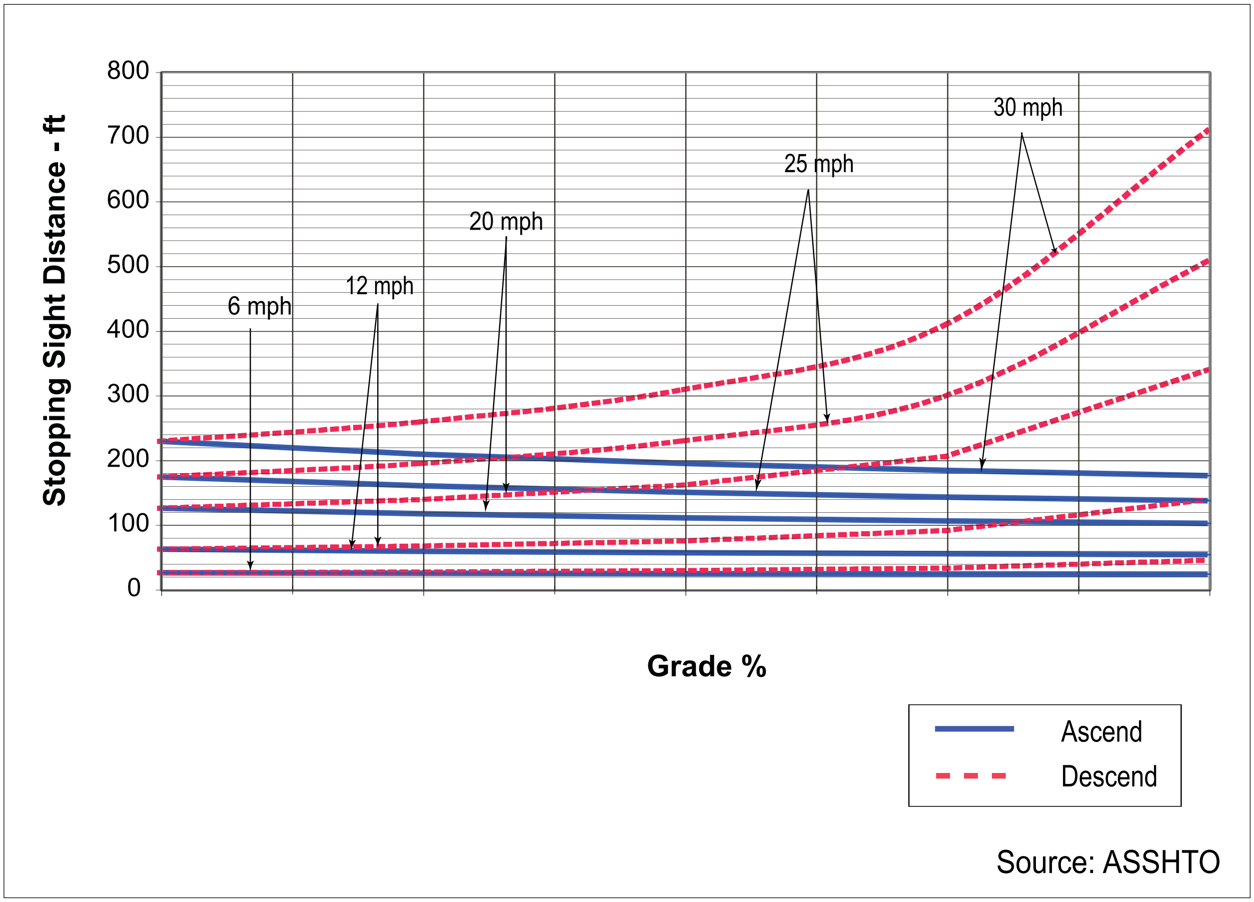
Design values for stopping sight-distance for bike facilities, which may be computed in the same manner as for highways, should be checked when locating and designing bicycle facilities. Stopping sight distance for bicyclists is calculated using a brake reaction time of 2.5 seconds. AASHTO recommends using a coefficient of friction of 0.25 to account for the general braking characteristics of bicycles. The eye height of bicyclists is generally assumed to be 1.4 m **(4.5 ft)** and an object height of zero is assumed (allowing bicyclists to notice any potential hazard on the pavement). The sight distance in the descending direction (where "g" is negative in the appropriate equation), will control the design. Stopping sight distance should therefore be increased where the path has downgrades.

Table 5-6 lists design recommendations for stopping sight distance at downgrades. Figure 5-8 provides minimum stopping sight distance for various grades and design speeds recommendations.

Table 5-6: Stopping Sight Distance for Downgrades

Design Speed	Stopping Sight Distance		
	0 % Grade	**5 % Grade**	**10 % Grade**
15 km/h **(10 mph)**	14 m **(50 ft)**	15 m **(53 ft)**	17 m **(59 ft)**
(12 mph)	**(63 ft)**	**(68 ft)**	**(76 ft)**
20 km/h **(15 mph)**	21 m **(85 ft)**	22 m **(93 ft)**	25 m **(105 ft)**
30 km/h **(20 mph)**	36 m **(127 ft)**	39 m **(140 ft)**	45 m **(162 ft)**
40 km/h **(25 mph)**	54 m **(175 ft)**	60 m **(196 ft)**	71 m **(231 ft)**
50 km/h **(30 mph)**	75 m **(230 ft)**	85 m **(260 ft)**	101 m **(310 ft)**

To develop the minimum sight distance for various grades and design speed, use the formula:



For English Units:

$$S = \frac{V^2}{30\left(f \pm G\right)} + 3.67\,V$$

Where:

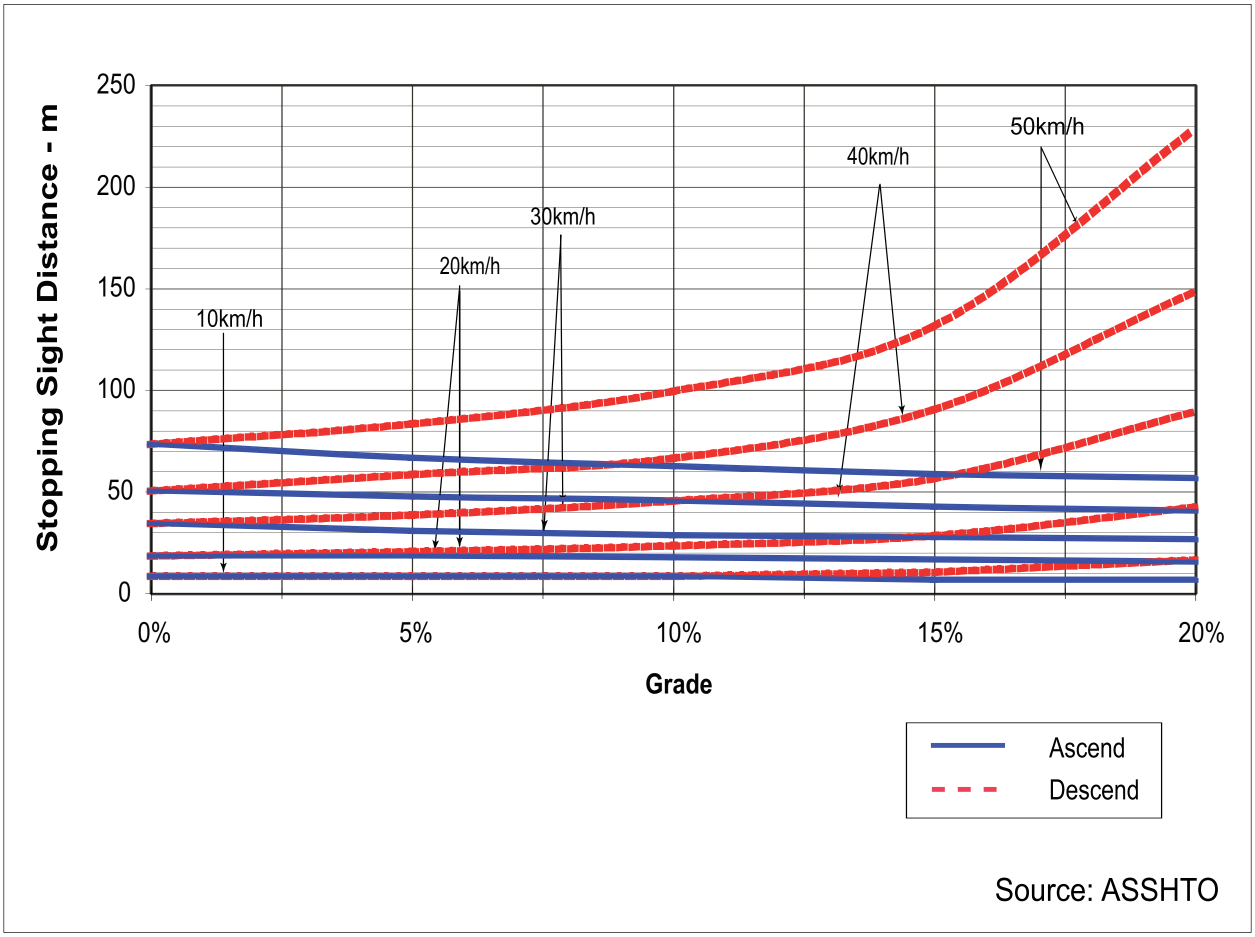
S = Stopping distance (ft)

V = Velocity (mph)

f = Coefficient of friction (use 0.25)

G = Grade (ft/ft) (rise/run)

Figure 5-8:
Minimum Stopping Sight Distance vs. Grade for Various Design Speeds (English)



For Metric Units:

$$S = \frac{V^2}{254\left(f \pm G\right)} + \frac{V}{1.4}$$

Where:

S = Stopping distance (m)

V = Velocity (km/h)

f = Coefficient of friction (use 0.25)

G = Grade (m/m) (rise/run)

Figure 5-8M:

Minimum Stopping Sight Distance vs. Grade for Various Design Speeds (Metric)

5-3.5.2 Sight Distance at Crest Vertical Curves

Sight distances at grade crests may be checked using the table below or associated equations. Longer vertical curves should be provided whenever practical.

The equations are based on an eye height of 1.4 m **(4.5 ft)** and an object height of zero. (Even something as small as gravel on a surface can be hazardous to a bicyclist.) See Table 5-7.

A	S = Stopping Sight Distance (ft)														
(%)	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300
2												30	70	110	150
3								20	60	100	140	180	220	260	300
4						15	55	95	135	175	215	256	300	348	400
5					20	60	100	140	180	222	269	320	376	436	500
6				10	50	90	130	171	216	267	323	384	451	523	600
7				31	71	111	152	199	252	311	376	448	526	610	700
8			8	48	88	128	174	228	288	356	430	512	601	697	800
9			20	60	100	144	196	256	324	400	484	576	676	784	900
10			30	70	111	160	218	284	360	444	538	640	751	871	1000
11			38	78	122	176	240	313	396	489	592	704	826	958	1100
12		5	45	85	133	192	261	341	432	533	645	768	901	1045	1200
13		11	51	92	144	208	283	370	468	578	699	832	976	1132	1300
14		16	56	100	156	224	305	398	504	622	753	896	1052	1220	1400
15		20	60	107	167	240	327	427	540	667	807	960	1127	1307	1500
16		24	64	114	178	256	348	455	576	711	860	1024	1202	1394	1600
17		27	68	121	189	272	370	484	612	756	914	1088	1277	1481	1700
18		30	72	128	200	288	392	512	648	800	968	1152	1352	1568	1800
19		33	76	135	211	304	414	540	684	844	1022	1216	1427	1655	1900
20		35	80	142	222	320	436	569	720	889	1076	1280	1502	1742	2000
21		37	84	149	233	336	457	597	756	933	1129	1344	1577	1829	2100
22		39	88	156	244	352	479	626	792	978	1183	1408	1652	1916	2200
23		41	92	164	256	368	501	654	828	1022	1237	1472	1728	2004	2300
24	3	43	96	171	267	384	523	683	864	1067	1291	1536	1803	2091	2400
25	4	44	100	177	278	400	544	711	900	1111	1344	1600	1878	2178	2500

when S > L $L = 2S - \dfrac{900}{A}$

when S < L $L = \dfrac{AS^2}{900}$

Height of cyclist's eye – 4 1/2 ft
Height of object – 0 ft

Shaded area represents S = L

L = Minimum Length of Vertical Curve (ft)
A = Algebraic Grade Difference (%)
S = Stopping Sight Distance (ft)

Minimum Length of Vertical Curve = 3 ft.

Table 5-7:
Minimum Length of Crest Vertical Curve (L) Based on Stopping Sight Distance (English)

A (%)	S = Stopping Sight Distance (m)																		
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
2														10	20	30	40	50	60
3									7	17	27	37	47	57	67	77	87	97	107
4							10	20	30	40	50	60	70	80	91	103	116	129	143
5					4	14	24	34	44	54	64	75	88	100	114	129	145	161	179
6				3	13	23	33	43	54	65	77	91	105	121	137	155	174	193	214
7				10	20	30	40	51	63	76	90	106	123	141	160	181	203	226	250
8			5	15	25	35	46	58	71	86	103	121	140	161	183	206	231	258	286
9			9	19	29	39	51	65	80	97	116	136	158	181	206	232	260	290	321
10		2	12	22	32	44	57	72	89	108	129	151	175	201	229	258	289	322	357
11		5	15	25	35	48	63	80	98	119	141	166	193	221	251	284	318	355	393
12		7	17	27	39	53	69	87	107	130	154	181	210	241	274	310	347	387	429
13		8	18	29	42	57	74	94	116	140	167	196	228	261	297	335	376	419	464
14		10	20	31	45	61	80	101	125	151	180	211	245	281	320	361	405	451	500
15	1	11	21	33	48	66	86	108	134	162	193	226	263	301	343	387	434	483	536
16	3	13	23	36	51	70	91	116	143	173	206	241	280	321	366	413	463	516	571
17	4	14	24	38	55	74	97	123	152	184	219	257	298	342	389	439	492	548	607
18	4	14	26	40	58	79	103	130	161	194	231	272	315	362	411	464	521	580	643
19	5	15	27	42	61	83	109	137	170	205	244	287	333	382	434	490	550	612	679
20	6	16	29	45	64	88	114	145	179	216	257	302	350	402	457	516	579	645	714
21	7	17	30	47	68	92	120	152	188	227	270	317	368	422	480	542	608	677	750
22	7	18	31	49	71	96	126	159	196	238	283	281	385	442	503	568	636	709	786
23	8	18	33	51	74	101	131	166	205	248	296	347	403	462	526	593	665	741	821
24	8	19	34	54	77	105	137	174	214	259	309	362	420	482	549	619	694	774	857
25	9	20	36	56	80	109	143	181	223	270	321	377	438	502	571	645	723	806	893

when $S > L$ $\quad L = 2S - \dfrac{280}{A}$

when $S < L$ $\quad L = \dfrac{AS^2}{280}$

Height of cyclist eye - 1400 mm
Height of object - 0 mm

Shaded area represents S = L

L = Minimum Length of Vertical Curve (m)
A = Algebraic Grade Difference (%)
S = Stopping Sight Distance (m)

Minimum Length of Vertical Curve = 1 m

Table 5-7M:
Minimum Length of Crest Vertical Curve (L) Based on Stopping Sight Distance (Metric)

5-3.5.3 Sight Distance at Horizontal Curves

The amount of lateral clearance required on the inside of a horizontal curve is a function of the design speed, the radius of curvature, and the grade. The centerline of the inside lane is used when measuring the length of the bicyclist's field of vision. Lateral clearances should be calculated based on the sum of the stopping sight distances for bicyclists traveling in opposite directions around the curve. When this sight distance cannot be provided, widen the path or paint a continuous centerline between the lanes the entire length of the curve and extending 9 m **(30 ft)** beyond it at both ends. Values and formulas for sight distance on horizontal curves are presented in Figure 5-9. Additional information can be found in Chapter 3 of the *Mn/DOT Road Design Manual*.

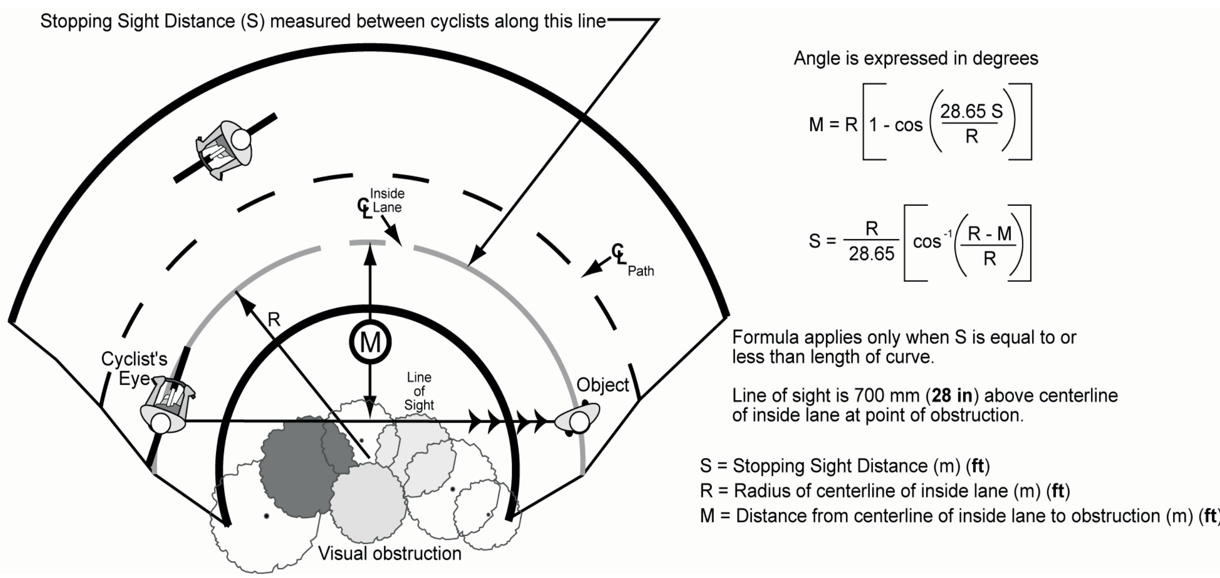


Figure 5-9:
Lateral Clearance at Horizontal Curves

5-3.6 Shared-Use Path Widths and Clearances

The overall width of a shared-use path includes the pavement width, graded shoulders on both sides, and an additional clear zone beyond the shoulders. Determining an appropriate pavement width requires project-specific evaluation, as discussed below.

Width, pavement design, and clearances should accommodate maintenance and emergency vehicles (pickups, mowers,

Figure 5-10:
Path width determinations should consider the needs of maintenance and emergency vehicles

ambulances, etc.) and should be wider than the widest anticipated vehicles in order to avoid pavement edge deterioration.

5-3.6.1 Pavement Width

Shared-use paths are designed for adequate width to accommodate the expected volume of bicycle and pedestrian traffic. The standard pavement width for shared-use paths is 3.0 m **(10 ft)**, but each proposed facility must be evaluated in detail to determine the appropriate pavement width. Variations in pavement width along a path are acceptable, and in some cases desirable, but each segment of a path should be designed to provide a consistent travel environment for users.

Table 5-8 provides recommended pavement widths for several combinations of bicycle and pedestrian traffic composition. Based on user experience, satisfactory designs must accommodate peak bicycle and pedestrian traffic conditions. The recommended pavement widths should be further evaluated in terms of geometric factors and other factors as discussed below. Separation of bicycle traffic from pedestrian traffic should be considered in certain cases as discussed below.

To determine appropriate pavement width, each segment of a shared-use path should be evaluated by considering the following factors:

- Path geometry, including grades, curvature, sight lines and intersections
- Bicycle traffic volume and speeds
  - Peak period bicycle traffic (typically weekends, evenings and holidays)
  - Bicycle users and destinations (commuters, access to commercial destinations, children going to and from school)
- Pedestrian volume and other users
  - Peak period pedestrian use (typically evenings, weekends, holidays and early mornings)
  - Pedestrian user types (children, elderly, dog walkers, runners)
  - Other user types (wheelchair, inline skaters, pedaled carts)
- Potential for conflicts between users, including bicyclists, pedestrians and other types
  - Highest potential for conflicts occurs during peak use times (evenings, weekends, holidays)
  - High potential for conflict when several different types of users are present
  - Consider how frequently users traveling at different speeds would encounter two other users on the path, and the severity of potential conflicts

Table 5-8:
Pavement Width Based on Bicycle and Pedestrian Traffic Composition

	Bicycle and Pedestrian Traffic Composition	Recommended Pavement Width
Two-Way Travel	Two-way bicycle travel with light pedestrian use	3.0 m **(10 ft)** (Standard width)
	Two-way bicycle travel with heavy pedestrian use, for short segments where right-of-way is restricted	
	Heavy two-way bicycle travel, with pedestrians on a separate path	
	Two-way bicycle travel, with pedestrians on a separate path	2.4 m **(8 ft)**
	Two-way bicycle travel where pedestrian use is likely to be infrequent	
	Two-way bicycle travel with light pedestrian use, for short segments where right-of-way is restricted	
	Two-way bicycle travel, with frequent pedestrian use	3.6 m **(12 ft)**
	Heavy bicycle travel, with light pedestrian use	
	Heavy bicycle travel, with light pedestrian use	
	Use by maintenance vehicles or emergency vehicles	
	Heavy bicycle and pedestrian travel	4.2 m **(14 ft)** or greater
	Path segments where queuing occurs, such as a road crossing	
	Minimum width for two-way pedestrian path, with light pedestrian use and bicycles prohibited (bicycle travel on a separate path)	1.5 m **(5 ft)**
	Recommended width for two-way pedestrian path with heavy pedestrian use or inline skating and bicycles prohibited (bicycle travel on a separate path)	2.0 m **(6.5 ft)**
One-Way Travel	Minimum width for one-way bicycle travel, with light pedestrian use	1.5 m **(5 ft)**
	One-way bicycle travel, where bicycles must frequently pass pedestrians	2.0 m **(6.5 ft)**
	Adjacent to curb, one-way bicycle travel, where bicycles must frequently pass pedestrians	2.4 m **(8 ft)**

Additional pavement width should be provided on sharp curves and where long grades are necessary. To mitigate excessive grades (where a hill is longer than recommended for a given grade as provided in Table 5-5), an additional 1.2 - 1.8 m **(4 - 6 ft)** paved width is recommended. On sharp curves having a radius less than a 24.4 m **(80 ft)**, additional paved width is recommended as provided in Table 5-9. Curves of any radius should also be wider along steep grades or other locations where bicycle speeds tend to be high [e.g., paths with grades of 6 percent or more and those longer than 75 m **(250 ft)**]. Along recreational routes, plan for added width for a ski trail if necessary.

Table 5-9: Pavement Width vs. Curve Radius

Curve Radius	Recommended Minimum Two-Way Path Width
0 - 8 m **(0 - 25 ft)**	3.6 m **(12 ft)**
8.1 - 15 m **(26 - 50 ft)**	3.5 m **(11.5 ft)**
15.1 - 25 m **(50 - 80 ft)**	3.2 m **(10.5 ft)**

For safety and traffic flow, pedestrians and bicyclists may need to be separated. Be sure to maintain the same configuration for a continuous segment, because conflicts will occur at transition points. There are two approaches to separation:

- Move slower users to a shoulder or slow-lane
- Provide separate paths for each user group.

With higher volumes, increased separation using pavement markings or separate paths (two-way or one-way) is desirable. See Figure 5-12.

Figure 5-11:
Path design allows for horizontal clearance from hazards

Separating pedestrians from bicyclists can be accomplished by signing and striping on a shared-use path, or by providing a bike path that is separate from a parallel sidewalk or pedestrian path. Separating bicycles from pedestrians is recommended in any of the following cases:

- Where conflicts between bicycles and pedestrians during peak user periods or other times are likely to present safety concerns
- In city centers and where buildings or bus stops are adjacent to the pedestrian and bike network
- Where peak daily pedestrian and bicycle user volume is greater than 2,000 individuals per day

- Where peak hour bicycle traffic is greater than 100 per hour
- Where both pedestrian and bicycle traffic occur at high volumes
- When there is likely to be a combination of use for fast or long-distance bicycling with use by less skilled bicyclists and/or pedestrians (especially children, people who are disabled, inline skaters or senior citizens).

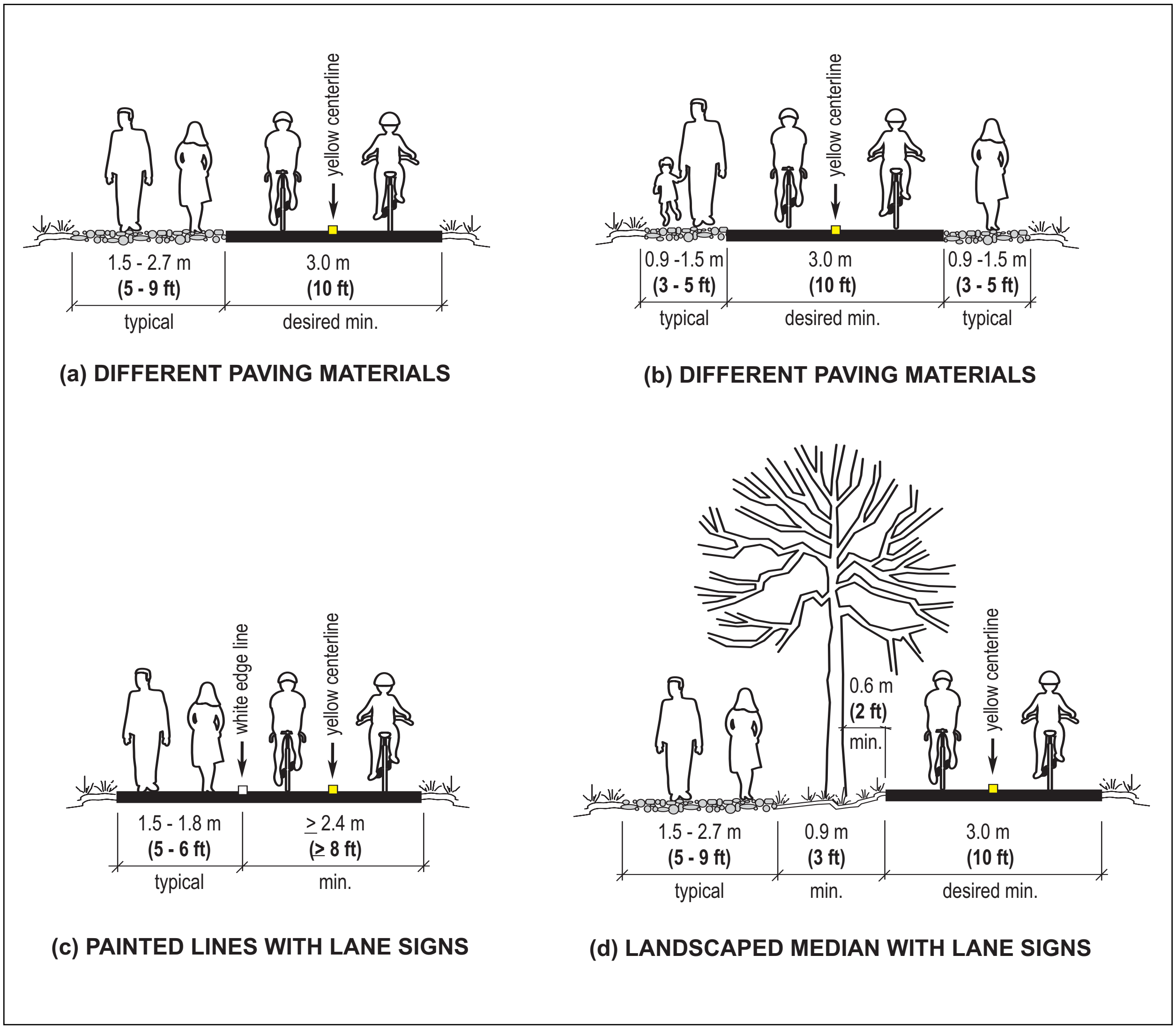


Figure 5-12:
Typical Cross Section, Pedestrian and Bicycle Traffic Separation

Extra width is necessary where separate pedestrian and bicycle paths converge and diverge, because pedestrians traveling in one direction of travel will enter the shared-use portion of the path on the left side and have to cross both bike lanes to reach the right side. Separating pedestrians and bicyclists should also consider local practices.

It should be assumed that bicycle and pedestrian traffic will intermingle on some segments of the shared-use path. Sign R9-7 in the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) (Figure 5-13) is designed to recommend a separation of bicyclists and pedestrians on shared-use paths.

Reduced pavement widths should only be considered when:

- Bicycle traffic is expected to be low, even on peak days or during peak hours
- Pedestrian use of the facility is not expected to be more than occasional
- Horizontal and vertical alignment will provide safe and frequent passing opportunities
- The path normally will not be subjected to maintenance vehicle loading conditions that would cause pavement edge damage.

Figure 5-13:
Shared-Path Restriction Sign, MN MUTCD Sign R9-7

5-3.6.2 Horizontal Clearance

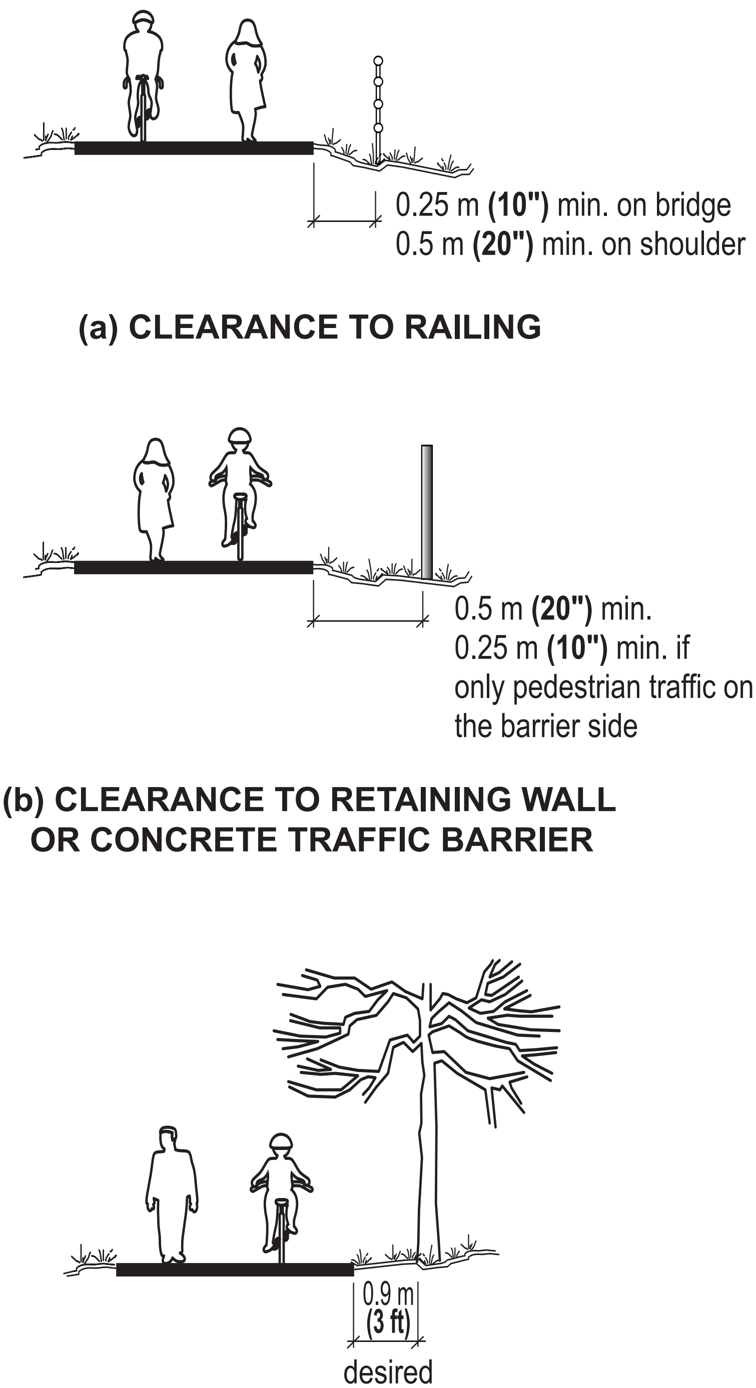
Shared-use paths should be designed to provide clearance from hazards, barriers, and slopes. Horizontal clearances are designed to provide emergency operating space in case path users must maneuver to avoid conflicts, or to safely recover control if they have drifted or have been forced off the path. The recommended horizontal clearance also allows for easier path maintenance.

On each side of the path, adjacent to the paved surface, a minimum 0.6 m **(2 ft)** graded shoulder area with a maximum slope of 6:1 is recommended. Such shoulders provide a measure of safety in case a bicyclist drifts off the side of the path. The shoulder surface should be level with the edge of pavement to prevent accidents caused by an uneven pavement edge.

An additional 0.3 m **(1 ft)** clearance is recommended from the shoulder to trees, poles, walls, fences, and other lateral obstructions.

If adequate clearance cannot be maintained between the path and obstructions, a warning sign should be used in advance of the hazard, with an object marker at its location. Figure 5-14 illustrates the recommended horizontal clearances to railings, walls and obstructions.

MN MUTCD recommends that lateral clearance for signage poles along shared-use paths shall be a minimum of 0.9 m **(3 ft)** and a maximum of 1.8 m **(6 ft)** from the near edge of the sign to the edge of the path pavement. See Figure 7-4 in Chapter 7 of this manual for details on sign placement.



*** FOR CLEARANCE TO SIGNS:**

Refer to Minnesota Manual on Uniform Control Devices *(MN MUTCD)*

Figure 5-14:
Horizontal Clearance

Design paths to protect bicyclists from adjacent rough terrain and steep slopes. Where a path is adjacent to canals, ditches, or down-slopes greater than 3:1, additional clearance should be considered. Flattening steep slopes to at least 4:1 or flatter and providing a smooth, preferably grassy, surface is desirable or a minimum 1.5 m **(5 ft)** separation from the edge of the path pavement to the top of the slope is desirable.

Depending upon conditions in the embankment or bottom of slope, a physical barrier such as a railing, fence or dense shrubbery may be needed at the top of the slope, where the slope and drop equal or exceed the following parameters and the separation is less than 1.5 m **(5 ft)** as illustrated in figure 5-16 :

- The slope is 3:1 or greater and the drop off is 1.8 m **(6 ft)** or more;
- The slope is 2:1 or greater and the drop off is 1.2 m **(4 ft)** or more; and
- The slope is 1:1 or greater and the drop off is 0.6 m **(2 ft)** or more.

The recommended height of the safety railing is 1.1 m **(3.5 ft)** or 1.2 m **(4 ft)** for precipitous dropoffs.

5-3.6.3 Vertical Clearance

If passage of an emergency or maintenance vehicle is required, vertical clearance shall be a minimum of 3m **(10 ft)**. If only bicycles and pedestrians are to be accommodated, vertical clearance shall be at least 2.4 m **(8 ft)**. Where local State-Aid Route Standards apply, vertical clearance shall be 10 feet (*Minn. Rules 8820.9995*). See Figure 5-15.

Figure 5-15:

Vertical clearance should be sufficient to allow passage of permitted vehicles

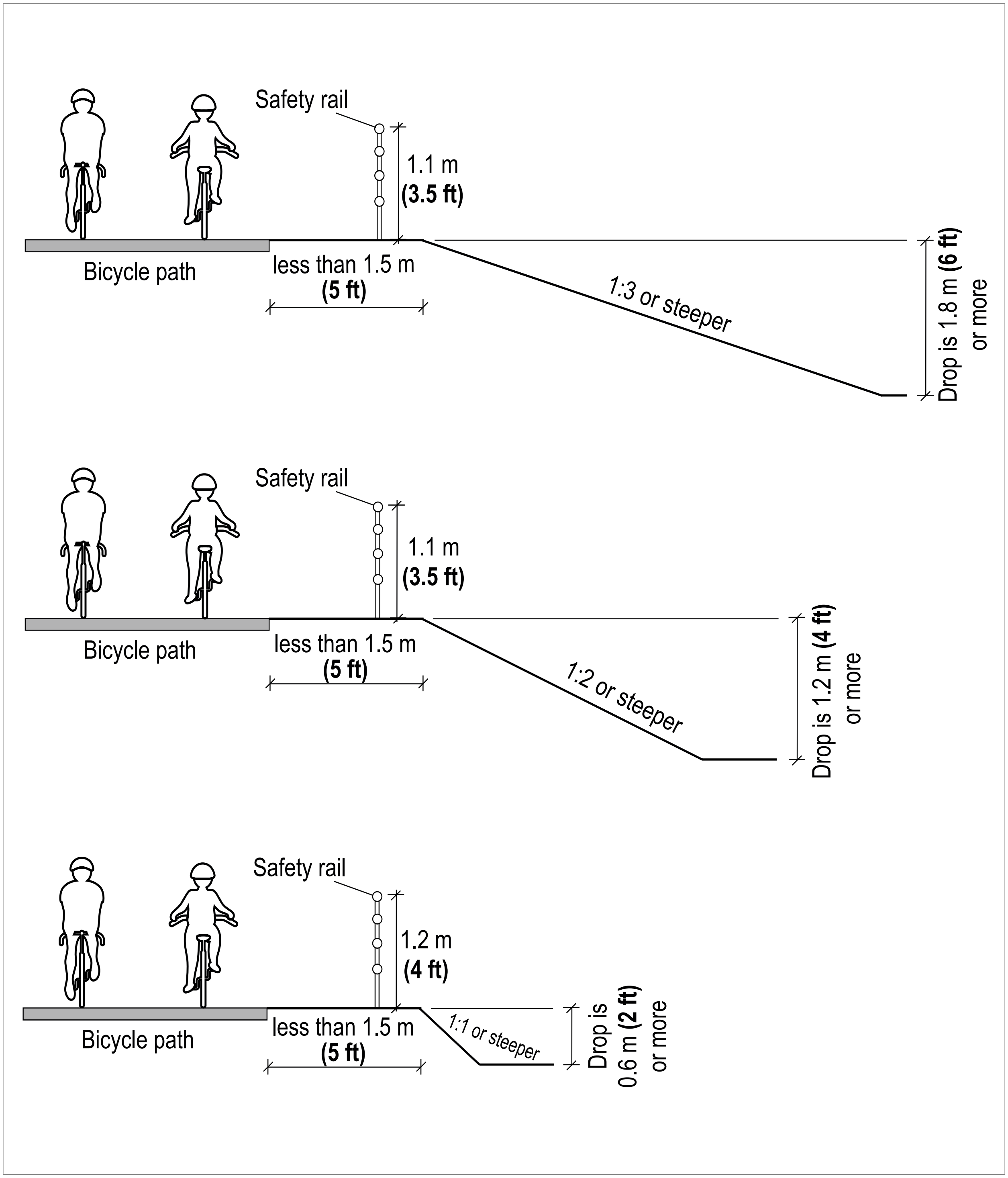


Figure 5-16:
Safety Rails Adjacent to Slopes

5-4.0 Intersections

Safety at intersections depends on traffic volume and speed, sight distances, crossing distance and available space, and user actions. A number of design techniques can help promote safe crossings.

Access to destinations from the shared-use path may require bicyclists and pedestrians to cross a busy roadway. Providing for a safe roadway crossing is critical because of the likelihood of serious injury or fatality when bicyclists or pedestrians are struck by vehicles. Signal timing, turning movements, pedestrian refuges, lighting, signage, sight lines, probable vehicle maximum speeds and other factors must be carefully evaluated and coordinated to provide a safe roadway crossing.

5-4.1 Path/Path Intersection Design

Bicyclists tend to slow their speeds as they approach intersections, thus a design speed for path intersections of 20 km/h **(12 mph)** is acceptable. The minimum intersection radius along paths should be 3 to 6 m **(10 to 20 ft)**, depending on the maintenance equipment used and the overall widths of the paths.

Intersections between two shared-use paths do not usually include a stop sign. Bicyclists must rely on sufficient sight-distance at path/path intersections to see other users with sufficient reaction time to avoid a collision. Figure 5-17 illustrates how the line of sight relates to stopping sight distance “d” at path/path intersections. Acceptable design stopping sight distance may vary depending upon design speed, approach grade and user mix as described in the following paragraphs:

- Where a path is used for trips to school, or if a large number of users will be children, seniors or disabled people, or if the intersection is heavily used in general, design the lines of sight to allow a stopping sight distance of 20 m **(65 feet)**, and limit downhill grades to 2 percent or less on the paths approaching the intersection. Under these conditions, braking will be smooth and path safety will be good.
- Under many conditions, where the user mix does not include those listed above, sight lines allowing a stopping sight distance of 15 m **(50 feet)** will be satisfactory, with downhill grades less than 4 percent on paths approaching the intersection, but bicyclists may have to brake sharply to avoid collisions.
- Under restrictive conditions, where topography or other features are beyond the control of the designer, sight lines allowing at least 10 m **(33 feet)** stopping sight distance may be used with signage and pavement markings warning bicyclists to slow before the intersection. Where downhill grades exceed 4 percent on paths approaching the intersection, stopping sight lines should be increased and signage and pavement markings used to warn bicyclists of the approaching intersection.

If practical, increase the stopping sight-distance where there is a downhill approach to an intersection. When the grade of a path is greater than 4 percent at the approach to a path/path intersection, increase the sight distance by 4.5 to 10.7 m **(15 to 35 ft)**, depending on the grades and length of the gradient. If the path slopes steeply toward a 4-legged intersection, consider dividing the crossing point into two T-intersections.

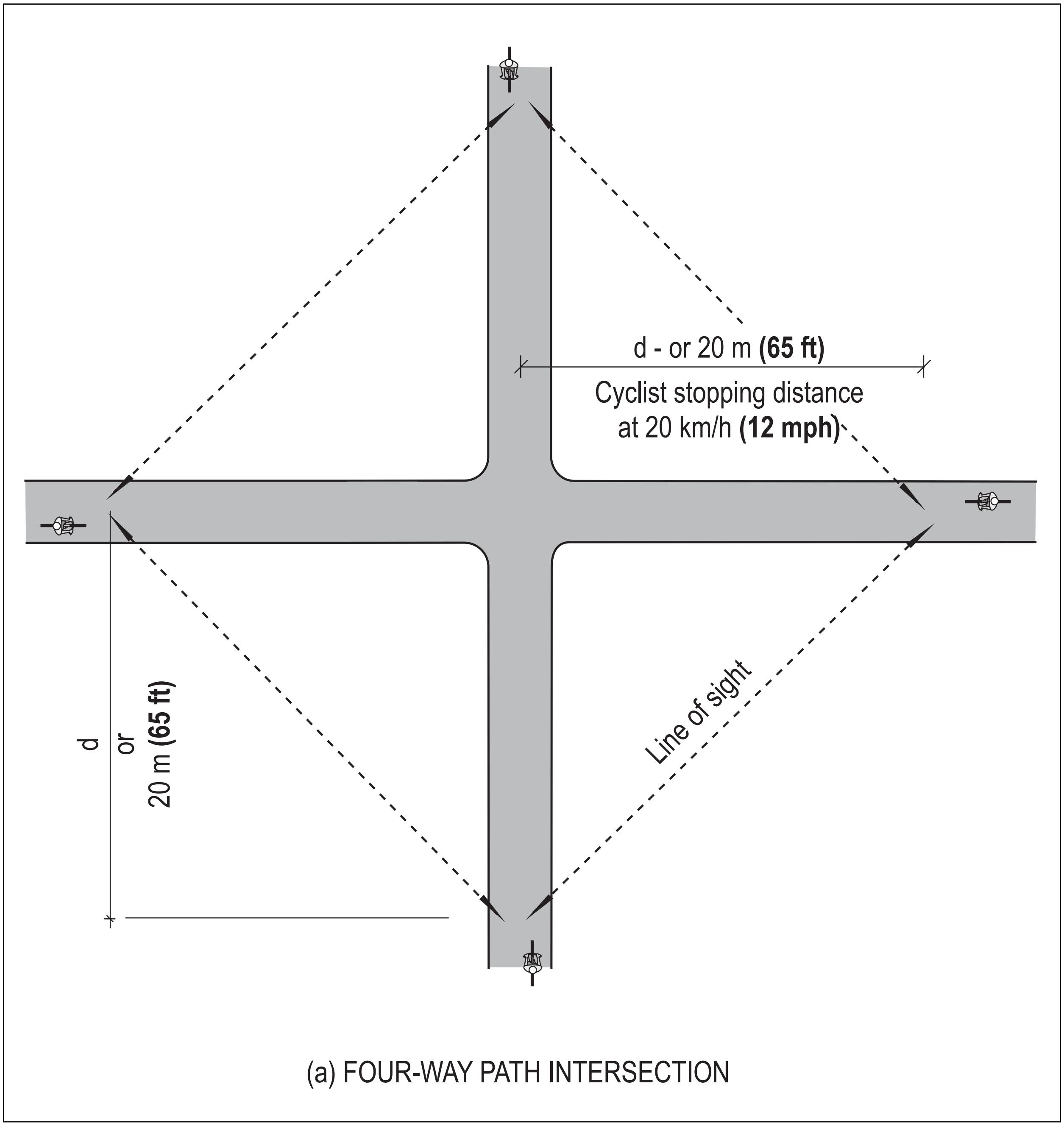


Figure 5-17:
Sight Distance for Bicycles at Path Intersections

5-4.2 Path/Roadway Intersection Treatment Selection

This section provides guidance for selecting an appropriate treatment for a crossing of a shared-use path or other bikeway and a roadway.

Intersections between paths and roadways are among the most critical issues in bikeway design. According to the National Highway Traffic Safety Administration, more than half of all bicycle crashes nationwide occur at these intersections. Due to the potential conflicts, careful design is critically important to the safety of bikeway users and motorists alike.

At intersections, bicyclists on paths face many of the same conflicts they do on a roadway, complicated by integration with pedestrians. Problems associated with at-grade crossings often relate to motorists' expectations that crosswalk users will be traveling at pedestrian speeds rather than typical bicycle speeds.

For paths parallel to roadways, intersections present many risks. When approaching a free-right turn, motorists typically do not anticipate any conflict on the right and are looking to the left for traffic entering the intersection, so they may not see bicyclists approaching the intersection on a parallel shared-use path. Turning motorists may not consider that bicyclists will be traveling off the road, yet in the right-of-way. When meeting a motorist, a bicyclist is often compelled to stop and yield to a left or right-turning vehicle. To account for these issues, the key is finding an appropriate balance by locating the crossing close enough to the intersection to allow adequate visibility, far enough away to allow sufficient motorist reaction time, yet not so far away that approaching vehicles are caught unaware of the crossing path. One-way paths at signalized intersections may increase visibility and safety, especially in regard to right-turning motorists and through-traveling bicyclists.

Table 5-10 recommends choosing a treatment for path/roadway intersections based on roadway speed and ADT, according to two different classes of crossing safety; "good" or "satisfactory." Choose the "good" crossing treatment if the path is used for trips to school, if a large number of users are children, seniors, or disabled people, or if the crossing point is heavily used at times of peak bicycle and pedestrian use. Also, choose the "good" crossing treatment if the roadway cross section is large or the bikeway is part of a main bike route, or if future land development is likely to result in a significant increase of bicycle traffic or motor vehicle traffic. The following table lists guidelines for intersection treatment recommendations; however, each intersection is unique and will require sound engineering judgment on a case by case basis.

Table 5-10: Recommended Bikeway Intersection Treatments

Motor Vehicle Speed	ADT	Bikeway Intersection Treatment
>80 km/h **(>50 mph)**	Any	Grade Separated (Good)
		Traffic Signal and 60 km/h **(40 mph)** Speed Zone (Satisfactory)
70 km/h **(45 mph)**	Any	Grade Separated (Good)
		Traffic Signals (Satisfactory)
60 km/h **(40 mph)**	>7,000	Grade Separated (Good)
		Traffic Signals (Satisfactory)
	<7,000	Traffic Signals (Good)
		Crosswalk + Median Refuge Island (Satisfactory)
50 km/h **(30 mph)**	>9,000	Grade Separated (Good)
		Traffic Signals (Satisfactory)
	5,000 to 9,000	Traffic Signals (Good)
		Crosswalk + Median Refuge Island (Satisfactory)
	<5,000	Crosswalk + Median Refuge Island (Good)
		Crosswalk (Satisfactory)

Consider the following when using Table 5-10 to select an intersection treatment:

- See Section 4-2.1 for discussion of motor vehicle speed.
- The type of crossing used for bicycle/pedestrian traffic at an intersection between a main road and secondary road is usually the same as for the main road.
- If the number of lanes to be crossed is greater than 3 in each direction, or the total intersection width is greater than 23 m **(75 ft)**, the intersection should have a pedestrian refuge or median island. Where bicyclists or pedestrians often wait at islands, a push button or bicycle-sensitive traffic detection device is desirable.
- At large intersections of very busy roads, rely on grade separation of pedestrian and bicycle traffic from both main and secondary roads, rather than signal controls
- If the speed limit along a section of road without traffic signals is greater than 60 km/h (40 mph) and it is not practical to provide a grade-separated crossing, reducing the speed limit to 60 km/h **(40 mph)** before the crossing, along with attention to signage and lighting, may be satisfactory.
- When choosing a location for a grade-separated crossing, pay special attention to ensure that ramp grades are minimized and that the location fits in well with the rest of the path network. Chapter 6 of this manual provides design guidelines for grade-separated crossings.

- At interchanges for motor vehicles, pedestrians and bicyclists may cross ramp terminals along minor roads and at diamond interchanges at grade; however, intersections with high volume of motorized traffic should be signalized.

5-4.3 Path/Roadway Intersection Design

FHWA provides the following general guidelines for at-grade intersections of shared-use paths with roads:

- The shared-use path should intersect the road at a 90-degree angle
- Increase path width at the intersection to reduce user conflicts
- Provide good sight lines for both motorists and path users
- Provide signage to alert motorists of the shared-use path crossing
- Provide a visible crosswalk across the intersection to increase path user and motorist awareness
- Signs, both on the road and the shared-use path, should clearly indicate whether motorists or path users have the right of way
- Curb ramps and detectable warnings are required to alert path users with vision impairments of the street crossing.

5-4.3.1 Crosswalk Width

A crosswalk is usually marked the same width as the shared-use path leading to it but never less than1.8 m **(6 ft)** wide. General guidance on crosswalk marking is provided in the MN MUTCD.

Figure 5-18: Mid-block refuge island crossing

5-4.3.2 Curbed Pedestrian Refuge Islands or Medians at Crosswalks

Pedestrian refuge islands allow pedestrians and bicyclists to cross one direction of driving lanes, rest, and assess when they are able to complete the street crossing. They provide a sense of security to pedestrians crossing busy streets with few gaps in traffic. Refuge islands are typically found at mid-block crossings, but are also acceptable to use at intersections. Refuge islands should be considered for path-roadway intersections where one or more of the following apply:

- High volumes of roadway traffic and/or speeds create unacceptable conditions for path users,
- The crossing will be used by a number of people with slow walking speed such as the elderly, schoolchildren, persons with disabilities, and others,

- The *Mn/DOT Road Design Manual* (Chapter 11) recommends pedestrian median islands at intersections wider than 23 m **(75 ft)** or where a pedestrian walking 0.8 m/s **(2.5 ft/s)** cannot cross a street completely in one green signal cycle.
- Mid-block or intersections where there are limited gaps in traffic.

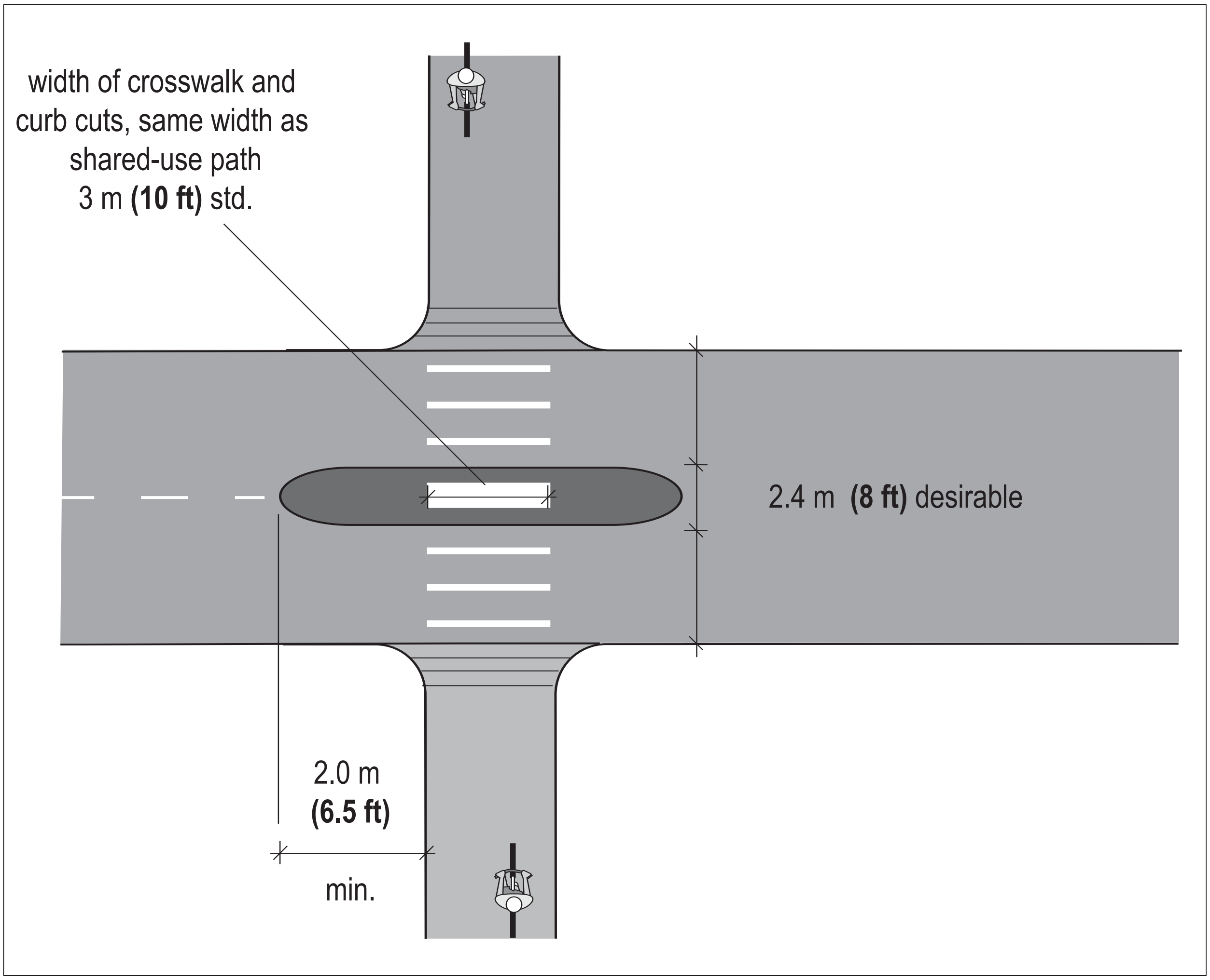


Figure 5-19:
Refuge Island in Crosswalk

Any raised islands in crossings shall be cut through level with the street, or have curb ramps at both sides (to comply with the ADA) and a level area at least 1.2 m **(4 ft)** long between the curb ramps. Refuge islands should be a minimum of 2.4 m **(8 ft)** wide when they will be used by bicyclists. In addition, the refuge island should be at least 2.0 m **(6.5 ft)** long on each side of the cut-through. Pedestrians and bicyclists should have a clear path on the island and not be obstructed by poles, sign posts, utility boxes, etc. The desirable width of the island and the width of the crosswwalk at the island are illustrated in Figure 5-19.

5-4.3.3 Curb Ramp Design and Arrangements

Use curb ramps at every intersection between a shared-use path and a roadway. If the approaching path is perpendicular to the curb, the width of the curb ramp should be at least as wide as the average width of the shared-use path. If the path is parallel to the curb, the width of the curb ramp should equal the path width or 2.7 m **(9 ft)** whichever is greater.

If a crossing or crosswalk is intended for bicyclists, the curb ramp or sloping pavement should be flush with the street. The slope of the curb ramp shall be no greater than 8.3 percent (12:1), and the slope of the curb ramp flares should be no greater than 10 percent (10:1).

Curb ramps shall include a 0.6 m **(2.0 ft)** wide strip of detectable warnings at their base to ensure that path users with vision impairments are aware of the intersection, according to the Americans with Disabilities Act Accessibility Guidelines (ADAAG). According to ADAAG and Mn/DOT Standard Plate 7036, detectable warnings should consist of raised truncated domes that meet the following specifications:

- Bottom diameter 23 mm **(0.9 in)** to 36 mm **(1.4 in)**
- Top diameter 50 to 65 percent of base diameter
- Height of 5 mm **(0.2 in)**
- Center-to-center spacing of 41 to 61 mm **(1.6 to 2.4 in)**
- A color contrasting with adjacent pavement, either light on dark or dark on light, which can help all path users to locate the curb on the opposite corner as well as provide visual cue of the truncated dome strip.

Other detectable surfaces, such as aggregate and grooves, are less detectable and less easily understood by people with vision impairments. ADAAG specifies truncated domes over rounded domes because they provide greater access to people with mobility impairments.

Example of swing-down bollard to allow emergency and maintenance vehicle access

Too many bollards inhibit path access.

Figure 5-20: Bollards

5-4.3.4 Controlling Motor Vehicle Access

A good method of controlling access onto a path by motor vehicles is to split the entry into two one-way sections of path, each 1.5 m **(5 ft)** wide, separated by low landscaping or other material. Emergency vehicles can still enter if necessary by straddling the landscaping. In most situations, this is preferable to bollards, chicanes, or other methods.

A bollard may also be used at the entrance to a bicycle path. See Figure 5-20. When used, a single bollard may be installed in the middle of the path to deny access to motor vehicles. Removable or hinged flexible bollards are recommended so service vehicles can use the path. When more than one bollard is used, there should always be one in the center of the path, and bollards on both edges, 1.5 m **(5 ft)** from the center bollard. This spacing will accommodate any type of bicycle or wheelchair.

Figure 5-21:
Gates across a bicycle path (not recommended)

Gates and other devices that require path users to maneuver around objects are strongly discouraged. See Figure 5-21.

5-4.3.5 One-Way Paths and Signalized Intersections

One-way paths have the advantage of increased visibility and safety at signalized intersections. Where there are substantial numbers of right-turning motorists and through bicyclists, the one-way path intersection design shown in Figure 5-22 should be considered. End the one-way path 20 to 30 m **(65 to 100 ft)** before the intersection and let bicyclists continue on a bicycle lane in the roadway.

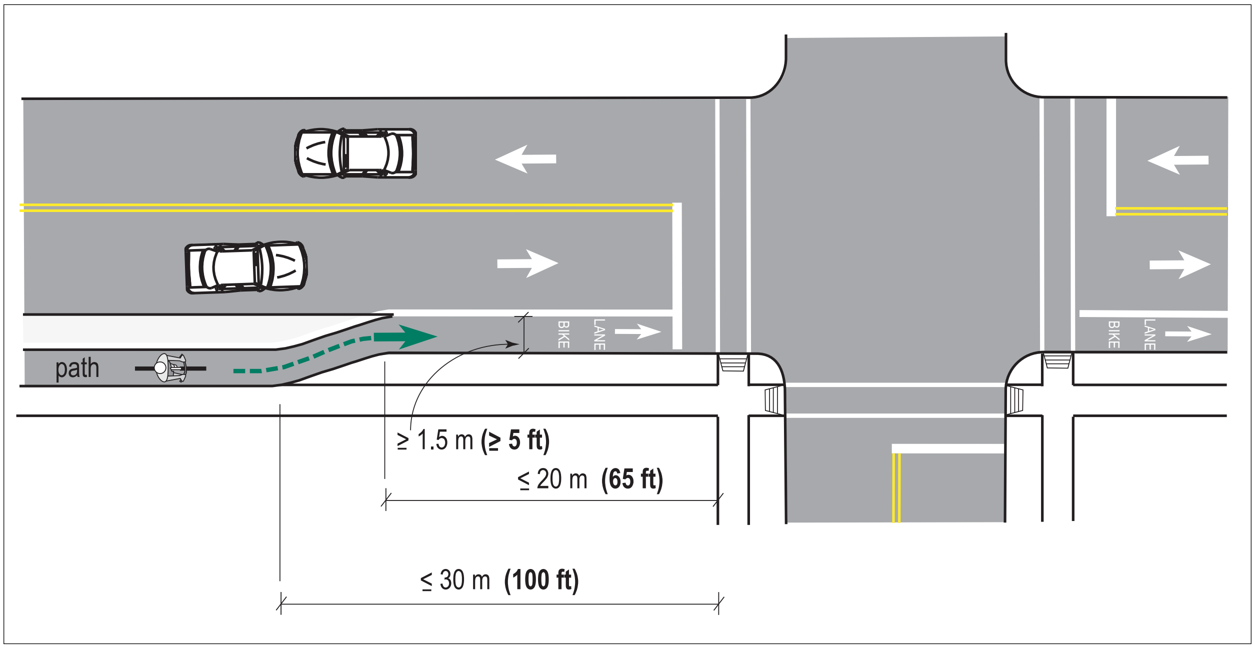


Figure 5-22:
One-Way Path Approaching Intersection

The use of recessed stop lines with the path continuing to the intersection may also be of benefit in reducing conflicts and accidents between right-turning motorists and through bicyclists, especially at the beginning of the green phase.

5-4.3.6 Intersections Without Signals

A path that parallels the roadway should be brought into the intersection to function like a crosswalk, as shown in Figure 5-23(A) or 5-23(B). There should be a marked crosswalk across every leg of an intersection where there is a continuous bicycle route. The alignment of a route and the location of the crosswalk at an intersection depend on the type of intersection and the separation technique. If the crosswalk is positioned immediately adjacent to the traveled way, bicyclists and motor-vehicle traffic have good views of each other. This is usually preferred.

A crosswalk not adjacent to the traveled way should be at least 30 m **(100 ft)** away to allow several vehicles to queue at the intersection without blocking the crosswalk. See Figure 5-23 C.

When a pedestrian refuge island exists at the intersecting street, the minimum setback distance for the crosswalk is usually 6 m **(20 ft)**.

If the bicycle route is only on one side of the road, signs may indicate where a crosswalk carries bicycle and pedestrian traffic across the main road and where crossing is restricted at the intersection. In the case of a connecting road, the crosswalk may be extended (by way of a sidewalk or path) over the connecting road so that pedestrian and bicycle traffic will be effectively guided onto the crosswalk.

5-4.3.7 At-Grade Roadway Crossings Not at an Intersection

This section discusses special considerations where a shared-use path crosses a road or highway independently of any crossroad. There is some evidence of high accident experience in isolated at-grade intersections of independent bikeways with motor vehicle roadways. This appears to stem from among the following factors:

- High motor vehicle operating speeds
- Insufficient sight distance
- Poor perception of, or reaction to, crossing signs and markings
- Motorists' expectation of entries to the crossing at pedestrian speeds rather than at typical bicycle traffic speeds
- Bicyclists' disobedience of stop or yield controls.

Independent path crossings of roadways merit particular attention to design detail, including the following.

- Provide proper sight clearances. Sight clearance assessment must consider obstructions due to roadway cross section profile (steep cuts or fills) as well as obstructions such as foliage.
- Locate the crossing a minimum of 76 m **(250 ft)** from any roadway intersection. According to AASHTO, vehicular movements at a bikeway-roadway intersection away

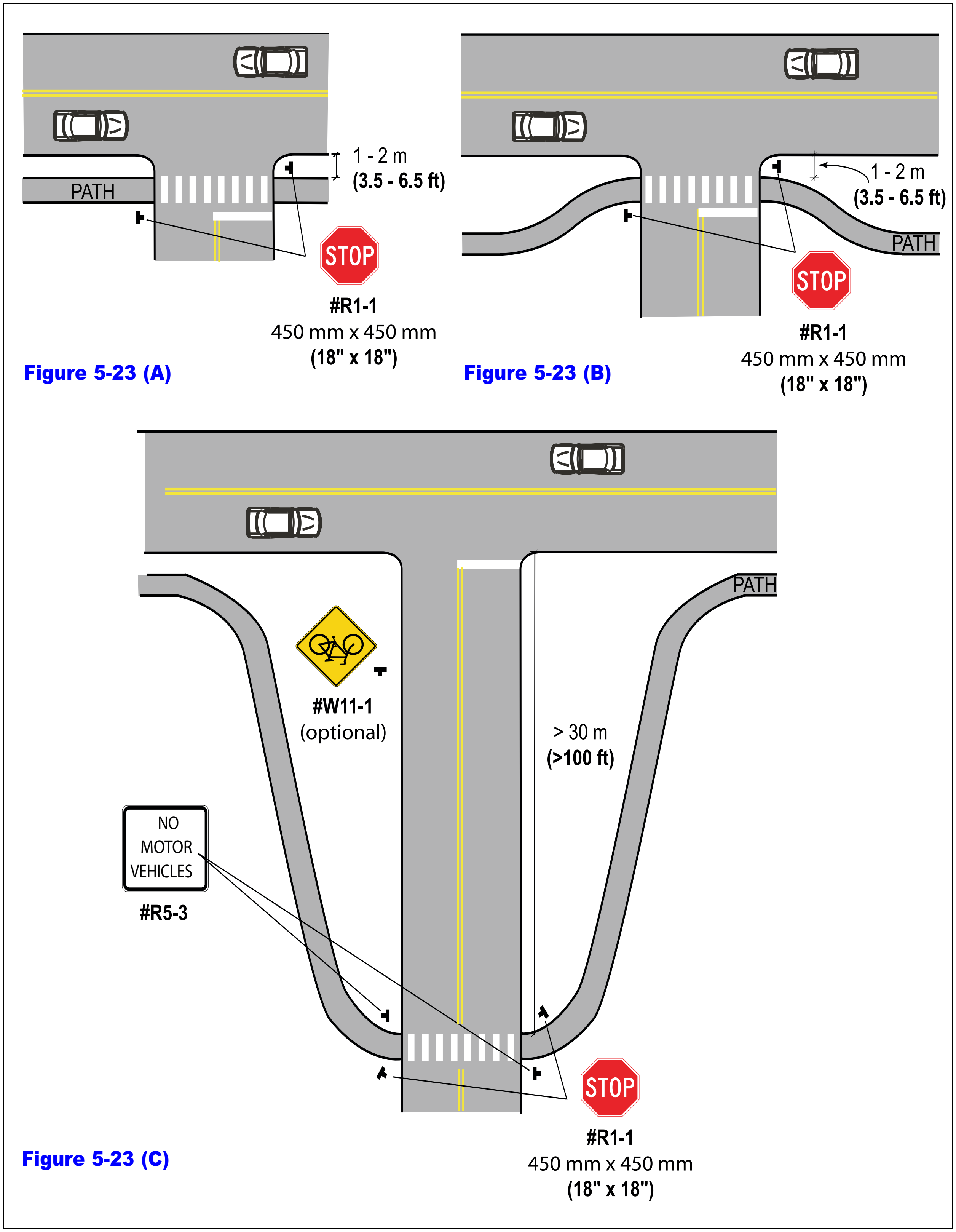


Figure 5-23 (A)

Figure 5-23 (B)

Figure 5-23 (C)

Figure 5-23:
Routing Two-Way Path Intersections with a Main Road

from a roadway-roadway intersection are more easily controlled through the application of standard traffic control devices and normal rules of the road.

- Align the crossing to intersect the motor vehicle roadway at right angles.
- Raise the crossing, and/or mark it with "zebra" or continental pavement markings, and/or a flashing warning light. "Bike Xing" signs should be placed 76 to 242 m **(250 ft to 800 ft)** in advance of motor vehicle approaches, with specific location depending upon roadway speed limit and proximity to adjacent intersections. Refer to the MN MUTCD).
- Place "Stop Ahead" or "Yield Ahead" signs on the bikeway approach approximately 45 m **(150 ft)** in advance of the crossing, or farther if a downhill approach may encourage bicycle speeds in excess of 30 km/h **(20 mph)**.
- Consider separating the crossing by grade with a bridge or underpass if a safe at-grade crossing can't be provided.

Sight distance requirements for an intersection between bicycle and motor vehicle traffic are shown in Figure 5-24. This diagram gives setback distances to enable a vehicle on the roadway to adjust its speed as it approaches the path crossing.

Example:

Given: Motor vehicle (A) traveling 80 km/h **(50 mph)** approaches the path.

Find: Required clear line of sight between motor vehicle A and bicyclist B

Solution: From the following chart (See Table 5-10), the driver of a motor vehicle traveling at 80 km/h **(50 mph)** should see a bicyclist who is 26 m **(85 ft)** from the lane edge, while being a minimum of 70 m **(220 ft)** from the intersection.

Table 5-10M: Distance Traveled in 3 Seconds (Metric)

Vehicular Speed	50 km/h	60 km/h	70 km/h	80 km/h	90 km/h	100 km/h	110 km/h
Distance	42 m	50 m	58 m	67 m	75 m	83 m	92 m

Table 5-10: Distance Traveled in 3 Seconds (English)

Vehicular Speed	30 mph	40 mph	45 mph	50 mph	55 mph	60 mph	70 mph
Distance	132 ft	176 ft	198 ft	220 ft	242 ft	264 ft	308 ft

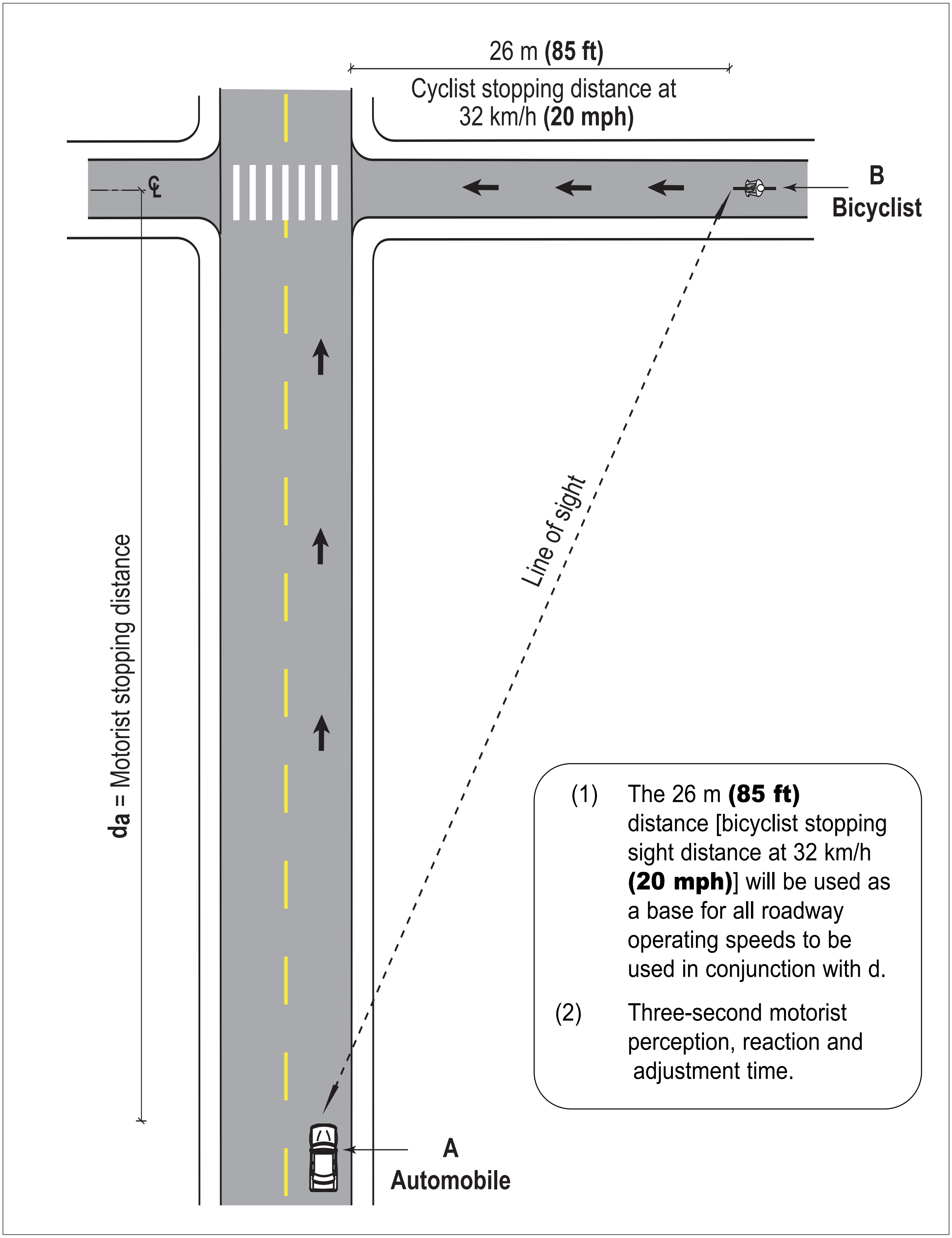


Figure 5-24:
Sight Distance for Motorist at Roadway/Path Intersection

5-4.3.8 Paths and At-Grade Railroad Crossings

When a shared-use path crosses railroad tracks, special care must be taken to ensure the safety of bicyclists. Whenever practical, the crossing should be straight and at right angles to the rails. The more the crossing deviates from 90 degrees, the greater the potential is for a bicyclist's front wheel to be trapped in the flangeway (the open space next to the rail), causing loss of control. When it is not practical to cross at 90 degrees, the path should be widened (at least as wide as the approach bikeway) to allow the bicyclist to cross as close to 90 degrees as practical. Refer to Figure 4-31 and Section 4-4.10 in the previous chapter.

5-5.0 Pavement Structure

The structural section of a path should be designed with consideration given to the quality of the subsoil and anticipated loads. Principal loads will normally be from maintenance and emergency vehicles. These vehicles should be restricted to axle loads of less than 3.5 or 4.5 metric ton **(4.0 or 5.0 ton, English)**, especially in spring.

Subgrade and surfacing recommendations should be requested from or reviewed by a materials or soils engineer, and included in the project's soils letter or other design documentation.

5-5.1 Subgrade Preparation

Prior to designing the pavement structure, soil and drainage conditions should be investigated, so any unstable or otherwise unsuitable soil conditions can be corrected. Establishing a suitable foundation for the pavement is essential and should include:

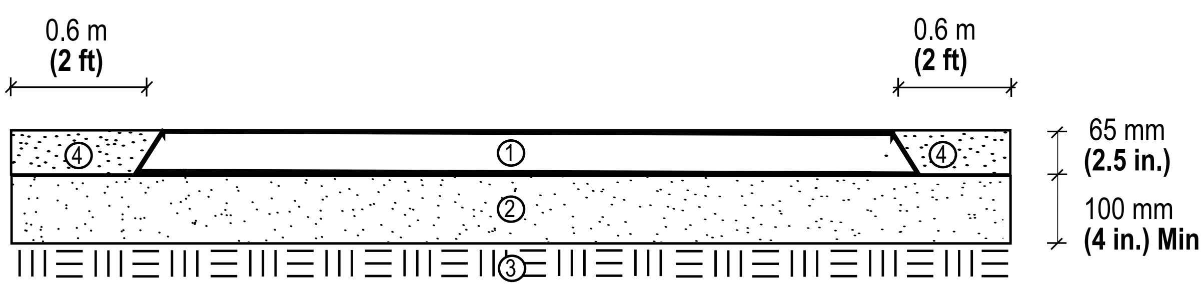
- Removing all vegetation, topsoil, silty soil and other soils that are considered unsuitable by the engineer. Any tree roots encountered under the path alignment should be removed to the maximum extent practical. Treating tree roots with appropriate herbicides is a good practice to prevent regrowth. (Herbicides should be applied only by licensed personnel.) Vegetation and root removal should extend laterally to the edge of the path, including any shoulder area, and to a minimum depth of 0.3 m **(1 ft)**.
- Removing organic soils from the bed of the trail, and stockpiling them for use as topsoil in turf or other plant establishment areas. Use excess organic or other unsuitable soils for slope flattening.
- Providing subgrade preparation in accordance with Mn/DOT Spec. 2112. Provide subcut corrections as determined by the Engineer. Soils should be scarified to a depth of 200 mm **(8 in)**. If the path is on a railroad embankment, a 0.3 m **(1 ft)** subcut is recommended.
- Constructing the path at least 0.3 m **(1 ft)** above the 100-year high-water level.
- Placing a geotextile fabric on unstable soils if determined appropriate by the Engineer. After placement, geotextile fabric should be covered with a minimum of 0.3 m **(1 ft)** of select granular borrow.

- Stabilizing granular subgrades, if necessary, by incorporating stabilizing aggregate (*Mn/DOT 3149.2C*) into the upper portion of the subgrade in order to achieve adequate surface stability.
- For further details, see Chapter 5 of the Minnesota DNR *Trail Planning, Design and Development Guidelines.*

5-5.2 Bituminous Structural Section

Preferred shared-use path surfacing is bituminous Type LV 4 Wearing Course Mixture, LVWE45030, 65 mm**(2.5 in)** thick, with an aggregate base. This mix requires no crushing, 100 percent passing the 12.5 mm **(1/2 in)** sieve, 50 blow Marshall density, 3 percent air voids, and a PG58-28 binder. (PG 52-34 may also be used.) Full-depth bituminous may be considered where subgrade soils are granular. It may be necessary to increase the pavement thickness shown below where numerous heavy vehicles use or cross the path (at driveways, for example). The aggregate base should be increased to 150 mm **(6 in)** in heavy soils (Clays - A-7-6) where maintenance and emergency vehicles may cause pavement damage. Aggregate base thickness may be reduced to 75 mm **(3 in)** for granular subgrade soils (less than 20 percent passing 75 micrometer sieve). See Figure 5-25. For further details consult the Minnesota DNR *Trail Planning, Design and Development Guidelines.*

On projects where a path is constructed at the same time as a roadway, it is practical to construct the path using the bituminous wearing course specified for the road surface.



① 65 mm **(2.5 in.)** Type LV4 wearing course mixture (LVWE 45030), edges tamped at 45 degrees

② 100 mm **(4 in.)** Min., Class 5 aggregate base.

③ Compacted subgrade. Refer to foundation preparation.

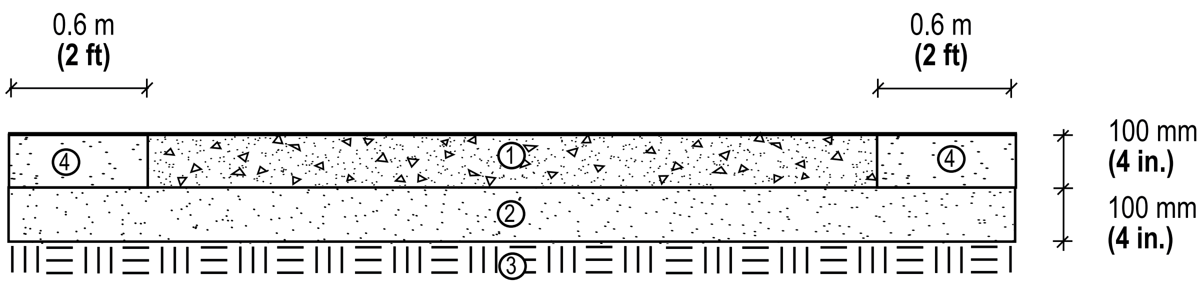
④ Class 5 aggregate, turf shoulder or concrete shoulder

Figure 5-25:
Bituminous Structural Section

5-5.3 Concrete Structural Section

Portland cement concrete (3A32 mix - 3900 psi, 0.5 Cement-Void ratios with 6.5 percent air entrainment) offers good rolling resistance characteristics, durable surface cohesion, and easy maintenance. See Figure 5-26, Concrete Structural Section. A thicker paving section may be required where heavy vehicles use or cross the path. The design engineer should evaluate each crossing location and increase the thickness if appropriate.

Causes of concrete pavement failures on shared-use paths include intrusion by large tree roots causing panel vertical displacement, poor foundation soils, or heavy vehicles (construction or maintenance equipment) in excess of pavement design load.



1 100 mm **(4 in.)** PCC with joints spaces at 2.4 m **(8 ft)**

2 100 mm **(4 in.)**, sand** (3149.B). ** if paved with slip form paver, use class 5 aggregate base

3 Compacted subgrade. Refer to foundation preparation.

4 Class 5 aggregate or turf shoulder.

Figure 5-26:
Concrete Structural Section

Concrete Pavement Recommendations for Shared-Use Paths

Materials:

1. Concrete mix Mn/DOT 3A32 per Mn/DOT Std. Spec. 2461.3 or as otherwise determined by the engineer (Mn/DOT Std. Spec. 2521)

2. Class 5 Aggregate base (Mn/DOT Technical Memorandum 04-19-MAT-02)
   a. 3 inches (min.) of compacted Class 5 base on granular subgrade
   b. 5 inches (min.) of compacted Class 5 base on non-granular subgrade
   c. Subgrade soil correction, if deemed necessary by engineer

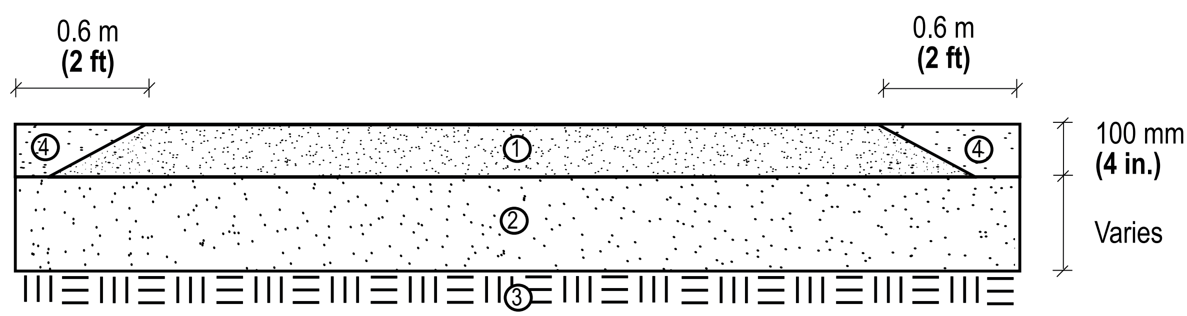
Installation:

1. Machine-installed concrete for consistent pavement smoothness (desirable). (If manually installed, ensure excess material during screening to avoid “bird bath” sags in panel centers)

2. Install concrete in accordance with Mn/DOT Std. Spec. 2301 or 2521, with the following recommended special provisions:
   a. Broom finish
   b. No longitudinal joints
   c. Transverse joints spaced at approximately 10 - 15 foot intervals
   d. Contraction joints installed by saw-cut for pavement smoothness
   e. Expansion joint installation:
      i. Vertical mis-alignment of adjacent panels; 3/16 inch (maximum)
      ii. Approximately 500-foot interval (maximum spacing)
      iii. Install expansion joints at all construction joints
      iv. Where new pavement will join existing pavement, saw cut existing pavement to create smooth vertical surface, use preformed expansion joint filler

5-5.4 Aggregate Structural Section

Aggregate structural surfaces, such as crushed limestone, may be used where few formal traffic control measures are necessary, or in natural settings. Crushed limestone is easy to repair, does not crack, and generally provides a comfortable riding surface. It also visually integrates into natural settings. However, crushed limestone loses its cohesion over time, thus increasing the risk of bicycle skidding. It is also subject to erosion and to encroachment by vegetation. In dry weather, rising dust may damage bicycle mechanisms and make riding unpleasant. Grades steeper than 3 percent should not be surfaced with crushed limestone because the surface will not provide sufficient traction. Periodically, a limestone path will need to be graded to fill ruts and depressions and to maintain surface drainage. To accommodate users with disabilities, use Mn/DOT Spec 3138 Class 2 aggregate modified to 100 percent passing the 9.5 mm **(3/8 in)** sieve. See Figure 5-27.



GRANULAR SUBGRADE

① 100 mm **(4 in.)** aggregate surfacing, class 2 (Specify limestone or dolomite).

② N/A

③ Compacted subgrade. Refer to foundation preparation.

NON-GRANULAR SUBGRADE

① 100 mm **(4 in.)** aggregate surfacing class 2 (specify limestone or dolomite).

② 100 mm **(4 in.)** class 5 aggregate base
-- or --
125 mm **(5 in.)** class 3 aggregate base
-- or --
200 mm **(8 in.)** select granular (3149.2B)

③ N/A

④ Class 2 or 5 aggregate or turf shoulder.

Figure 5-27:
Aggregate Structural Section

5-5.5 Surface Smoothness and Maintenance

It is important to construct and maintain a smooth riding surface both for safety and to extend the life of the path. Consult with a District materials or soils engineer for recommendations on proper materials and construction.

Path surfaces tend to oxidize more rapidly than a highway. The use of surface treatments may help lengthen pavement life by slowing this process. Recommended treatments are listed in Table 5-11, based on the relative degree of path deterioration. Note that it is best to consider treatments at very early stages of deterioration.

Table 5-11 Treatment of Deteriorated Surfaces

Surface Deterioration	Recommended Treatment
Slight*	Fog seal (Mn/DOT 2355)
Moderate (Slight Raveling)*	Seal coat (Mn/DOT 2356, FA1 or FA2) or Slurry seal Type 1
Serious*	Overlay 25 mm (1 inch min.)
Cracks	Crack seal - No overband (use Mn/DOT 3719 or 3723)

- Localized areas that are seriously deteriorated should be reconstructed prior to application of the seal and/or placement of the overlay. To provide for safe bicycling during seal coating, sand-type aggregate (FA1 or FA2) only should be used, signs should be provided warning of loose sand, and the excess aggregate should be removed as soon as possible. If possible, provide an alternate route. Also, cracks should not be overbanded with sealant. Pavement overlay design through tunnels and underpasses must maintain required vertical clearance as discussed in this manual and the Mn/DOT RDM.

For additional information, see Surface Quality Smoothness and Utility Work guidelines in Chapter 9 of this manual.

5-6.0 Drainage

On paths, a cross-slope of 2 percent is recommended for proper drainage. Sloping to one side usually simplifies longitudinal drainage design and surface construction, and is the preferred practice. Ordinarily, surface drainage from the path will be adequately dissipated as it flows down gently sloping terrain. When a path is constructed on the side of a hill, a drainage ditch of suitable dimensions will be necessary on the uphill side to intercept the hillside

Figure 5-28: Path drainage design example

drainage, as illustrated in Figure 5-28. Culverts or bridges should be used where a path crosses a drainage channel. Sizing of the required waterway opening should be determined by a hydraulics engineer. Typical minimum culvert size used for bikeway drainage is 450 mm **(18 in**) in diameter.

Drainage inlet grates shall have openings sufficiently narrow and short to prevent bicycle tires from dropping into the grates, regardless of the direction of bicycle travel. Where it is not immediately feasible to replace existing grates with standard grates designed for bicycles, 25 mm by 6mm **(1 in by 0.25 in)** steel cross straps should be welded to the grates at a spacing of 100 mm **(4 in)** to reduce the size of the openings. Figure 5-29 illustrates both a bicycle-unsafe and a bicycle-safe drainage grate.

Grates with a gap between the frame and the grate, or with slots parallel to the roadway, can trap the wheel of a bicycle resulting in a loss of control. To prevent this, drainage inlet grates and utility covers should be installed flush or adjusted flush to the adjacent pavement surface.

Example of bicycle unsafe grate with openings parallel to direction of travel

Example of grate that will not catch a bicyclist's wheel.

Figure 5-29:
Drainage Grates

5-7.0 Traffic Barriers, Railings and Fences

In order to maintain safety for bicyclists and pedestrians, potential encroachments by motorists should be minimized. Barriers may be a hazard and should not be used as a substitute for proper design. Channelization fences may be used to direct bicycle traffic, divide it into streams, or eliminate the risk of conflict between bicyclists and pedestrians. See Section 5-3.1, 5-3.6.2 and Section 6-2.0 of this manual for additional guidance.

5-8.0 Lighting

Lighting for shared-use paths should be considered wherever low light or night usage is expected, including areas serving college students or commuters and at highway intersections. Fixed-source lighting, as shown in Figure 5-30, reduces crashes along shared-use paths and at intersections, and allows the bicyclist to see the path direction, surface condition, and obstacles.

Figure 5-30: Example of fixed-source lighting

Roadways, bikeways, and walkways may be illuminated in accordance with recommended design values in the *Mn/DOT Roadway Lighting Design Manual*. Lighting off-road walkways and bikeways permits some freedom in system and luminaire design. The designer should provide light quality that fits site needs and meets recommendations.

The lighting system as a whole should provide adequate horizontal and vertical illumination along the entire length and width of the bikeway, without significant variations in luminous intensity (dark or bright spots) to which bicyclists and motorists might experience difficulty adjusting. Horizontal illumination, measured at pavement level, enables bicyclists to read pavement markings and to be able to easily follow the bikeway. Vertical lighting, measured 1.8 m **(6 ft)** above the pavement, is most effective for illuminating bicyclists and obstacles.

To avoid sharp differences in brightness, the uniformity ratio of illumination is determined by dividing the average illumination level by the minimum illumination level.

At intersections, illuminating the path for 25 m **(75 ft)** on either side is desirable. Transitional lighting is recommended on an unlit street crossed by the path.

See Table 5-12 for recommended bikeway/walkway illumination levels. These represent average maintained luminance levels and should be considered minimums, particularly when security or the ability to identify path users from a distance is important. The table is for bikeways that are straight and level or have only minor curves and grade changes. In areas of visibility problems or where complex maneuvering may be required (abrupt curves, grades, intersections, interchanges, overpasses, and underpasses, for example), special consideration is necessary. Crosswalks traversing roadways in the middle of long blocks and at street intersections should receive additional illumination. Lighting should be placed wherever there is signage (especially warning signs) and accessible electricity.

Light poles must meet recommended horizontal and vertical clearances as outlined for other obstructions along the path. Luminaries and poles should be at a scale appropriate for a shared-use path.

Table 5-12:

Minimum Average Maintained Illumination (Eh) and Maximum Uniformity Ratios by Facility Classification and Pavement Classification

Roadway and Walkway Classification		R1		R2 & R3		R4		Uniformity (avg/min)
		Foot-candles	Lux	Foot-candles	Lux	Foot-candles	Lux	
Sidewalks	Commercial	0.9	10	1.3	14	1.2	13	3:1
	Intermediate	0.6	6	0.8	9	0.7	8	4:1
	Residential	0.3	3	0.4	4	0.4	4	6:1
Pedestrian Ways and Bicycle Lanes		1.4	15	2.0	22	1.8	19	3:1

Notes:

R1 = cement/concrete

R2 = asphalt/gravel & R3 = asphalt/rough texture (typical highway)

R4 = asphalt/smooth texture

Source: *Mn/DOT Roadway Lighting Design Manual* (2004); Section 4.1.1.3

Chapter 6: Bridges, Over/Underpasses, Rest Areas and Shuttle Sites

6-1.0 Introduction

This chapter provides guidelines for planning and designing bikeways on bridges used by vehicular traffic, bicycle and pedestrian overpasses and underpasses, and bicycle accommodations at rest areas and scenic overlooks. The chapter concludes with a discussion of bus or van shuttles across barriers to bicycle and pedestrian movement.

6-2.0 General Considerations

Bridges provide essential links for bicyclists and pedestrians. Understanding the future transportation demand, including bicycle and pedestrian modes, is an important step in life cycle planning of bridges, which are typically reconstructed less frequently than connecting roadways.

Bridges and interchanges on major highways are investments of public funds that are often expected to result in new development and significant growth in travel demand. Designed and constructed to last fifty years or more, bridges on or across highways should be planned, designed and constructed with pedestrian and bicycle facilities appropriate for future development patterns. For bridges in urban areas or other areas that are likely to see increased development, this may require additional width and accommodations for bicycles and pedestrian modes of travel on or under a bridge. In areas with low population density, where development is unlikely, bicycles and pedestrians would be reasonably accommodated by current design standards for bridge shoulders. Current bicycle and pedestrian demand may not be a reasonable basis for planning and design of a bridge that will remain in service for 50 years after construction, or up to 70 years after the time the bridge is planned.

The determination to provide a grade-separated crossing for bicycles and pedestrians should be analyzed on a case-by-case basis. Analysis is based upon expected bicycle/pedestrian traffic volume, latent demand for bicycle/pedestrian facilities, safety hazards, existing and desired bicycle/pedestrian routing, motor vehicle speeds and volume, and other factors listed in Chapter 4 of this manual. Table 5-12 in Chapter 5 provides guidelines for conditions where a grade-separated bikeway crossing is warranted, but additional factors should be considered based on existing conditions and the community.

Determining the appropriate type of grade-separated crossing for bicycles and pedestrians depends on practicality at an individual site. Topography, right-of-way limits, and other constraints may dictate whether an underpass or overpass is more appropriate.

6-3.0 Highway Bridges with Bikeways

Bridge structures should be coordinated with approaching bikeways so that facilities are compatible and continuous, with a smooth transition from the bikeway pavement to bridge abutment. On all bridge decks, bicycle-safe expansion joints should be used (as close to 90 degrees to the direction of travel as possible, with small gaps and non-skid plates). Many expansion joints and plates currently in use are very slippery, especially when wet. As a safety consideration, materials should be evaluated for bicycle traction under wet conditions.

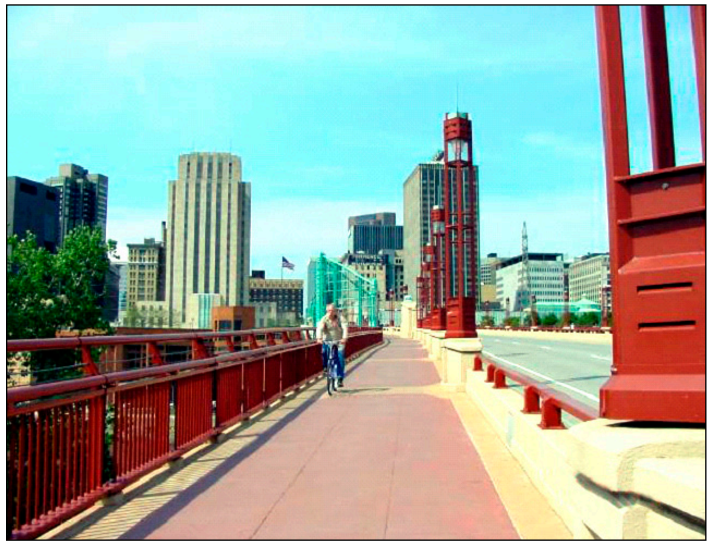


Figure 6-1:

Example of accommodating bicycle and pedestrian traffic along a bridge adjacent to highway traffic

Where future demand for a bikeway is anticipated, even if current bicycle use is minimal, new highway bridges and bridge rehabilitation should be planned, designed, and constructed with sufficient width to accommodate bicycle and pedestrian traffic. Bicyclists on highway bridges can be accommodated with a separated bike path, shoulders, bike lanes, wide curb lanes, or sidewalks. However, sidewalks are not preferred for bicycle use, for reasons discussed in Section 5-1. Sidewalks, bikeways, and paved shoulders all shall have a minimum cross slope of 1 percent for drainage, but as required by the ADA, no more than 2 percent for the safety of those with mobility impairments.

On highways with high-speed, high-volume vehicle traffic, an off-road path is typically the best design to accommodate bicycle and pedestrian traffic. Where an off-road bikeway is carried across a highway bridge, the bikeway width on the bridge should be the same as the approaching shared-use path, plus an additional 0.6 m **(2 ft)** clear width, up to a maximum width of 4.2 m **(14 ft)**. However, for certain types of bridge structures 3.6 m **(12 ft)** may be a practical maximum width based on cost. Carrying the clear width across the structure provides minimum horizontal shy distance from the railing or barrier and offers maneuvering space to allow bicyclists to avoid conflicts with other users.

Interchange bridges require careful planning and design to accommodate bicyclists. Each situation should be evaluated to consider vehicle speed and volume, signals, bicycle approach geometrics, bicyclist and pedestrian needs, maintenance, and type of interchange.

- The bike lane may be carried all the way across the bridge adjacent to a through lane, or
- The bicycle lane may be placed to the right of a turn lane to a point where the bicyclist can cross the ramp lane at a right angle and continue across the bridge.

- If a wide curb lane on the approach roadway is used to accommodate bicyclists, the extra width should be carried across the bridge in a through lane.
- Where bicycles are legal on both roads, a bicycle lane, wide curb lane, or paved shoulder should be included on the ramps, as well as across and under the bridge.

If there is not a designated bicycle or pedestrian facility on a highway bridge, paved shoulders should be provided to accommodate one-way bicycle travel on each side of the bridge. When shoulders are intended to facilitate bicycle traffic, a minimum of 1.5 m **(5 ft)** clear width should be provided. Use Table 4-2 and the other factors listed in Chapter 4 to determine if wider shoulders are warranted based upon vehicle traffic volume and speed.

Unless bicycles are prohibited by law from using the shoulder of a roadway, the shoulder surface should be as smooth as the travel lanes on the bridge. Rumble strips are not used on bridge shoulders.

6-3.1 Retrofitting Bikeways on Existing Highway Bridges

On many existing highway bridges, it is possible to use retrofits to accommodate bicyclists and pedestrians. Certain bridge features, however, restrict bicycle access, create unfavorable conditions for bicyclists, and make retrofitting difficult. These features include bridge width narrower than the approach roadway (especially where combined with relatively steep grades), open grated metal decks, low railings or parapets, and certain types of expansion joints, such as finger-type joints, that can cause steering difficulties. These restrictions may be overcome by adding width during reconstruction, creating a bike lane by filling open grating with lightweight concrete, modifying railings, or adding a steel plate or elastomer filler to part of the joint. If a stairway is the only feasible way to connect a shared-use path to a bikeway on an existing bridge, a bicycle wheel ramp should be included on the stairway to facilitate walking a bicycle up the stairs to the bridge.

Where a shared-use path is retrofitted onto a bridge, there are a large number of design variables to consider. The best bikeway design must be determined for each case, using a flexible approach to the design process. Several retrofit alternatives are suggested in this section.

Carry the shared-use path across the bridge on one side

This retrofit should be done where (1) the bridge facility will connect to a path at both ends, (2) sufficient width exists on that side of the bridge or can be obtained by narrowing or re-striping lanes, and (3) provisions are made to physically separate bicycle traffic from motor vehicle traffic. If approach bikeways are two-way, the bridge's bikeway facility should also be two-way.

An existing highway bridge over a barrier such as a roadway, railway, or waterway can be reconfigured to add bicycle facilities for connecting shared-use paths running parallel to and on opposite sides of the barrier. Where feasible, remove or reconfigure vehicle travel lanes to include a 3 m **(10 ft)** vehicle shoulder and a 3-3.6 m **(10-12 ft)** shared-use path. The shared-use path should be separated from vehicular traffic by a 1.2 m high **(4 ft)** barrier. This configuration is illustrated in Figure 6-2.

Provide wide curb lanes or bicycle lanes over the bridge

This retrofit is advisable where (1) the shared-use path transitions into bicycle lanes at one end of the bridge, (2) sufficient width exists or can be obtained by widening or re-striping, and (3) there is a separate sidewalk for pedestrians. This option should only be exercised if the bike lane or wide outside lane can be accessed without increasing the potential for wrong-way riding or inappropriate crossing movements.

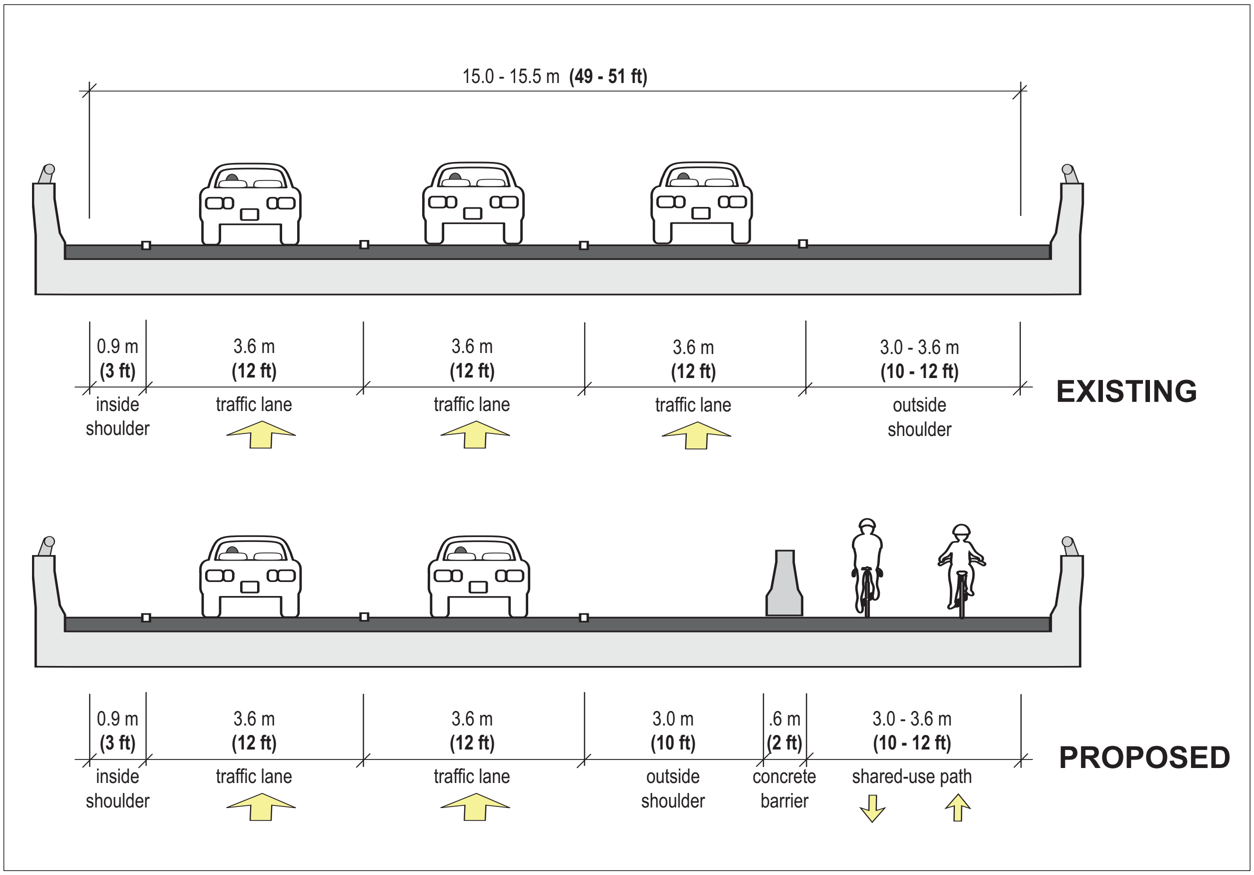


Figure 6-2:
Shared-Use Path on Bridge with Barrier Separation

Consider using the existing bridge sidewalks for bicycle traffic

This retrofit may be appropriate when the sidewalk is wide enough to accommodate bicyclists and pedestrians, particularly if the approach paths are one-way facilities. In general, however, the designated use of sidewalks (as a signed, shared facility) for bicycle travel is unsatisfactory, particularly if the sidewalk is raised and no railing exists between the sidewalk and traffic lanes. Remember, too, that employing extremely wide sidewalks does not necessarily increase safety, since wide sidewalks encourage higher bicycle speeds and increase potential conflicts with pedestrians and fixed objects.

Sidewalk bikeways should be considered only under certain limited circumstances where unfriendly bicycle and pedestrian elements exist. For example, they may be appropriate on long, narrow bridges where the rightmost travel lane is too narrow to accommodate both a cyclist and motor vehicle.

Sidewalk bikeways must be at least 2.4 m **(8 ft)** wide, and preferably 3 m **(10 ft)** or greater. Sidewalks should be modified to have adequate drainage and must be accessible to bicyclists and pedestrians, including those with mobility impairments. Signage warning cyclists of substandard bikeway conditions and a 1.4 m **(4.5 ft)** railing is required on the outside of the sidewalk.

Where necessary, curb cuts and flush ramps shall be installed at path approaches so that bicyclists are not subjected to the hazard of a vertical lip crossed at a flat angle. Curb cuts should have a minimum width of 2.4 m **(8 ft)** to accommodate tricycles for adults and two-wheeled bicycle trailers. A curb cut width of 1.8 m **(6 ft)**, which meets ADA minimum requirements, is not wide enough for bicycle traffic on a shared-use path.

6-3.2 Railings and Protective Screening on Bridges

A list of standard railing applications for barriers on combined (vehicle traffic and bicycle/pedestrian) bridges and bicycle/pedestrian bridges is provided in Table 13.2.1 of Chapter 13 (Railings) in the Mn/DOT *LRFD Bridge Design Manual (October 2003)*. That manual discusses three general classes of bridge railings or barriers:

- Traffic railings, designed to contain and redirect vehicles
- Bicycle/pedestrian railings, designed for pedestrian and bicyclist safety
- Combination railings, designed to contain bicycles as well as vehicles

Where a designated bikeway is constructed on a bridge, and motor vehicle speed is 45 mph or greater, a traffic barrier is required between the bikeway and the vehicle lanes, with a bicycle/pedestrian railing or combination railing on the outside edge of the bridge. The type of traffic barrier required will depend on the speed of vehicular traffic. Additional considerations in selecting barriers may include aesthetics, volume of vehicular traffic, and the expected amount of bicycle and pedestrian traffic.

On bridges with motor vehicle speeds of 40 mph or less, where a bikeway is on a raised sidewalk, or where a bicycle lane is striped on the roadway next to a raised sidewalk, a combination railing may be used on the outside edge of the bridge without a traffic barrier between the roadway and bikeway. The sidewalk curb height shall be 200 mm **(8 in)**. If there is no sidewalk, and the designated bikeway is at the same elevation as the roadway (bikeway on the shoulder), a traffic barrier or combination railing should be used between the roadway and the bikeway, with a bicycle/pedestrian railing or combination railing at the outside edge of the bridge.

Bicycle/pedestrian railings must be a minimum height of 1.4 m **(4.5 ft)**. For bridges over roadways, the opening between elements of a bicycle/pedestrian railing or combination railing shall not permit a 100 mm **(4 in)** sphere to pass through the lower 0.7 m **(27 in)** of the railing, and a 150 mm **(6 in)** sphere shall not pass through any opening above 0.7 m **(27 in)**.

Mn/DOT has developed a bicycle railing attachment to the Type F barrier for use when bridge shoulders carry a bicycle route. (See *Bridge Details Manual Part II*, Figure 5-397.158.) This railing may be applied to other traffic barriers where the same or greater offset distance to the face of metal rail is provided and the post attachment has the same or greater strength.

If the bridge is over a roadway or railroad, protective screening or fencing to a height of 1.8 to 2.4 m **(6 to 8 ft)** is required to prevent objects from being thrown onto the roadway below. Mn/DOT policy requires a protective screening system to be incorporated into the railing on new bridges, or when railings are replaced on existing bridges. The standard height for protective screening is 2.4 m **(8 ft)**. The protective screening shall not allow passage of objects greater than 150 mm **(6 in)**.

6-4.0 Bicycle and Pedestrian Overpasses

A shared-use bridge structure allows bicyclists and pedestrians to cross busy roadways, railways, or bodies of water to reach popular destinations. Preferred applications for bicycle/pedestrian overpasses include:

- Locations that would otherwise be difficult or impossible to cross (freeways, rivers, railroads, etc.)
- Connecting schools to neighborhoods over high-volume, high-speed arterial roadways where signalized crossings are more than 137.5 m **(450 ft)** apart
- When a reasonably direct on-road alignment is not available, or the direct on-road connection is perceived by the public to be unsafe
- When bicyclists and pedestrians would otherwise be required to negotiate a significant change in elevation

Figure 6-3:

Example of creative use of an overpass for non-motorized users

Overpass Characteristics

Positive:

- Good visibility from surrounding areas (greater sense of user safety)
- Good light during the day
- Open and airy

Negative:

- Typically requires greater elevation change than underpasses
- Open to the elements
- Downward speeds can be a safety hazard

- When vehicular bridges do not provide bicycle route continuity and directness.

The design of a bicycle and pedestrian overpass shall consider requirements for grade, turning radius, width, cross slope, and speed. In some cases, for the safety of all types of traffic, the bicycle design speed may need to be reduced from the approaching bikeway. The profile across a bridge should follow a smooth line with no sharp changes in grade over the piers.

To ensure the safety of users of all ability and skill level, bicycle and pedestrian overpasses should be designed in accordance with the *AASHTO Guide for the Development of Bicycle Facilities (1999),* the *AASHTO Standard Specifications for Highway Bridges* and the Mn/DOT *LRFD Bridge Design Manual*. ADA standards for accessible design are also applicable, but, for the most part, those have been incorporated into AASHTO standards, since accessible design benefits bicyclists and able-bodied pedestrians as well as those with mobility impairments.

The recommended minimum width of an overpass for bicyclists and pedestrians is 3.6 m **(12 ft)**, or the paved width of the approach path plus 0.6 m **(2 ft)**, whichever is greater. The desirable width of an overpass is the width of the approach path plus 1.2 m **(4 ft)**. The bridge width is measured from the face of handrail to face of handrail.

Carrying the clear areas across the structure provides necessary horizontal shy distance from the railing and provides maneuvering space to avoid conflicts with pedestrians and oncoming bicyclists. Access by emergency, patrol, and maintenance vehicles should be considered when establishing vertical and horizontal clearances. The path’s shoulder width should taper as necessary to match the overpass width (if applicable). Greater width may be appropriate in heavily traveled urban corridors, and near university campuses or near facilities that have pedestrian event-clearing peaks.

When physical constraints limit the width of a bicycle/pedestrian overpass, it may be necessary to provide a substandard width. In very rare instances, a reduced width of 2.4 m **(8 ft)** may used, but only where all of the following conditions occur:

- Bicycle traffic is expected to be low, even on peak days or during peak hours.
- Only occasional pedestrian use of the facility is expected.
- Horizontal and vertical alignment will provide safe and frequent passing opportunities.
- Normal maintenance vehicle loading conditions or widths will not exceed the bridge design parameters.
- State Aid funds are not being used on the project.

The vertical clearance from the pavement to any overhead object on an overpass shall be a minimum of 2.4 m **(8 ft)** for bicyclists, but 2.7 m **(10 ft)** vertical clearance may be appropriate to accommodate occasional maintenance or security vehicles using the overpass. The vertical clearance of the bottom of the overpass structure over a street or highway is typically at least 5.2 m **(17 ft)**, but requirements must be verified on a case-by-case basis.

The access ramps for bicycle/pedestrian overpasses must meet ADA design standards, for which the preferred maximum grade is 5 percent (20:1). However, grades up to 8.33 percent (12:1) are permitted if a platform 1.5 m **(5 ft)** long is provided between each 0.75 m **(2.5 ft)** change in elevation. A 1.8 m **(6 ft)** clear flat platform is to be provided at the bottom of each ramp.

Overpasses require railings for both bicyclists and pedestrians. The railing height for bicyclists shall be 1.4 m **(4.5 ft)** from the overpass deck, with a pedestrian handrail at a height of 1.1 m **(3.5 ft)**. Where a bicycle/pedestrian overpass crosses a roadway or railway, 2.4 m **(8 ft)** high protective screening shall be used to prevent objects from being thrown off the bridge. Refer to Section 6-3.2 for guidance on bicycle/pedestrian railings and protective screening.

Structures designed for pedestrian live loads are satisfactory for bicycles. The Mn/DOT *LRFD Bridge Design Manual* (Section 3.4.4, Pedestrian Live Load) specifies that bridges carrying only bicycle/pedestrian traffic should be designed with a live load intensity of 0.085 ksf. However, if maintenance and emergency vehicles may need access to the overpass, the structure must be designed for the vehicle load.

6-5.0 Bikeways Under Existing Bridge Structures

Highways, particularly freeways, can be significant barriers to bicycle and pedestrian movement. Many bridges can be retrofitted to provide a bicycle/pedestrian crossing under the barrier by creating a crossing where there are no bicycle or pedestrian accommodations, or by upgrading the existing bicycle/pedestrian crossing. Provide adequate lighting under structures, in tunnels, and at approaches.

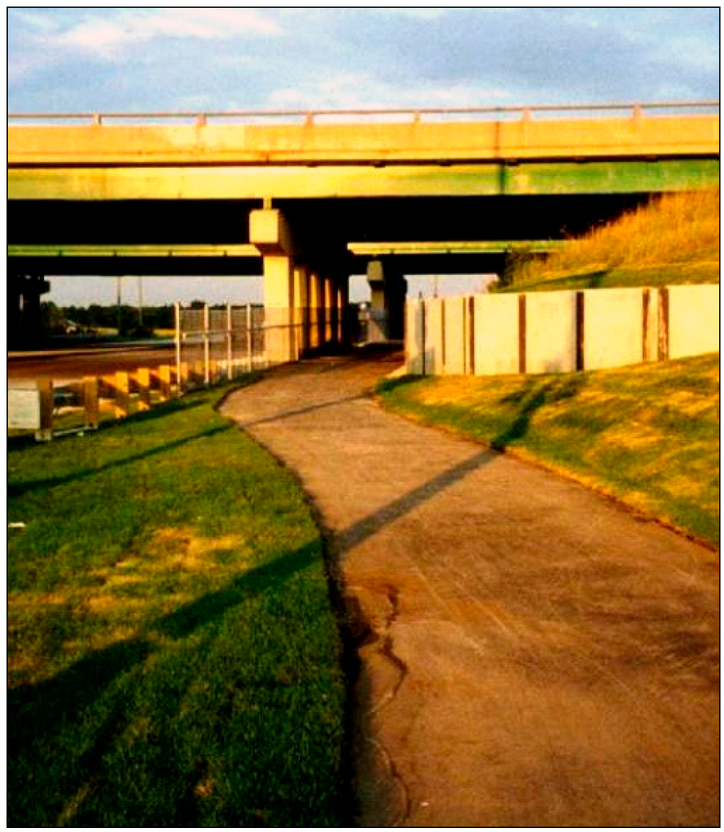


Figure 6-4:
Example of bikeway under an existing bridge structure

Figure 6-5 provides examples of locations, separations, and widths for modifying existing roadway facilities to accommodate a bikeway. The bikeway and/or sidewalk width should be continuous under the highway structure. It is preferred that bikeways have a width of 3 m **(10 ft)**, but a 2.4 m **(8 ft)** width may be allowable for short segments. Where access for emergency vehicles is necessary, vertical clearances shall be a minimum of 3 m **(10 ft)**. Where access for emergency vehicles is not needed, vertical clearances over the bikeway shall be a minimum of 2.4 m **(8 ft)**. A full engineering and design analysis is required for every proposed bikeway under an existing bridge structure.

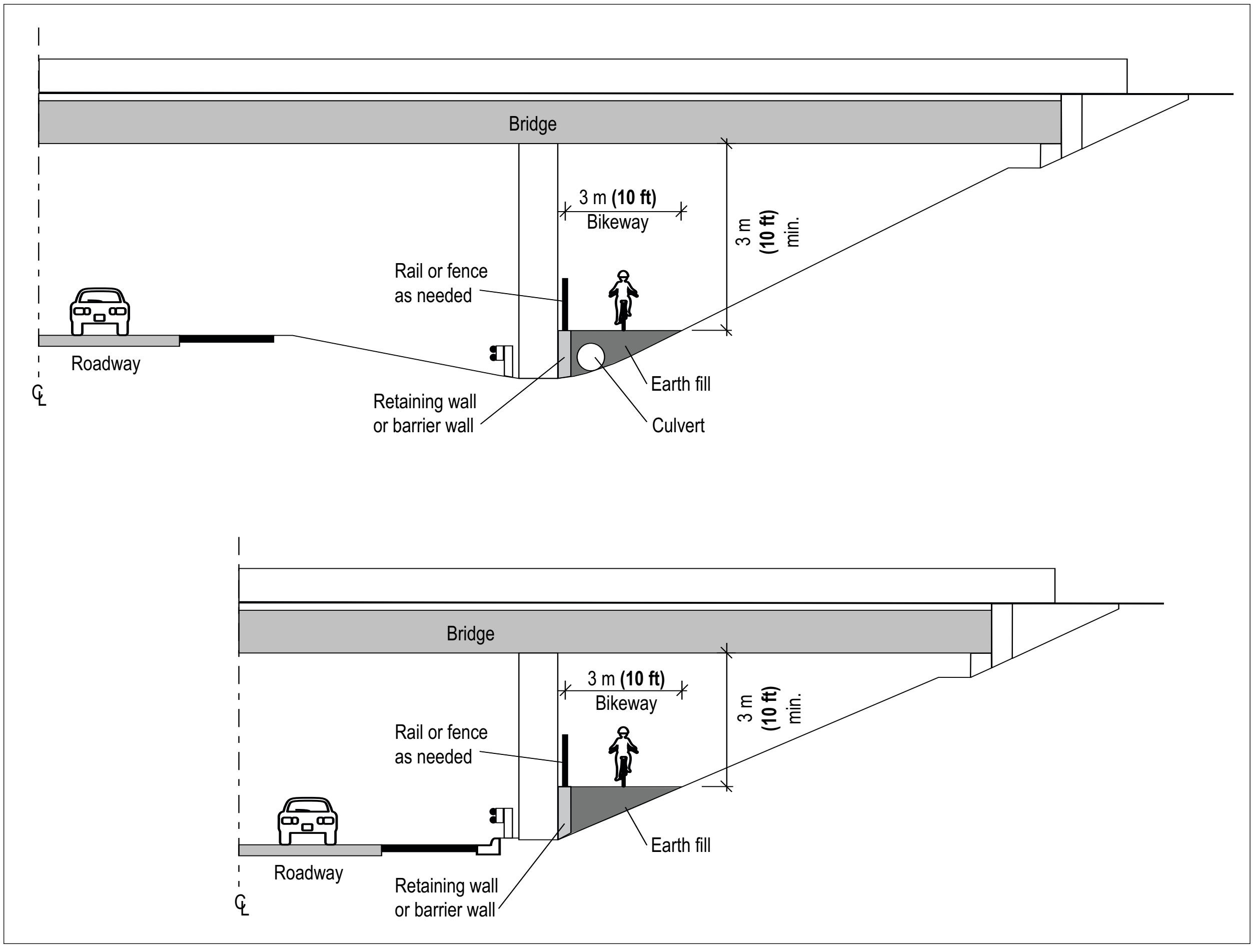


Figure 6-5:
Bikeway under an existing bridge structure

6-6.0 Bicycle and Pedestrian Underpasses and Tunnels

A bikeway underpass should be considered if there is no safe and direct on-street crossing, if the facility to be crossed is elevated, if an existing motor vehicle under-crossing is too narrow for a bicycle facility, and when the underpass would not require bicyclists to negotiate significant elevation changes. Underpass costs may be lower than those for overpasses.

Underpass Characteristics

Positive:

- Protected from weather
- Less ramping and change in elevation than overpasses due to clearance requirements

Negative:

- Can be dark and intimidating
- Users may not be able to see through to the other side
- Users may feel claustrophobic
- May be difficult to maintain

An underpass may have less grade change for a bicyclist to negotiate than an overpass because a typical overpass requires a 5.2 m **(17 ft)** vertical clearance over the highway. A disadvantage is that unless it is well located and openly designed, it may be intimidating and avoided by bicyclists and pedestrians. Providing adequate drainage may also be a problem; providing a surface that does not become excessively slippery when wet is important. Proper drainage design is a key element to prevent wet silt deposits that are a common hazard for bicyclists using underpasses. The inclusion of gutters at the edge of the underpass and the base of a retaining wall are good design elements to ensure a clear riding surface.

Underpasses are usually constructed of pre-cast concrete in a shape having the proper vertical and horizontal clearances. See Figure 6-6.

Figure 6-6:

Example of precast concrete underpass with adequate vertical clearance

The horizontal and vertical alignments in an underpass should be straight for the full length and for an adequate distance on each approach. The minimum width of an underpass for bicyclists and pedestrians should be 3.6 m **(12 ft)**, or the paved width of the approach path plus 0.6 m **(2 ft)**, whichever is greater. The recommended width of an underpass is 4.2 m **(14 ft)**, which allows several users to pass one another safely. Greater width may be justified in areas with many potential users or at a location where there is an event-clearing peak demand. The recommended vertical clearance is 3 m **(10 ft)** for a pedestrian/bicycle underpass. If access for emergency vehicles is not required, vertical clearance for bicyclists shall be at least 2.4 m **(8 ft)**.

Underpass design and layout should carefully consider its location and user safety. Visibility through a tunnel and adequate lighting enhance users' perception of personal safety. When the underpass is long (e.g., when traversing a four-lane road), wider or flared openings are recommended to improve natural lighting and visibility. Channeling with fences or walls into a tunnel should be evaluated for safety. If it is likely that bicyclists and pedestrians will avoid the underpass and try to cross the road or railway in unsafe conditions, barrier fencing or visual screening with dense vegetation may be needed to help direct users to the underpass. Approaches and grades should provide the maximum possible field and range of vision toward the underpass, for both bicyclist and pedestrian.

For short underpasses or tunnels, modest lighting may be all that is required. Generally, the longer the structure, the greater the need for illumination. In certain cases, lighting may be required on a daily, 24-hour basis. For tunnels longer than 15 m **(50 ft)**, constant illumination is recommended. All lighting should be recessed and vandal resistant. Providing skylights in the middle of the structure (an opportunity occurring with an overhead urban section roadway with a raised median) can reduce lighting needs during daylight hours. See Section 5-8 for more information on lighting.

6-7.0 Rest Areas and Overlooks

Paths, rest areas or overlooks should be created at points along the path where bicyclists are most likely to stop, such as waterways or other features of interest. Consideration should be given to a bicycle pull-off on or abutting a bridge. In instances where the bridge is on a crest, a pull-off area serves as a scenic overlook. Rest areas featuring old railroad stations or other historic structures add interest to the route and serve as points of reference. Interpretive signs installed at natural or historical points of interest serve to educate path users.

Figure 6-7:
Example of a rest area with interpretive signage

Locations already offering services, such as restaurants and museums, tend to attract bicyclists and are natural locations for rest areas. Sheltered, sunny spots can offer better climactic conditions and increase the length of the bicycling season.

Rest areas and overlooks can offer a more pleasant experience if exposure to wind and noise levels is mitigated. Planting trees and shrubs is the most aesthetically pleasing way to create windbreaks. Spruces, firs, and cedars, with their full bases, form a more wind resistant grove than trees with higher branching patterns. Reduce the ambient noise level on a bikeway located near freeways, boulevards, or industries by installing acoustic screens, such as earth berms or low walls. Avoid creating an environment where bicyclists or pedestrians might feel isolated and vulnerable.

Ideally, on a recreational bikeway, there should be a rest area every 5 km **(3 mi)**. Access routes from the path to rest areas should be clearly marked and lead directly to bicycle parking, in order to prevent bikes being locked to trees, shrubs, and other vulnerable objects.

Rest stops may be equipped with tables or benches, secure parking facilities, waste receptacles, and trail literature. Access to restrooms and drinking water for bicyclists is desirable. At major rest areas (or trailheads), minor repair services, telephones, and covered shelters may be made available.

To facilitate entering and leaving a busy path, an access path extending 30 m **(100 ft)** on either side of the rest area's entrance may be created. This is especially recommended if the entrance is located on a steep grade or is not visible at a distance of more than 40 m **(130 ft)**. A physical demarcation such as a low-lying hedge or ditch may discourage crowds from gathering on the path and prevent children from wandering onto it while playing.

6-8.0 Bus and Van Shuttles

Where existing bridges cannot be modified to safely accommodate bicyclists, bus or van shuttles are a way to facilitate crossing areas that are impassable except by vehicle. A shuttle service can operate on a fixed-route schedule or be initiated through a demand-response for special events.

Buses are retrofitted with racks for two bicycles, and are already offered on public transit in many cities. Vans can be equipped with special trailers to haul bicycles.

Figure 6-8:
Bike rack-equipped bus, Minneapolis

Chapter 7: Traffic Controls

7-1.0 Introduction

Traffic control devices help ensure roadway and bikeway safety by giving instructions for orderly, predictable traffic movement. Types of traffic control devices include signs, signals, pavement markings, and object markings.

To be effective, a traffic control device should meet five basic criteria:

1. Fulfill a need
2. Command attention
3. Convey a clear, simple meaning
4. Command respect from road users
5. Give adequate time for proper response

Design, placement, operation, maintenance, and uniformity all should be carefully considered in order to maximize the effectiveness of a traffic control device. Operating speed of vehicles and bicycles is an important element that influences the design and placement of various traffic control devices.

The Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD), Part 9, Traffic Controls for Bicycle Facilities, should be used in conjunction with this guide to determine proper design, application, and installation of traffic control devices. All traffic control devices installed must conform to *MN MUTCD* under the provisions of Minnesota Statutes 169.06. Also, refer to the *Mn/DOT Traffic Engineering Manual* Parts 1, 2, and 3, which offer guidance that complements *MN MUTCD* and clarifies accepted Mn/DOT procedures.

All signs, signals, and markings should be properly maintained to command respect from both the bicyclists and vehicle drivers. Prior to installing traffic control devices along bicycle facilities, a particular agency should be designated to maintain them.

7-2.0 Signs

Bicycle facilities require much of the same sign planning and design as do motor vehicle ways. Signage helps create a legible, small-scale network within a larger transportation infrastructure.

Bicycle-related signs on roadways and bikeways serve three basic purposes: regulating bicycle usage, directing bicyclists along pre-established routes, and warning cyclists of unexpected conditions. All signs must be user-friendly and easily understood.

The main classifications of signs used within on-street bicycle facilities and multi-use paths are as follows.

Figure 7-1: Regulatory sign MN MUTCD Sign R9-X1

Regulatory Signs

Regulatory signs notify bicyclists, pedestrians, and motorists of traffic laws or regulations. Regulatory signs and markings are also used to assign right of way at intersections, both path/path crossings or at path/roadway crossings.

Figure 7-2: Warning sign MN MUTCD Sign W7-5

Warning Signs

Warning signs alert bicyclists or motorists of potentially hazardous conditions on or adjacent to bikeways, trails, streets, and highways. Warning signs and markings let bikeway/path users know about issues such as tight curves, low clearances, obstacles, and other hazards. Typically, signs are used for permanent conditions that cannot be easily corrected. In advance of traffic controls and intersections, it may be helpful to place warning signs that alert users to the specific conditions, especially where a situation is not easily apparent (e.g. an intersection around a curve).

Route Guide Signs and Bicycle Route Markers

Route Guide Signs inform bicyclists of changes in route direction and help confirm that this direction has been accurately understood. Bicycle Route Markers identify a designated bike route that typically extends through multiple jurisdictions and is of regional significance. Both sign types can be installed on either shared used paths or shared roadways (i.e. bike lanes).

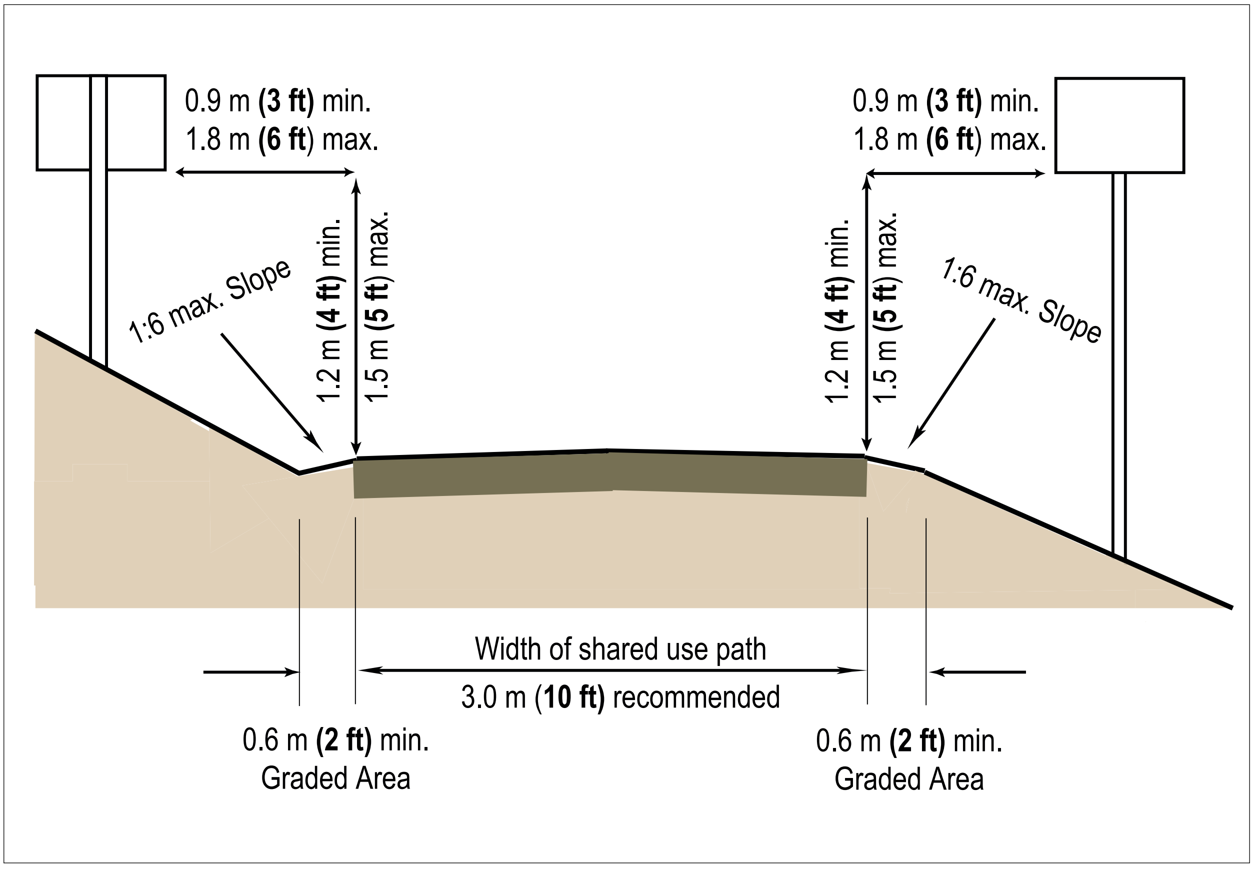
Figure 7-3: Guide sign MN MUTCD Sign D11-1

Guide Signs and Route Markers may also be supplemented with destination arrows or supplemental plaques to provide essential information about major destinations and distance markers. Bicyclists often find the supplemental information helpful to know where a path goes and its relationship to the roadway network, the distance to certain destinations, and if a section of a path is named or numbered. Typical destination information includes city limits, bicycle trail and street names, schools, museums, parks, recreational facilities, rivers, streams, historical sites, and business district names.

7-2.1 Sign Placement

Chapter 9 of the *MN MUTCD* lists rules for bikeway signage setbacks from roadways and trails, horizontal clearances, and posting heights. Some basic guidelines (Figure 7-4) for signage placement include:

- On shared-use paths, the lateral sign clearance must be a minimum 0.9 m **(3 ft)** and a maximum of 1.8 m **(6 ft)** from the near edge of the sign to the near edge of the path. Because of cyclists' and pedestrians' lower line of sight, the bottom of signs should be 1.5 m **(5 ft)** above the path.
- The mounting height for ground-mounted signs on shared-use paths is a minimum of 1.2 m **(4 ft)** and a maximum of 1.5 m **(5 ft)**, measured from the bottom edge of the sign.
- When overhead signs are used on shared-use paths, the clearance from the bottom edge of the sign to the path surface shall be a minimum of 3 m **(10 ft)** to allow for the passage of maintenance vehicles.



Source: AASHTO

Figure 7-4:
General Guidelines for Sign Placement

Signs designed for the exclusive use of bicyclists and pedestrians should be located so that they do not confuse drivers. Stop or yield signs placed to control the bicyclist may in fact cause confusion for some vehicles on a through street. If it is difficult for users to determine if signage is intended for bicycle or vehicular traffic, consider the following alternatives:

- Use pavement markings to reinforce message.
- Add louvers to the sign to shield it from the highway and direct the sign message toward the intended direction of travel.
- Use smaller sign sizes as a cue to bike users (see following section).

In construction areas, signs should be installed to direct bicyclists through, or direct them to a route to bypass the work. Care should be taken to avoid placing signs in the travel path of bicyclists, which may result in dangerous weaving movements.

The *MN MUTCD* encourages conservative use of regulatory and warning signs; if used to excess, these signs tend to lose their effectiveness. The frequent display of bicycle route signs, however, helps keep the bicyclist on track with no diminishment of the message.

7-2.2 Bikeway Sign Size Guidance

The *MN MUTCD* recommends designing sign size, font, and content based on travel speed. Travel speed determines how much time a user has to read, process, and safely respond to messages.

Since bicycle and pedestrian speeds on paths and on-street routes are much lower than those of automobiles, signs intended exclusively for bikeway users should be smaller than those needed for automobile drivers. Figure 7-5 illustrates different sign sizes based on users speeds. The smaller sign size will reduce visual clutter and clarify to motorists the intended audience. However, larger signs may be used on shared-use paths where appropriate.

Appendix C of the *MN MUTCD* lists all recommended sign sizes, including those for bikeway applications.

Figure 7-5: Sign Dimensions Based on User Speeds

7-2.3 Signage for Shared-Use Roadways

When a roadway has been identified as a preferred bike route, signage advises motorists that bicycles are present, and tells cyclists about advantages to using the route, such as safety or access to destinations. Bike route signs may also be used on streets with bike lanes and on shared-use paths. For all facility types, destination information should be included on the signs.

Signage should be provided at decision points along designated bicycle routes, including information on route direction changes and confirmation of route directions. Bike route signs should be repeated at regular intervals so bicyclists entering from side streets know that they are on a designated route. Adherence to a spacing standard helps create a legible network and a degree of predictability for bicyclists.

On routes that lack paved shoulders or other bicycle facilities, but are still used by bicyclists, "Share the Road" signs (*MN MUTCD* W16-1 in conjunction with W11-1) can help reduce motor vehicle/bicyclist conflict. Recommended installation of the W11-1 sign is approximately every 1 km **(0.6 mi)** on undesignated urban routes frequently used by bicyclists, where curb lanes are at least 4.2 m **(14 ft)** wide. On rural routes lacking paved shoulders but frequented by bicyclists, install "Share the Road" signs every 0.5 km to 1 km **(0.3 mi to 0.6 mi)**.

Figure 7- 6:
Share the Road sign
MN MUTCD Sign W11-1 and W16-1

Where automobiles and bicyclists share travel lanes, "Change Lanes to Pass Bicycles" signs are advised. An optional "Bicycles Allowed Full Use of Lane" can be used to reinforce the message that bicycles are permitted on roadway lanes. These signs can be used on urban streets with travel lanes of 3.9 m **(13 ft)** or less and on rural roads without paved shoulders and relatively low traffic volumes (under 2,000 ADT). In urban areas, the signs can be placed every 300 m **(1,000 ft)** and on rural roads approximately every 0.5 to 1 km **(0.3 to 0.6 mi)**.

On alternative bicycle routes, directional and informational signs should be posted at every major road intersection, at intersections with other bicycle routes, any confusing junctions, and along continuous routes approximately every 300 m **(1,000 ft).**

7-2.4 Signage for Bike Lanes

For bike lanes, signage requirements are described in *MN MUTCD* Chapter 9. Bike lane signage must provide regulatory warnings that indicate to drivers the rights of bicyclists on the road, and advise bicyclists of changing conditions around intersections.

Traditional bike lane signs mark the route and regulate lane usage However, this signage does not describe a network, give the rider a sense of where the bike lanes lead, or provide distance to desired destinations. To remedy this, directional arrows, destinations, and distances, should be incorporated into bike lane signage when appropriate.

For additional information, refer to Chapter 4 of this manual and the *MN MUTCD*.

7-2.5 Signage for Shared use Paths

Multi-use trails should receive the same types of regulatory, warning, and guidance signage as on-street bikeways The *MN MUTCD* details the signage and marking design treatments at intersections. Minor side streets should yield or stop at heavily used paths. Some bicyclists do not stop if traffic is not present. A yield sign allows this practice. Generally, signing driveway entrances and commercial entrances should be avoided because of the potential confusion. For additional information on shared-use paths and intersections, see Chapter 5 of this manual.

7-2.6 Signing Bicycle Routes

Special way-finding signage systems are recommended to guide touring and recreational bicyclists along significant bicycling routes in either rural or urban areas. The special bikeway signage offers a more recognizable identity to help inform both bicyclists and motorists. Use special bikeway signs sparingly, primarily at locations where the route turns and at junctions with other bicycle routes

Way-finding signage is illustrated in *MN MUTCD* as sign M 1-8 and M 1-9, and unique signs also can be designed and applied (Figure 7-7). Supplemental destination plaques and arrows should be added beneath the route identity sign.

Figure 7-7:
Examples Special Bikeway Signage

7-3.0 Signals and Vehicle Detectors

Traffic signals are used by motorized, bicycle, and pedestrian traffic. The Recommended Intersection Treatments chart, Figure 5-10, indicates when signals should be used to control intersections of bicycle and vehicle traffic. As a general principle, bicycles should be considered in all traffic signal cycles.

At signalized intersections of multi-lane streets, Average Bicyclists may have difficulties crossing if the clearance interval is not of adequate duration. Car-bike collisions occurring as motorists start or speed up on a new green are one of the major types of bicycle accidents. One possible reason for this phenomenon is inadequate transition time, which can be alleviated by all-red clearance intervals. Another reason could be that the bicycle has not been detected by the signal system.

Extremely short clearance intervals should not be used. Evaluating clearance time required for bicycles should be standard practice for each signalized intersection along a roadway or bikeway. To check the clearance interval, a bicyclist's speed of 15 km/h **(10 mph)** and a perception/reaction/braking time of 2.5 seconds should be used. With wider intersection designs and acute angle intersections, the traffic engineer must pay especially close attention to crossing times. Geometric designers and operations staff must work closely together to create supportive bicycle crossings. As with all calculated signal timing, field observations should be undertaken prior to making any adjustments to the minimum green or clearance intervals.

Providing separate bicycle signal heads mounted at appropriate heights is desirable.

7-3.1 Bicycle Detector-Activated Signals

At signalized intersections where bicycle traffic exists or is anticipated, a method of detecting the presence of the bicyclists should be considered.

Many traffic signals in urban areas are activated by wire detector loops buried in the roadway. Typically, the loop is placed behind the stop line at an intersection. Detectors for traffic-actuated signals should be installed where bicyclists are likely to travel. This includes the right side of through travel lanes and the center of bicycle lanes.

Detection loops are an effective method for detecting many bicyclists. However, as more bicycles are being made of non-ferrous metals, detection loops may be less effective. Quadrupole and diagonal-type loop detectors provide better bicycle detection. Examples of detection loop types are illustrated in Figure 7-8.

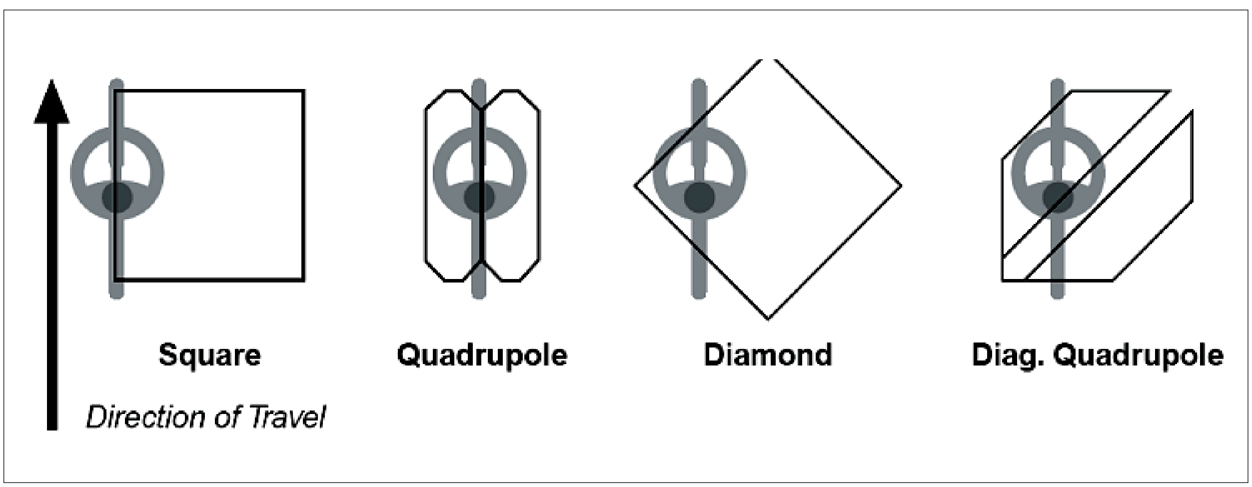


Figure 7-8:
Bicyclist Detection Loops

Type Q (quadrupole) loops are often used in bike lanes and Type D (diagonal quadrupole) loops on shared roadways. Recent research recommends that the predominant design be a 1.7 by 1.7 m **(5.5 by 5.5 ft)**, 45-degree skewed loop within 100 mm **(4 in)** of the surface. This configuration most accurately detects motor vehicles and bicycles. Standard rectangular or square loops tend to only detect bicycles along the loop edges. An extended loop detector (see Figure 7-9) can serve to detect traffic in two lanes.

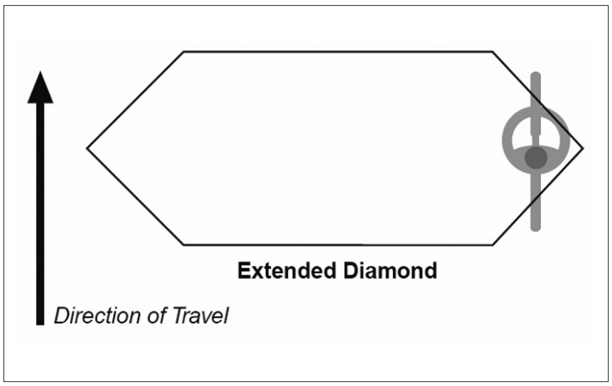


Figure 7-9:
Extended Loop Detector

Deep buried loops are not recommended for bicycle detection. Additionally, marking the location and most sensitive portion of the loop is helpful. Figure 7-10 illustrates the suggested pavement marking in the 1999 *AASHTO Guide for the Development of Bicycle Facilities*. The position of the loop depends upon the type of loop selected as shown in Figures 7-8 and 7-9.

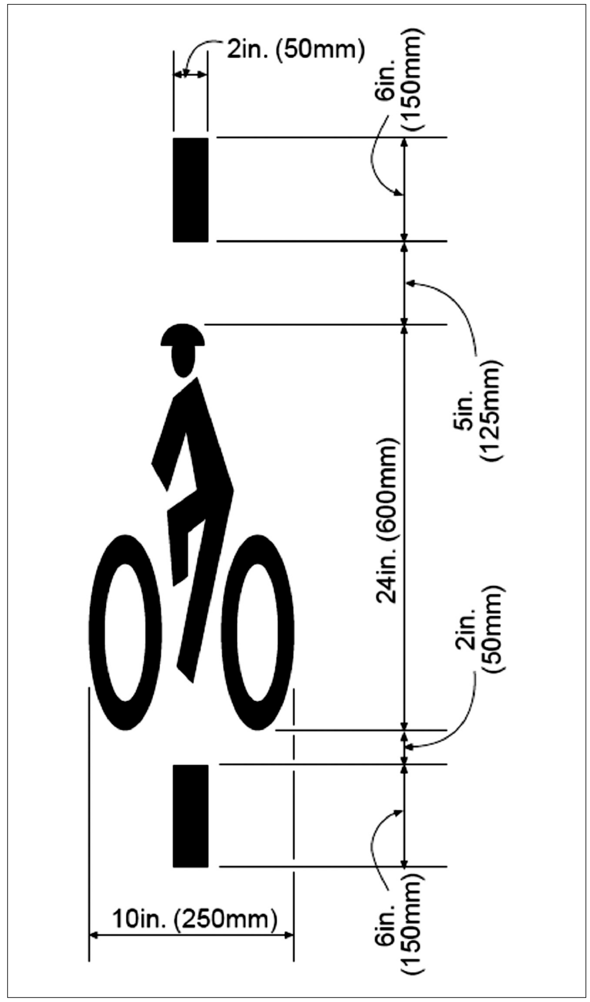


Figure 7-10:
Bicycle Loop Pavement Marking

7-3.2 Bicycle and Pedestrian Push Button-Actuated Signals

For on road cyclists the green traffic signal for a bicyclist should be actuated without pushing a pedestrian button. Detector loops are usually supplemented with a manually activated signal for pedestrians, but actuated buttons should not be considered a substitute to loops for detecting cyclists.

In certain locations, such as a shared-use path at a road intersection, it may be necessary for bicyclists to be directed to a pedestrian button at the intersection. When the use of a push button by cyclists is required, buttons should be located in a position that is easily accessible from the path, 1.2 m **(4 ft)** above the ground, so that bicyclists will not have to dismount to activate the signal. Bicyclists should be able to push the button while holding themselves upright using the top of the pedestal or button mounting. The button should be clearly visible, on the right edge of the roadway or path in the direction of traffic flow, out of the flow of cross traffic.

Installing a bicyclist/pedestrian activated signal at a marked shared-use path crossing or crosswalk may be warranted under any of the following conditions:

- At mid-block crossings of high-volume, high-speed roadways.
- Where the roadway is adjacent to schools or other high bicyclist/pedestrian activity areas where safety is paramount.
- When anticipated use of the crossing is high enough for motorists to get accustomed to stopping frequently for a red light.

The signal may accompany other traffic-calming treatments, such as curb extensions. Warning signs should be installed for motor vehicles in advance of the signal. A full engineering review should accompany any planning and/or decision-making for these techniques.

Figure 7-11:

Example of an accessible crosswalk push button

7-3.3 Signal Sequencing

At installations where programmed signals are used, special attention should be given to include bicyclists in the signal phasing and adjust the signal heads so bike lanes or path users can see them. If programmed signals cannot be aimed to serve the bicyclist, then separate signals should be provided.

It may be advisable to time traffic signals to accommodate bicyclists at typical bicycle operational speeds of 24 km/h **(15 mph)**. This signal sequencing may slow vehicular traffic, but provides for more efficient movement of bicyclists. This is most applicable in business districts or shopping districts, central business areas, or along designated bicycle routes that could benefit from traffic calming. This is a site-specific treatment and should only be considered after a full engineering review and a planning process.

7-4.0 Pavement Markings

7-4.1 Bike Lanes

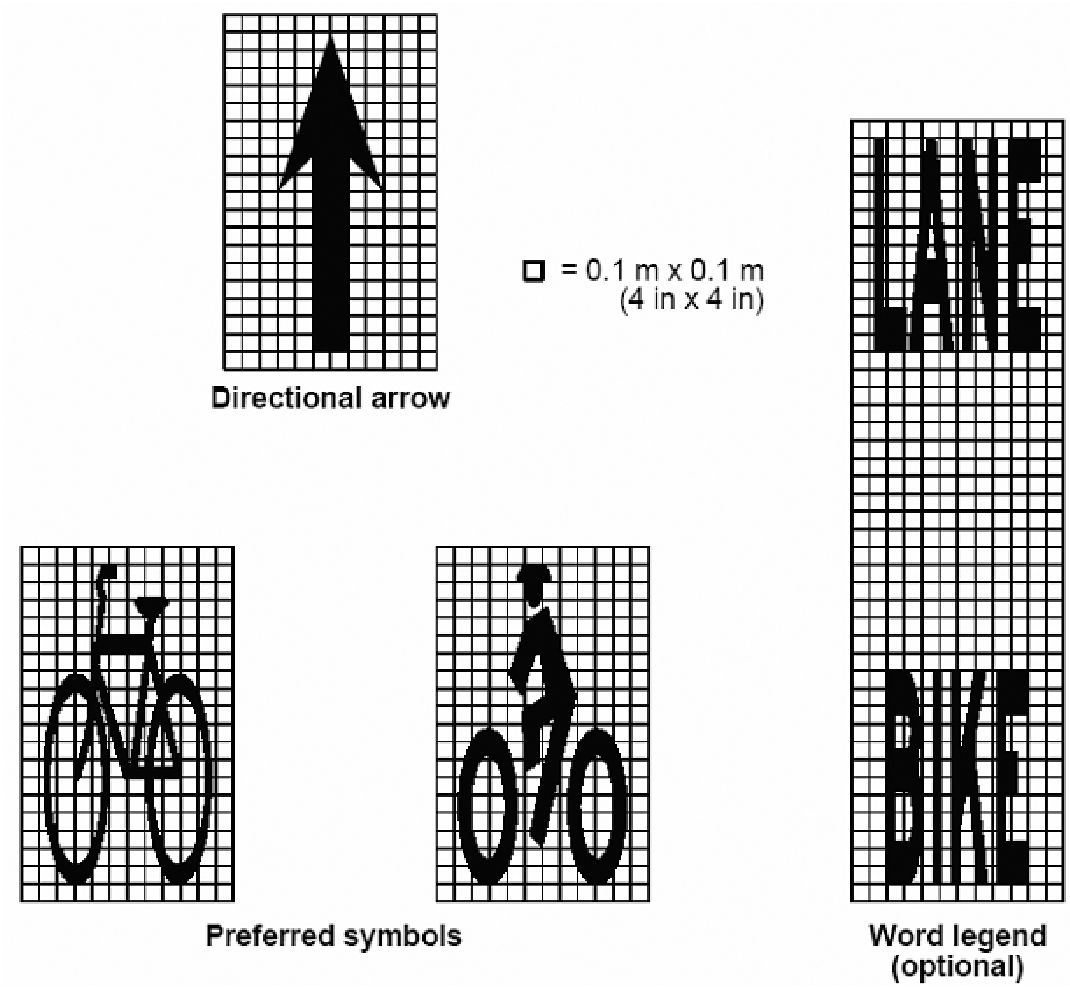
Pavement markings are important on roadways with a designated bicycle lane. Pavement markings indicate separation of lanes for motor vehicles and bicycles on streets and highways, assist the bicyclist by indicating assigned travel paths, indicate correct position for traffic signal actuation, and can provide advance information for turning and crossing maneuvers. Markings are also desirable to delineate bus stops, pedestrian walkways, and busy public access areas. The frequent use of symbols and words on pavement is a helpful way to reinforce sign messages.

Figure 7-12:
Proper use of a bike lane symbol

A bike lane should be delineated from the motor vehicle travel lanes with a 100 mm **(4 in)** solid white line. Some jurisdictions may wish to use a 200 mm **(8 in)** line for added distinction. An additional 100 mm **(4 in)** solid white line can be placed between the parking lane and the bike lane, and is recommended where there is high parking turnover. This second line will encourage parking closer to the curb, and provide added separation from motor vehicles. Where parking is light it can discourage motorists from using the bike lane as a through travel lane. For examples, see Chapter 4 of this manual beginning with Figure 4-10.

A bike lane should be painted with standard pavement symbols to alert bicyclists and motorists. The standard pavement symbols are one of two bicycle symbols (or the words "Bike Lane") and a directional arrow (Figure 7-13). These symbols should be painted on the far side of each intersection. Additional stencils may be placed on long, uninterrupted sections of roadway. All pavement markings are to be white and reflective.

Bike lane pavement marking and signage treatments at intersections require a high level of planning and design to facilitate safe bicyclist movement. Numerous design treatment options are available, specific to turning movements and roadway lane configuration. See Chapter 4 of this manual, and Part 9 of the *MN MUTCD* for additional design guidance.



Refer to Part 9 of the *MN MUTCD*

Figure 7-13:
Typical Bike Lane Symbols

7-4.2 Shared Use Paths

In most cases striping is not needed for shared use paths. Instances where a centerline marking on shared use paths may be considered are where the shared use path has a minimum width of 10 feet and one or more of the following applies:

- There is a demonstrated need to separate bicycle and pedestrian traffic.
- The shared use path has heavy volumes of traffic,
- On curves with restricted sight distance,
- On unlighted paths where night riding is expected, and in dark underpasses.

A skip dash stripe should be used where passing is allowed, and a solid line where passing is unsafe, such as on curves. Edge lines can also be beneficial where night bicycle traffic is expected.

The basic requirements for bikeway pavement markings are similar to those for motor vehicle markings: visibility (or reflectivity), durability, and rolling resistance. Consult the most recent version of the *MN MUTCD* for the appropriate striping design specifications.

7-4.3 Materials

Care should be exercised in the choice of pavement marking materials, which may increase bicyclists' likelihood of skidding. Avoid marking materials that are slippery when wet and seek out non-skid materials, particularly at locations where bicyclists may be leaning, turning, or stopping. This is especially true at intersections, where the ability of the bicyclist to remain in control is important. Adding silica micro-bead to marking products increases their surface roughness and offers good rolling resistance. Refer to the most recent edition *Mn/DOT Standard Specifications for Construction* for additional information on marking materials.

7-5.0 Object Markings, Delineators, and Curbs

The primary functions of object markings, delineators, curbs, fences, and barriers are:

- Controlling traffic to encourage safe and expeditious operation
- Supplementing traffic sign warnings
- Independently identifying certain regulations or hazardous conditions

Vertical barriers and obstructions, such as abutments, piers, and other features causing bikeway constriction, should be clearly marked to gain the attention of approaching bicyclists. This treatment should be used only where the obstruction is unavoidable, and is by no means a substitute for good bikeway design. Signs, reflectors, diagonal yellow markings, or other treatments may be appropriate to alert bicyclists to potential obstructions.

7-5.1 Object Markings

Object markings identify physical obstructions in or near the roadway or bikeway that may constitute a hazard. Such objects can be marked with highly visible, reflective materials to make their identification by approaching bicyclists more certain. Care should be taken to ensure that object markers do not themselves become hazardous objects. Refer to Chapter 3C of *MN MUTCD* for proper application and design.

7-5.2 Delineation

Delineators are light-reflecting devices mounted in a series at the side of the roadway or bikeway to indicate the alignment. They are effective aids for night driving and are considered as guidance rather than warning devices. Care should be taken to avoid having delineators become hazardous objects, if used; a traffic engineer should determine delineator type and placement.

7-5.3. Curbs and Medians

Curbs and medians can separate and delineate the corridor reserved for bicyclists. Permanent curbs or medians at bus stops should be at least 0.9 m **(3 ft)** wide to provide a loading platform for transit users. Where applicable, the pedestrian pass-through on median refuge islands should be at grade level.

Curbs should have openings to accommodate driveways and bikeways and to allow storm water runoff to flow properly. During the winter months, keep curb or median openings free of snow and other obstructions to ensure proper use and drainage.

Whenever bicyclists are directed from signed shared roadways to sidewalks, curb cuts should be flush with the street to assure that bicyclists do not have to cross a vertical lip at a flat angle. Curb cuts at every intersection are necessary, as well as bikeway yield or stop signs at uncontrolled intersections. Curb cuts shall follow all ADA requirements and shall be wide enough to accommodate adult tricycles and two-wheel bicycle trailers.

Chapter 8: Bicycle Parking

8-1.0 General

Bicycle parking facilities are essential elements for bicycle transportation. Every bicycle trip begins and ends with the need for a safe and secure place to park one's bike. A lack of adequate and secure parking will discourage people from biking. Bicycle parking facilities thus should be provided at both trip origin and destination points and offer protection from theft and damage. Local zoning, licensing, and permit processes may designate the types and numbers of bicycle parking required.

8-2.0 Bicycle Parking Security Levels

The wide variety of bicycle parking devices is generally grouped into two security levels: secure and less-secure parking. Some trips require long-term parking (more than two hours) while other trips may require only short-term parking (less than two hours). The longer term parking security issues include the threats of bicycle theft and theft and/or vandalism of the bicycle and various critical accessories. Accessories include lights, saddle bags, frame pumps, water bottles, tool kits, computers and bicycle helmets. The minimum needs for each are described in greater detail below.

The amount of security needed to prevent theft must be evaluated for each area. Bicycle parking facilities or devices can be classified into two security categories:

SECURE

Facilities protect against theft of the entire bicycle and its components and accessories, and protect the bicycle from inclement weather. These include bike lockers or facilities located inside a building or shelter, sometimes with an attendant.

LESS-SECURE

Bike racks consist of a stationary object upon which a bicycle frame and both wheels may be secured with a user-provided cable or chain and lock, or with a lock alone. Shelter from weather is desired.

No one type of parking product will satisfy all needs; on most bike facilities, a mix of high and low security parking is advisable. In a retail setting, a simple low-security outdoor rack, visible through a store window, will usually suffice for customers, but employees will prefer a higher security facility. Generally, high security parking is preferred for long-term parking and low security is often acceptable for short-term parking.

Bicycle parking areas should be illuminated at the same levels as motor vehicle parking areas. Refer to Section 5-8 of this manual for more information on lighting standards.

8-2.1 Secure Bicycle Parking

Secure bicycle parking is needed at locations where bicycles are left unattended for long periods (generally more than two hours), such as workplaces, schools, multi-family dwellings, transit stations, and park-and-ride lots. Secure parking also meets the needs of bicyclists who do not carry a bicycle lock. Long-term bicycle parking facilities should secure the frame, both wheels, and accessories and offer protection from the weather. Bicycle lockers, shelters cages or designated rooms in buildings, and attended storage areas are good examples of long-term parking facilities.

Placing long-term bicycle parking at transit stations and park-and-ride lots provides opportunities for multi-modal travel and supports alternative transportation choices. Bicycle parking devices should be tailored to the needs of the user. Generally, bike commuters prefer parking facilities that most completely protect their bicycle and accessories.

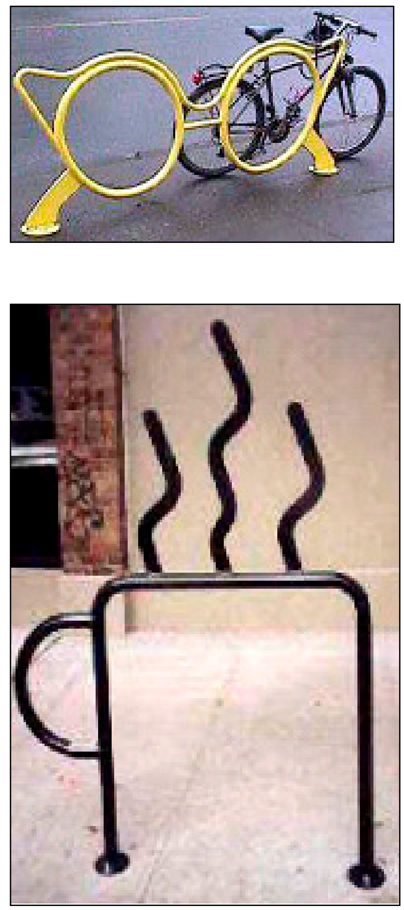


Figure 8-1: Decorative Bike Racks

8-2.2 Less-Secure Parking

Less-Secure bicycle parking includes decentralized parking or areas where the bicycle is left for durations usually under two hours. Less-Secure parking provides a facility where the bicycle frame and both wheels can be locked. They will not necessarily provide accessory and component security or weather protection.

Both security levels of bicycle parking are applicable for destinations such as shopping centers, libraries, recreation areas, and post offices. Less-secure parking should be conveniently located near building entrances or other highly visible areas that are self-policing. Less-secure parking incudes standard inverted U-shaped or wave-shaped racks, or unique decorative designs that represent adjacent businesses or other attractions, as shown in Figure 8-1.

8-3.0 Design Considerations

8-3.1 Location of Bicycle Parking

If bicycle parking is not properly located and designed, bicyclists will use trees (Figure 8-2) , railings, and other appurtenances. Long walks from bike parking to the bicyclist's destination may lengthen trip times to the point of making bicycling inconvenient and deterring its use. A parking location should be selected to ensure that bicycles will not be damaged by motor vehicles or interfere with traffic flow or block pedestrian access.

In general, bicycle parking should be in a highly visible, well-traveled location. This not only encourages use, but also decreases the chances of theft. Bike racks or lockers located in remote areas, behind fences or shrubs, or in quiet alleys make it easier for thieves to steal bicycles and harder for bicyclists to find the parking.

Figure 8-2:

Evidence of Insufficient Bicycle Parking—Bicycles Locked on Trees

Bicycle parking placed in a public right-of-way or parking lot should be removed from the natural flow of traffic and pedestrians, avoiding curbs and areas adjacent to crosswalks. Racks should be installed a minimum of 1.8 m **(6 ft)** from other street furniture (e.g., street signs, mailboxes, benches, telephones) to comply with the ADA. Bike racks shall be installed at least 4.5 m **(15 ft)** away from other features, such as fire hydrants or bus stop shelters, to allow for adequate pedestrian movements or access.

Some additional general guidelines for bicycle parking facility location:

- U-shaped bike racks parallel to a street right-of-way should be at least three feet from a curb. See Figure 8-3.
- Parking should be easily accessed from the street yet protected from motor vehicles.
- Parking should be covered where users will leave their bikes for an extended period.
- The parking area should be lit at levels similar to automobile parking.
- The bicycle rack should be located 0.6 to 0.9 m **(2 to 3 ft)** from any street encroachments, such as planters or utility poles.
- Any street utility vaults must have a 0.6 m **(2 ft)** clearance from a bicycle parked at a rack, not the rack itself.

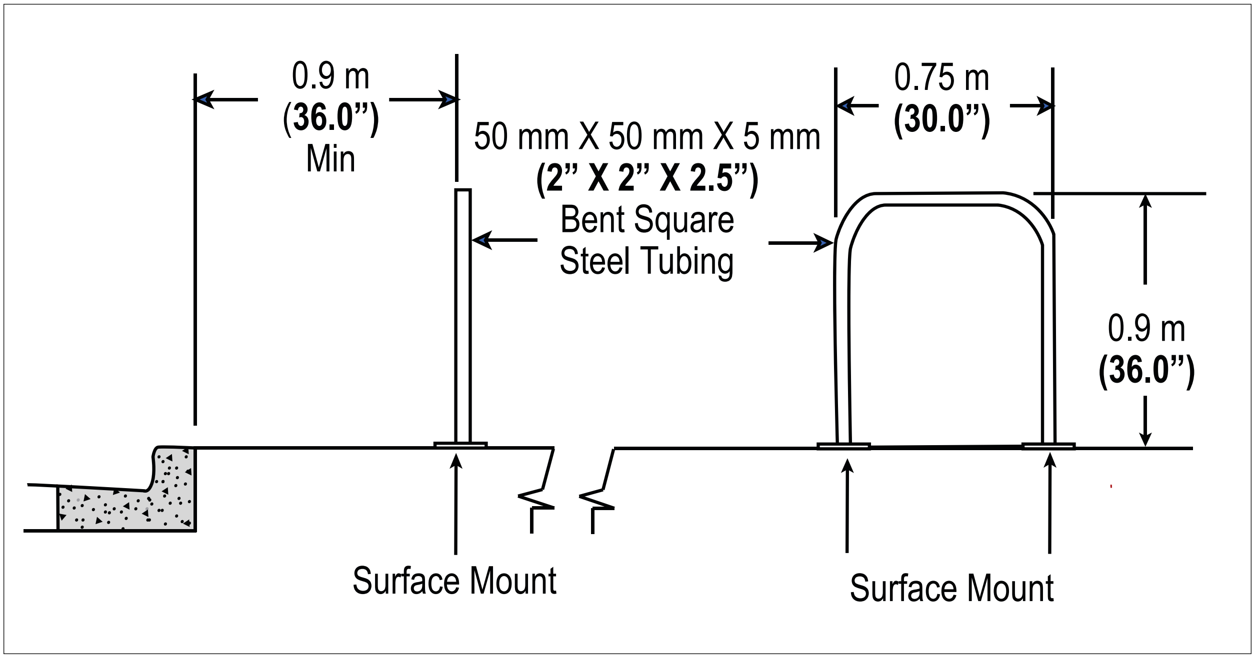


Figure 8-3:
U-Shaped Bicycle Rack

8-3.2 Bicycle Parking Operating Space

The basic building block of bicycle parking design is the bicycle footprint (Figure 8-4). Put simply, the footprint is the size of the bicycle in three dimensions: 1.8 m **(6 ft)** long, 0.6 m **(2 ft)** wide and 1.2 m **(4 ft)** high. Whether the bicycle is oriented horizontally or vertically, these dimensions capture the maximum dimensions of standard upright bicycles in use today. It should be noted that this footprint does not include any space for riders accessing the parking fixtures, nor does it take into account the dimensions of recumbent (reclining) bicycles, tandems, or bicycle trailers.

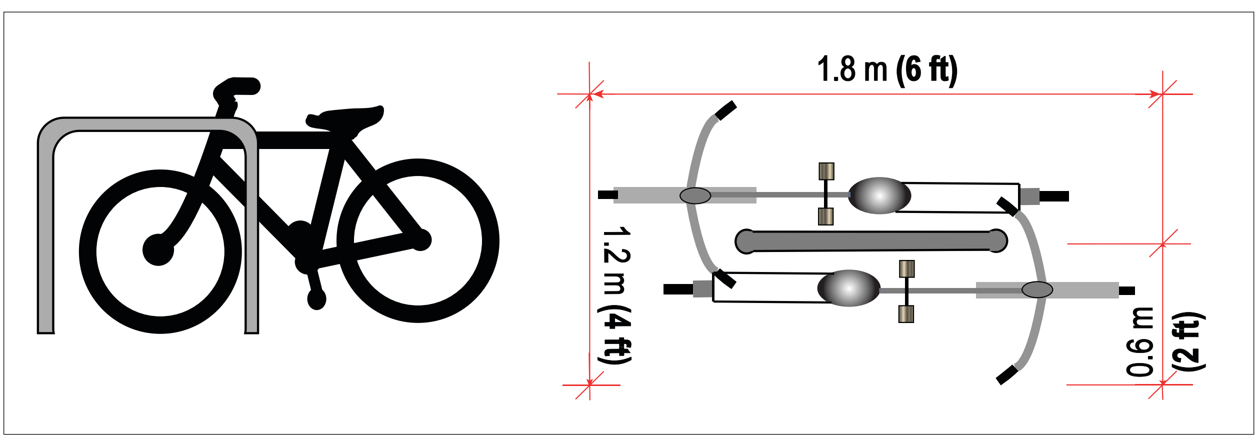


Figure 8-4:
Bicycle Parking Footprint for U-Rack

Bicycle parking operating space is the area needed to access and use bicycle parking facilities. Operating space is required to allow space near adjacent parking facilities, structures, street furniture, and landscaping. If a bicyclist cannot comfortably access bicycle parking, the facility will be underutilized. Bicycle operating space is illustrated in Figure 8-5.

- Bicycle parking facilities should provide at least a 0.6 m **(2 ft)** clearance from the centerline of each adjacent bicycle. Adjacent bicycles may share this access.
- An aisle or other space should be provided for bicycles to enter and leave the facility. This aisle should be at least 1.5 m **(5 ft)** wide, located to the front or the rear of a standard 1.8 m **(6 ft)** bicycle parked in the facility.
- Overhead clearance should be at least 2.4 m **(8 ft)**.
- Bicycle racks should be installed at a minimum of 0.9 m **(3 ft)** from a parallel wall and at least 0.9 m **(3 ft)** from a perpendicular wall (as measured to the closest inverted-U rack).

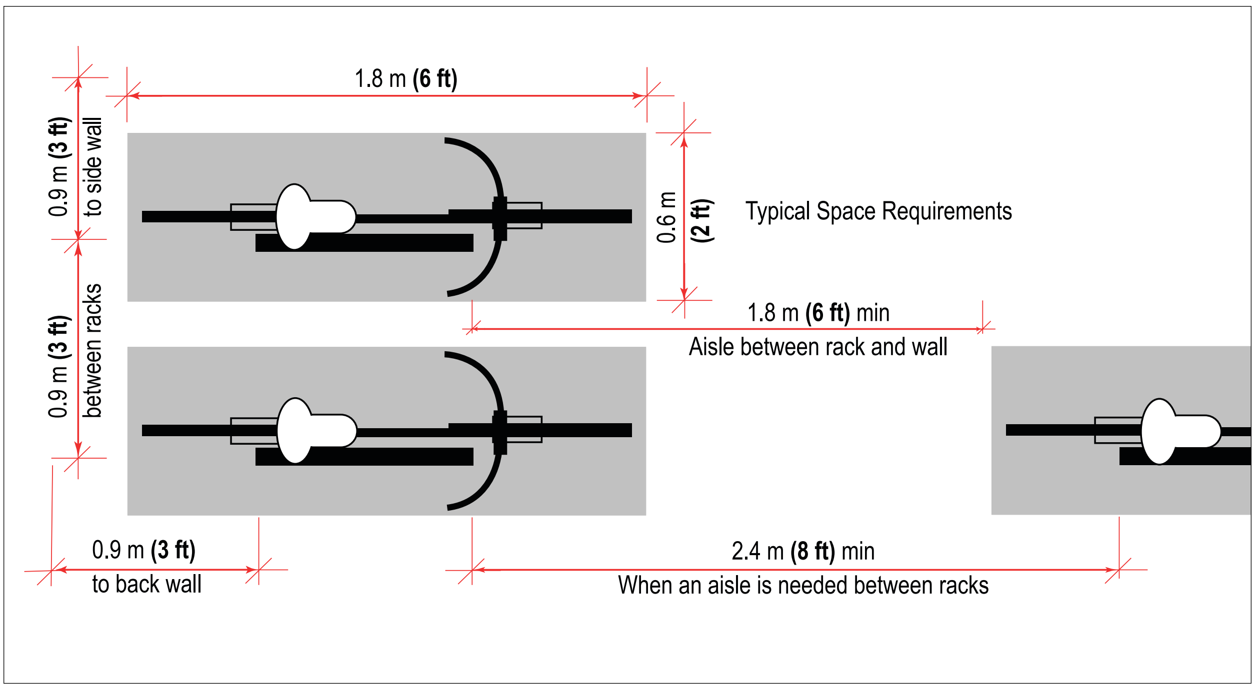


Figure 8-5:
Bicycle Parking Operating Space

8-3.3 Bike Rack

Bicycle parking facilities should be designed to accommodate the typical bicycle footprint at minimum (see Figure 8-4), and ideally to accommodate a wide range of bicycle shapes and sizes. Parking facilities should be simple to operate. Convenience and ease of use are related to the amount of effort it takes to lock the bicycle to the security device. Better devices allow for a variety of locking strategies and lock types. Security devices that need cumbersome locks, lengthy cables, or chains discourage use; racks should accommodate all popular locking devices used by bicyclists, in particular cables and U-shaped bike locks. In some circumstances, particularly high-security parking areas, signs should be posted depicting how to operate the device or facility.

Figure 8-6:
Bicycle Rack with Insufficient Operating or Access Space to the Back (Wall) Side

A bicycle parking device must support, protect, and secure the bicycle. The ideal device completely supports the frame and the wheels in unison. Devices that support only the frame or support the wheels alone fail to control for the lateral movement of the bike, which can result in bent wheels or other damaged parts. Also, because they do not allow the frame of a bicycle to be sufficiently secured, theft can result. Any wheel support should preferably be in tandem with frame support and should protect more than 180 degrees of the wheel arc. Devices that require hanging the bike by a wheel should allow for either swing movement or frame support to protect against lateral movement.

Design specifications depend on the type of bicycle facility installed at a given location. Generally speaking, optimal bicycle parking fixtures are those that follow the following design criteria:

- Maximize space available
- Provide a secure environment that allow a cyclist to easily lock the bike frame and one wheel to the rack (preferably without removing the front wheel from the bicycle)
- Use durable materials that will last for many years with minimal maintenance. For durability and maintenance reasons, parking facilities should have as few moving parts as possible
- Lighting and other security design features should be provided in bicycle parking facilities equivalent to that provided in the facilities for motorized vehicles.

Outdoor bicycle parking should be located on smooth, level surfaces. Rack design should allow for permanent in-ground installation, and installation should conform to the requirements set forth by the manufacturer.

Bicycle parking racks need not conform to typical designs as long as they protect bicycles and deter bicycle theft. Racks may be fabricated to incorporate public art or historical preservation themes.

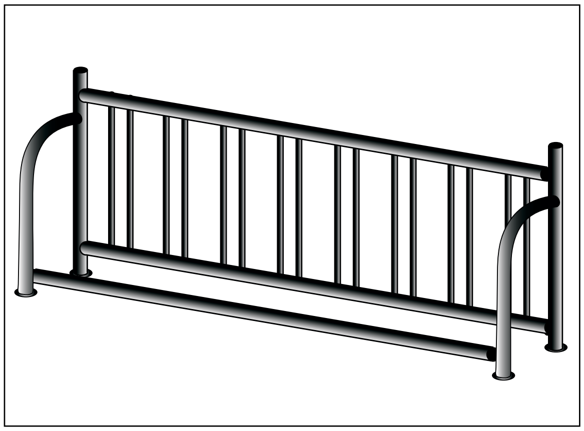


Figure 8-7:
Examples of Unacceptable Bicycle Racks

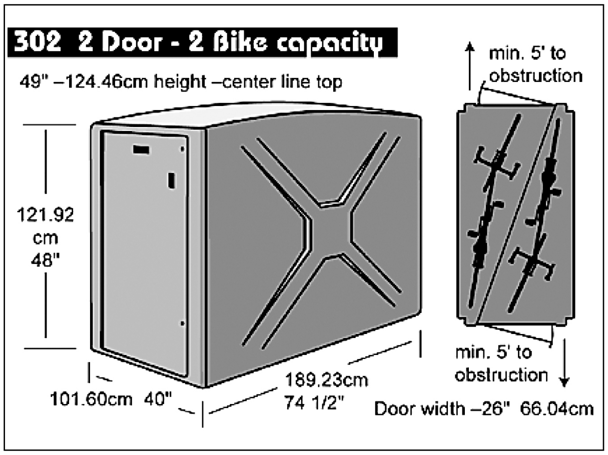
8-4.0 Bicycle Parking Products

8-4.1 Bike Lockers

Bike lockers can be generally characterized as low-capacity, high-security systems of bicycle parking. In general, bicycle lockers utilize a single enclosure to hold either one or two bicycles. Since no bicycle parts or gear is exposed, they are very secure and weatherproof. In addition, the dead space inside the locker can be used for commuter gear storage. Since there is no internal rack element to which to lock the bicycle, the user must depend on the security of the locker design and materials.

Since lockers employ individual enclosures to protect one or two bicycles, they are less space-efficient than other arrangements, such as a series of racks with a shelter covering the entire area. Double-sided lockers are able to achieve some reduction in the effective footprint of the bicycle [to 0.45 m x 1.8 m **(1.5 ft 6 ft)**] this is still larger than the effective footprint of bikes parked on an inverted-U rack [0.3 m x 1.8 m **(1 ft x 6 ft)**]. Of course, this footprint does not take into account the actual footprint of the locker itself, which is significantly larger than the effective footprint of the locked bicycles.

See Table 8.1 for size and other locker details



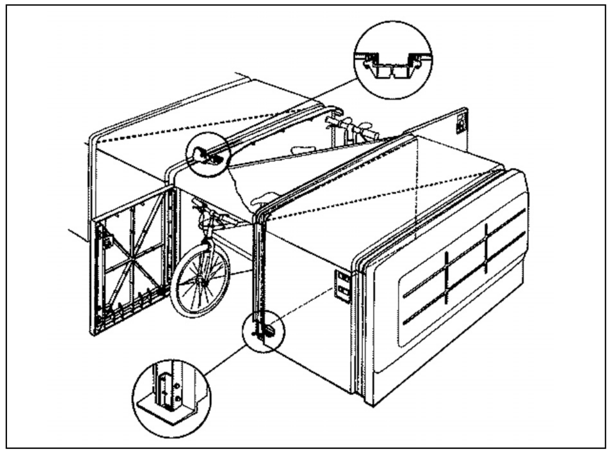


Figure 8-8:
Bike Lockers (Double-capacity locker and double-capacity horizontal locker system)

8-4.2 Horizontal Bike Racks

Horizontal bicycle racks offer a lower level of security than lockers but provide more opportunities for placing fixtures in a given space. Rack designs can be divided into three categories: single racks (e.g., inverted-U or post-and-ring); high-capacity multiple loop racks; and single-bicycle high-security parking systems such as the Bike Bank.

Single Racks

Inverted-U and post-and-ring bicycle racks have become the standards for North American bicycle parking. These racks are simple to install and maximize the space available to park a bicycle by minimizing the space used by the parking fixture itself. Both types of racks are usually constructed from durable, low-maintenance materials. These racks allow locking of at least one wheels (usually both) and the frame, supporting the bicycle at two points so that it remains upright. However, since these racks are typically located outdoors –exposed to both the elements and would-be thieves—they are regarded as primarily short-term parking fixtures.

Figure 8-9:
Inverted-U Bicycle Rack

Multiple-Loop Racks

Multiple-loop racks, rather than being anchored individually to the surrounding surface, are welded together to form a large contiguous unit. They provide the advantage of flexibility. Although they are usually too heavy to be moved easily, they can be relocated by a properly-equipped crew allowing their replacement to be fine-tuned for maximum use.

Figure 8-10:
Multiple-Loop Bicycle Rack

Figure 8-11:
Multiple-Loop Bicycle Rack High/Support

Bike Bank

In a footprint not much larger than a standard inverted-U rack, it is possible to provide an increased level of security for users. Bike Banks, high-security bicycle parking units, are typically compatible with standard U-locks and have space for gear storage. The storage element and movement of the locking Bike Bank swing-arm is shown in Figure 8-12. Due to its dependence on moving parts to facilitate secure parking, the Bike Bank has been shown to experience maintenance problems in the long-term. Moving parts may make the Bike Bank more susceptible to vandalism and some users find its operation unclear without instruction.

Single-capacity Bike Bank without integrated commuter gear storage locker

Figure 8-12:
Bike Bank

8-4.3 Vertical Bike Racks

Vertical bike racks, which store bicycles in an upright position, provide comparable security to standard horizontal racks while occupying a smaller footprint. Like standard horizontal racks, they are constructed with durable materials and finishes and require little or no maintenance. Installation of wall-mounted racks is usually done by vertically staggering the fixtures, thereby preventing handlebar conflicts while enabling the individual bicycle footprints to be overlapped. This achieves significant space savings over conventional horizontal bicycle racks.

Secure vertical bicycle parking racks in indoor bike room

Detail of hook and cable attachment for secure vertical bike rack

Figure 8-13:
Vertical Bike Racks

There are two disadvantages to wall-mounted bicycle racks. Since the fixture requires the user to tilt their bicycle into a vertical position onto its rear wheel and lift, only users of a certain height and strength level can use them. However, this is not an obstacle for the majority of users, because proper placement of the racks requires the user to lift their bicycle only 0.45 m **(1.5 ft)** off the ground.

The second disadvantage relates to ADA design requirements. Because some wall-mounted racks protrude up to 1.2 m **(4 ft)** from the surface of the wall, they require some kind of cane detection device surrounding the parking area to prevent injury of the vision-impaired.

8-4.4 Bike Rack Type Summary

Table 8-1 summarizes the relative strengths and weakness and basic footprints of the bicycle parking facilities discussed in this section.

Table 8-1:
Bicycle Parking Fixtures – Design Features

Class of Fixture Type	Model	# bikes parked per fixture	Total dimensions for fixture & operating space (m)	Approximate total sq m. for fixture & operating space	Sq Meters for fixture & operating space per bike	Advantage	Disadvantage
Less-Secure	Inverted-U	**2**	3 x 0.8 **10 x 2.5**	2.4 sq m **25 sq ft**	1.2 sq m **12.5 sq ft**	Durable, maintenance-free, inexpensive, easy to install, highly modular, easy to use, maximizes horizontal space, less-secure than others	Not as space- efficient as vertical or two-tiered racks
	Multiple Loop	**12**	3 x 4.2 **10 x 14**	12.6 sq m **140 sq ft**	1.05 sq m **11.65 sq ft**	Same as above	Same as above
	Bike Bank	**2**	3 x 2 **10.75 x 5.5**	5.6 sq m **60 sq ft**	2.8 sq m **30 sq ft**	Higher security than standard inverted-U; stores gear with rack.	More maintenance & replacement, not intuitive to use, not as space- efficient as other fixtures.
	Wall Rack	**2**	1 x 2.5 **3.75 x 8**	2.75 sq m **30 sq ft**	1.38 sq m **15 sq ft**	Durable, inexpensive, maintenance-free, modular, maximizes space by reducing bicycle footprint, fairly secure for short-term use, easy to use, fits in covered or indoor areas easily	Not as secure as inverted-U or bike bank, may be more difficult to install due to weight requirements for wall-mounting, may be difficult to use for smaller commuters
Secure	Modular or Locker System	**12**	Modular: 5 x 7 (island) **16.12 x 2** 3.5 x 9 (row) **11.25 x 30** Locker: 6 x 7 **18.5 x 24.5**	36 sq m (island) **388 sq ft** 31.5 sq m (row) **338 sq ft** Locker: 40.7 sq m **453 sq ft**	3 sq m (island) **32.3 sq ft** 3 sq m (row) **28.2 sq ft** Locker: 3.4 sq m **37.75 sq ft**	Increased security, modular locker design is space-efficient and excellent weather protection.	Require maintenance and lease management, security dependent on construction materials, may be flammable; require more operating space due to locker door.

8-5.0 Bicycle Access to Transit

An FHWA National Biking and Walking Study reported that a large proportion of parking spaces at public transit park-and-ride lots are occupied by automobiles that have been driven distances of 5 km **(3 mi)** or less. Many people are willing to walk half a mile (or approximately 20 minutes) to points of public transportation access. However, some people are also willing to bicycle for 20 minutes – or ride for 5 km **(3 mi)** or more– to access public transit.

There is opportunity to create a mode shift for many commuters from automobiles to bicycles. Encouraging bicycle access to transit can help increase transit ridership and reduce automobile trips. One way to encourage bike access to transit is to create good bicycle accommodations at transit stations (including bus transit centers, park-and-ride lots, and rail stations).

Accommodations for bikes at transit facilities can range from short-term, low-security parking (bike racks) to long-term, high-security parking (bicycle lockers and a staffed bicycle commuter station). Space permitting, a mix of parking types should be provided at transit stations. See Table 8-1 for descriptions of various bicycle parking types and their associated footprint, capacity, level of security and other characteristics.

Accompanying amenities or services desirable to bicyclists at transit stations include gear storage lockers, bicycle repair, retail sales of parts and clothing, bike rental, food and snack sales, information kiosks, and shower and changing facilities. These services are especially in demand at key transfer points with significant existing and potential bicycle parking.

8-5.1 Bicycle Parking at Transit Stations

Transit stations should provide a combination of security levels of bike parking. There is typically a greater demand for long-term parking at transit stations. In high-traffic areas with limited space, consider the installation of vertical racks. All transit bike parking facilities should have a roof to protect bicycles from snow and rain.

Estimating the demand for bicycle parking at transit stations is in its infancy. Puget Sound and the City of Chicago have estimated the potential market for bicycle parking based on population within a one-mile radius of a transit station, percent of people who commute via bicycle, and potential employment destinations. In addition, seasonal constraints, site-specific design constraints, and local bicycling conditions affect usage. A facility’s design, which may include size and location, hours of operation, and phasing of implementation, should be determined after estimating the potential demand.

The route by which bicyclists access parking areas should not be an afterthought to facility design and location. The entrance to the parking should be level and free of obstructions. Access to the bicycle parking facility and the access route itself should be well marked. When developing traffic circulation patterns for transit facilities, special attention should be given to the following:

- Location and number of access points to the public streets (especially in relation to existing traffic controls and mass transit facilities)
- Width of interior aisles and access points

- General interior circulation
- Separation of pedestrian and vehicular traffic
- Provision of adequate operating area for bicycles
- Access to community facilities
- Secure, convenient arrangement of parking areas that do not detract from the use and enjoyment of adjacent or proposed buildings and other features

8-5.2 Access to Buses and Trains

Providing bicycle access on public transit buses, trains, and light rail allows commuters to extend the effective length of a bicycle commute and thereby reduce the number of automobiles on the road. Bicycles should be permitted on buses, light rail trains, and commuter rail vehicles to allow for more flexibility in transportation choice.

8-5.2.1 Bicycle Access to Buses

Many public transit agencies around the United States, including the Metropolitan Council, the public transit agency serving the Minneapolis-St. Paul metropolitan area, and most Greater Minnesota Transit Systems have installed bike racks on many or all buses. Typically, racks accommodating two bicycles are mounted on the front end of a bus. Bicycles can be mounted on racks in 10 to 15 seconds, not seriously inconveniencing customers or delaying buses. Externally mounted racks prevent bus passengers from being disturbed and prevent dust and dirt being tracked into the bus.

Figure 8-14:
A bike rack on transit bus

Federal funding under the Congestion Mitigation and Air Quality Improvement Program (CMAQ) and other programs are often available to subsidize the cost of bus racks.

Bus racks are available as an after-market product and installable on most buses. In the Twin Cities and most metropolitan areas, use of the racks is free to encourage ridership.

8-5.2.2 Bicycle Access to Commuter Rail

It is recommended that any new commuter rail system or rail car addition include provisions for bicycles. Generally, the bicycle storage area and area for wheelchair users is shared, with the wheelchair users receiving priority seating.

The Metropolitan Council planned for bicycle storage on all trains on the Hiawatha Light Rail Line. Each train has storage for four bicycles, but that number may be limited during peak commuter periods.

Before a program of bicycles on trains is initiated, it is recommended to first launch a pilot program during non-rush hours. Depending on demand and customer feedback, the bike-on-trains program can be expanded.

8-6.0 Estimating Parking Provisions

No general rule can predict how much bicycle parking will be needed. The amount will vary depending on land uses and local habits. Wherever possible, local empirical data should be used as the basis for establishing the number of spaces provided. A simple bicycle count or a survey might suffice, allowing for the growth anticipated when adequate access facilities are provided.

Some municipal parking regulations call for bicycle parking spaces as a percentage of the number of auto spaces required. Examples are 10 percent of auto parking for offices, hotels, and retail to 30 percent for recreation sites, community centers, and sports clubs. A good practice is to supply a given amount and then monitor usage to determine if more may be required. High-demand locations should allow room for addition of more racks if needed at a later date.

Table 8-2 illustrates general recommendations for bicycle parking provisions. In high-demand areas, and as bicycle use increases, localities may wish to provide more than the number recommended.

Some municipalities have determined that bicycle parking should be required at a fixed rate based on the quantity of automobile parking. Naperville, Illinois, requires that bicycle parking should be equal to 10 percent of automotive parking. The City of Santa Cruz, California, requires bicycle parking to be 35 percent of auto parking.

Table 8-2:	**Bicycle Parking Provision Recommendations**			
Land Use		**Bicycle Spaces Required**	**Secure (%)**	**Less-Secure (%)**
Residential	Single Family / Two family	N/A	N/A	N/A
	Apartment / Town house	1 per unit plus 6 space rack at each building entrance	100	6 space rack
Commercial	Hotel/Motel	>75 rooms – 1 per 15 rooms <75 rooms – 6 space visit rack	60	40
	Office, rental sales of goods and services, restaurants, research establishments, laboratories	1 per 750 SF gross floor area for first 15,000 SF and 1 per 1,500 SF of additional area	50	50
	Shopping Center	1 per 750 SF gross leasable area for first 15,000 SF and 1 per 1,500 SF for gross leasable area of any additional area	30	70
Institutional	All	1 per 3,000 SF	80	20
	Hospital	1 per 1,500 SF	75	25
	Schools	All levels: 1 per 10 employees	10	90
	Elementary	1 per 10 students	-	100
	Junior Secondary	1 per 8 students	-	100
	Senior Secondary	1 per 8 students	-	100
	College	1 per 5 students	-	100
	University	1 per 5 students (full time, max. attendance)	-	100
	Places of Worship	1 per 50 members	-	100
	Library/Museum/Art Gallery	1 per 300 SF gross floor area	20	80
	Personal Care/Nursing Home/Group Home	1 per 15 dwelling	75	25
	Correctional Institutions	1 per 50 beds	70	30
Cultural and Recreational	Community Center	1 per 240 SF of gross floor area	20	80
	Stadium, Arena, Pool, Exhibition Hall	1 per 300 SF of surface area	20	80
	Gymnasium, Health Spa	1 per 240 SF of surface area	20	80
	Bowling Alley	1 per 2 alleys	20	80

Secure: Bicycle parking provides protection for bicycles and equipment.
Less-Secure: Racks where bicycles can be securely locked.
SF = Square Feet

Source: Victoria Transport Policy Institute; Vancouver, British Columbia.

Example: City Bicycle Parking Code

Bicycle Parking in the Minneapolis Zoning Code

Chapter 530. Site Plan Review

530.170

Interior landscaping of parking lots. The corners of parking lots where rows of parking spaces leave areas unavailable for parking or vehicular circulation shall be landscaped as specified for a required landscaped yard. Such spaces may include architectural features such as benches, kiosks or bicycle parking.

Chapter 535. Regulations of General Applicability

535.140

>>>

(d) Content of plans. Any TDM shall contain at least the following:

A description of mitigating measures designed to minimize the transportation impacts of the development, including but not limited to on-site transit facilities, transit use incentives, preferential location of car pool and van pool parking, on-site bicycle facilities including secure storage areas and amenities, staggered starting times and telecommuting opportunities.

Chapter 541. Off-street Parking and Loading

541.220.

Bicycle parking. (a) Uses. A minimum of four (4) bicycle parking spaces may be provided in lieu of not more than one (1) required automobile parking space.

(b) Location. Bicycle parking spaces and racks shall be located in a convenient and visible area no farther from the principal entrance to the building served than the closest automobile parking space. With the permission of the city engineer, bicycle parking may be located in the public right-of-way. Bicycle parking may be provided within a building, but the location shall be easily accessible for bicycles.

(c) Covered spaces. If accessory automobile parking spaces are covered, bicycle parking spaces shall also be covered.

541.440.

Bicycle parking in the downtown districts. Where passenger automobile parking is provided, one (1) secure bicycle parking space shall be provided within the parking facility for every twenty (20) automobile spaces, but in no case shall fewer than four (4) or more than thirty (30) bicycle parking spaces be required. Where automobile parking spaces are monitored or are covered or weather protected, bicycle parking spaces shall be provided on the same basis. For the purposes of this section, a secure bicycle parking space shall include a bicycle rack which permits the locking of the bicycle frame and one (1) wheel to the rack, and which supports the bicycle in a stable position without damage to wheels, frame or components.

Chapter 549. Downtown Districts

549.170.

Bicycle facilities in new developments. (a) In general. All developments containing five hundred thousand (500,000) square feet or more of new or additional gross floor area shall include secure bicycle parking spaces, shower facilities and clothing storage areas as provided in Table 549-3, Required Bicycle Facilities. Such facilities shall be for the use of the employees and occupants of the building. Where a development includes automobile parking spaces that are monitored or are covered or weather protected, bicycle parking spaces required by this section shall be provided on the same basis. For the purposes of this section, a secure bicycle parking space shall include a bicycle rack that permits the locking of the bicycle frame and one (1) wheel to the rack, and that supports the bicycle in a stable position without damage to wheels, frame or components.

(b) Exceptions. This section shall not apply to buildings used primarily as hotels or for retail or residential purposes.

551.175.

Transit Station areas. The following additional regulations shall govern development within PO Overlay Districts in and around the following transit stations, as shown on the official zoning maps:

Cedar-Riverside LRT Station
Lake Street/Midtown LRT Station
38th Street LRT Station
46th Street LRT Station

(6) Bicycle parking requirement.

(a) Nonresidential uses. Each nonresidential use shall provide a minimum of two (2) bicycle parking spaces or one (1) space for each ten (10) accessory automobile parking spaces, whichever is greater.

(b) Multiple-family dwellings. For multi-family residential uses, a minimum of one secured bicycle parking space shall be provided for each dwelling unit. Bicycle parking spaces shall be in enclosed and secured or supervised areas providing protection for each bicycle from theft, vandalism and weather.

8-6.1 Bike Parking in Garages

Public parking garages are encouraged to install bicycle parking areas. If bike parking areas were not included in the original design, the facility may be retrofitted by replacing automobile stalls with bicycle racks. The ratio of bicycle parking that should be provided at pubic garages can be determined case-by-case based on local demand. The City of Portland, Oregon, recommends providing one bicycle parking space for every 20 automobile parking spaces (with a minimum of 10 bike spaces).

The design of certain parking structures creates “dead space,” or striped areas that are not feasible for car parking. These areas can be converted to bicycle parking. Control of bicycle parking can eliminate the possibility of abandoned bicycles. In addition, the parking area can be contained with fencing materials to limit access and create a safer environment.

San Francisco passed legislation that mandates the installation of bicycle parking in all City and privately owned garages that rent automobile space to the public. Such garages are subject to the bicycle parking requirements of the San Francisco Planning Code.

8-7.0 Fixtures and Services to Accompany Bicycle Parking

Auxiliary fixtures and services can enhance a bicycle parking environment and are generally appreciated by bicyclists. A variety of services should be considered in areas of high-volume bicycle parking. These elements include but are not limited to the following.

- Lockers to store gear
- Information on transit and area bicycling resources
- Vending machine sales of commonly needed supplies (e.g., bicycle inner tubes, patch kits, beverages, snacks)
- Air hose
- Drinking water (free)
- Attended retail (e.g., coffee cart, café, dry cleaning service)

- Attended free bicycle parking
- Bicycle repair shop (small or satellite of nearby shop)
- Bike boxing services (at locations en route to Amtrak or airports)
- Flexcar pickup and rental of alternative fuel “station cars” and other vehicles
- Bike rentals
- Showers and changing rooms
- Offices or meeting rooms
- Storage for bicycles recovered from transit lost and found programs

Chapter 9: Maintenance

9-1.0 Introduction

The maintenance of bikeways is closely linked to bicyclists' safety and the preservation of the bikeway function and investment. Poor maintenance, resulting in the accumulation of sand, gravel, broken glass, or branches, and the development of potholes, corrugations, and other rough surface conditions brings about unsafe bicycling conditions and may cause bicyclists to avoid the bikeway to choose an alternative route that may not be suitable or safe. Maintenance should be regarded as an investment in the bikeway and insurance against repairs that can be costly.

This chapter covers the primary tasks involved with maintaining surface quality, maintenance, vegetation management, snow and ice control, and the role and tasks associated with maintenance agreements and maintenance plans. Further guidance is available through the most current edition of the *Maintenance Manual and Maintenance Bulletins*.

The needs of all road users, motorists, transit, bicyclists and pedestrians, including those with disabilities, through a temporary traffic control zone, shall be an essential part of construction and maintenance operations. Temporary traffic control plans and devices are the responsibility of the authority having jurisdiction for guiding road users. Shared use paths also need temporary traffic control to guide bicyclists and other path users during construction or maintenance activities. For information about temporary traffic control for maintenance operations, see *MN MUTCD* and the *Temporary Traffic Control Zone Layouts: Field Manual*. For information about work zone safety, contact the Office of Maintenance for technical support and guidance on temporary traffic control and safety during maintenance operations.

9-2.0 Surface Quality

The quality of a bikeway's surface, whether a shoulder, shared use path or bike lane, is critical in promoting safe and efficient bicycle transportation. Shared use paths also serve other users such as pedestrians and in-line skaters who also benefit from a smooth riding surface. Often, shoulders need also to be maintained for pedestrians as well. Gaps between pavement slabs, drop-offs, and patches parallel to the direction of travel can trap a bicycle wheel and cause a bicyclist to lose control. Potholes and bumps can cause bicyclists to swerve into the path of other users or motorized vehicles. Pavements on shoulders and bike lanes should be at least as smooth as the adjacent road. Bicyclists and pedestrians may avoid a facility designed for their use if it is not maintained.

Surface irregularities include two types of hazards: cracks and projections. Cracks are generally fissures such as the gap between two slabs of pavement. Cracks can be longitudinal or transversel to the direction of the pavement or path. There are also joints (controlled cracks) that may fail and become a hazard to pedestrians and bicyclists. Projections are depressions or concavities, for example a pothole or pavement sinking. Projections may be caused by sinking drainage grates or crude patch jobs. Projections can also be convexities or bumps, for example heaving of pavement. They are further classified as having a parallel or perpendicular orientation. A single surface irregularity may not cause as much hazard as a group of irregularities or continuous irregularities if the irregularity has not exceeded the maximum acceptable width or height. Table 9-1 shows the recommendations for maximum acceptable surface irregularities on bikeways.

Table 9-1: Maximum Acceptable Surface Irregularities on Bikeways

Orientation of the Irregularity to Bike Traffic	Width of Cracks *	Height of Projections **
Parallel	13 mm (0.5 in)	10 mm (0.375 in)
Perpendicular	20 mm (0.75 in)	20 mm (0.75 in)

* Cracks/fissures are in the surface. Cracks are often found in hot-mix asphalt surfaces or between slabs of Portland cement concrete.

** Projections are abrupt changes in the surface of a traveled way. Sinking drainage grates, crude asphalt, pavement joints, pedestrian ramp transitions, or root growth under pavement may cause projections.

The following actions promote a well-maintained surface for bicyclist's safety and comfortable bicycling experience and should be included in an overall maintenance plan:

- Install public utilities such as manhole covers and drainage grates outside of bikeways.
- Inspect control joints on paths, shoulders and bike lanes.
- Schedule regular maintenance to remove sand (including early removal of sand left by winter operations), earth, snow, ice, and other matter that may cause skidding. The tires on most bicycles range in width from 20 mm to 60 mm (.8 to 2.4 in) with a contact surface of approximately 3 mm (.12 in) or wider. They often provide little traction. If the pavement is wet or covered with sand or leaves, the bicycle has even less traction and needs more room to brake. (Initial proper cross-slope and drainage ditch design is a key to preventing surface debris).

Figure 9-1: Deteriorated Shared-Use Path and Faded Markings

- Localized areas that are seriously deteriorated should be reconstructed prior to application of the seal and/or placement of the overlay. To provide for safe bicycling during seal coating, sand-type aggregate (FA1 or FA2) only should be used, signs should be provided warning of loose sand, and the excess aggregate should be removed as soon as possible. If possible, provide an alternate route. Also, cracks should not be overbanded with sealant. Pavement overlay design through tunnels and underpasses must maintain required vertical clearance as discussed in this manual and the Mn/DOT RDM.

- Eliminate surface irregularities that may make bicycling bumpy, and/or cause bicyclists to choose a different route that may not have adequate bicycle accommodation.
- Ensure that drainage grates, if located on or near a bikeway, have narrow openings and that the grate openings are placed perpendicular to the riding surface.
- Potholes should be repaired and be a part of routine maintenance procedures. Pavement fill should be flush with surrounding pavement.
- Replace obsolete signage and upgrade signage that is damaged or not retroreflective. See the *MN MUTCD* for standards and guidelines.

9-3.0 Vegetation Management

The management of vegetation is generally considered the responsibility of maintenance staff. To provide long-term control of vegetation, the management of vegetation should be considered during design and construction. Vegetation management helps to maintain smooth pavement surface, as well as clear zones, sightlines, and sight corners to promote bicycling safety.

The following are examples of vegetation control methods that may be done before or during construction.

- Place a tightly woven geotextile or landscape fabric under the asphalt pavement. This method may be chosen in sensitive areas where a nonselective herbicide is undesirable. Several brands of geotextiles are available. Many provide additional structural support for the asphalt paving as well, and may allow reduced pavement thickness.
- Control undesirable "volunteer" vegetation and noxious weeds during construction. Vegetation shall be controlled for all state listed prohibited noxious weeds and all secondary noxious weeds listed by the county where the work will be conducted. In addition to the specified state and

Figure 9-2:
Urban Shared-Use Path Lacking Vegetation Control

county noxious weeds, the contractor, or the jurisdiction performing the maintenance function, shall be responsible for control of the following species: Wild Parsnip *(Pastinaca sativa)* as well as the vegetation listed below.

Canada thistle	Sow thistle
Bull thistle	Musk thistle
Plumeless thistle	Wild hemp
Poison ivy	Leafy spurge

Cite the state and county noxious weed list (and website address) in any agreement. Although the list may change in any maintenance or vegetation management agreement, the agreement should refer to the current list of state and county noxious weeds. It may be determined that other species should be controlled. This is on a case by case basis. For example, restricted noxious weeds (the buckthorns) could be added to the list of species to be controlled.

- Root barriers can be beneficial to prevent root intrusion to the path surface. Suckering plants are the ones most likely to come through the path surface.
- Place a non-selective herbicide such as Arsenal (imazapyr) under asphalt paving. All applications must be done according to label directions. The applicator must be licensed with the proper endorsements (A, J and possibly E) by the Minnesota Department of Agriculture. It is common for thin bituminous surfaces with shallow subsurface treatments, such as shared use paths, to be ruined by vegetation. This herbicide will prevent vegetative growth from penetrating the asphalt paving for a number of years. Caution is needed in applying non-selective herbicides. They may injure nearby trees if their root systems grow into the treated area.
- Vegetation blocking sight lines or sight corners should be removed. In a contract, require selective vegetation removal of vegetation such as low-hanging branches. Also, bikeways and pedestrian facilities should be checked after severe weather events to evaluate, remove and/or clear any fallen trees or other debris.

9-4.0 Snow and Ice Control

Snow removal is a critical component of bicycle safety. In designing roadways, roads should be designed to allow for snow storage. The roadside should have adequate space to place plowed snow so that it does not block a pedestrian way or a share use path that may be adjacent to the road. Separation between road and path, such as a wide planting strip, allows for snow storage.

Snow and ice can force bicyclists onto facilities that may not have adequate bicycle accommodation or require them to take a route that is a longer distance. When the surface of the road is covered by snow, the pavement markings that guide and warn motorists and bicyclists may be difficult to see. Care should be taken to clear roads so that pavement markings are identifiable. After a snow event, snow should be plowed so that it does not block bike lanes, sidewalks or curb ramps (pedestrian ramps). Clear snow from curb to curb, to allow bicyclists to travel as far as possible to the right side of the road.

As part of maintenance operations, public agencies' standards and practices must ensure day-to-day operations keep the path of travel open and usable for persons with disabilities, throughout the year. This includes snow and debris removal, maintenance of pedestrian traffic in work zones, and correction of other disruptions. Maintenance plans and maintenance agreements need to identify how snow and ice control will meet ADA requirements. Identifying locations that would significantly impede bicycling access and safety if not cleared of snow and ice allows maintenance staff to focus on clearing snow and ice at these locations immediately after a storm event. High priority locations are pedestrian ramps and road crossings.

9-5.0 Maintenance Agreements

The responsibility for maintenance and operations belongs to the jurisdiction that owns the facility. However, maintenance agreements can be used to assign maintenance responsibilities to another agency and specify reimbursement of maintenance costs. Maintenance responsibility should be established before construction if another jurisdiction will carry out the maintenance function. During the scoping phase of the project, well before construction, state and local agencies should reach an agreement regarding responsibilities for operation and maintenance. Typically, for road shoulders, maintenance is the responsibility of the jurisdiction that owns the road. For shared use paths, a maintenance agreement with another agency may be used to perform routine, minor, and/or major maintenance. Maintenance agreements and shared responsibilities can result in consistent, cost effective and timely maintenance.

Following the construction of a shared-use path, the path may be operated and maintained by the local agency through a maintenance agreement with Mn/DOT.

Typical bikeway operations and maintenance tasks may include, but are not limited to, the following. See section 9-6.0 for other tasks associated with a maintenance plan.

- Developing a maintenance plan.
- Operating the shared-use path in accordance with local standards and guidelines of local agency and state law.
- Maintaining bikeway year round, including clearing snow and ice and sweeping sand or other debris early in the spring. This includes removing snow and ice that may accumulate as a result of plowing operations on adjacent highways.
- Keeping the shared-use path free from obstructions and impediments that may interfere with bicycle and pedestrian traffic. Maintenance will include all necessary preventive and corrective actions to preserve the path and its associated walkways, drainage structures, ditches, bridges, tunnels, and shoulders.
- Performing landscaping alongside path and shoulders, including regular mowing; tree, shrub and flower upkeep and replacement; litter and debris collection and disposal in accordance with state law and the standards and guidelines of the local agency.
- Inspecting and maintaining the signing, striping, traffic control devices, fencing, railings, safety devices, lighting systems, and any decorative enhancements.
- Paying all the associated utility bills and notifying Gopher State One Call prior to any work. Maintenance could affect utilities along the bike lane, shoulder or path.

9-6.0 Maintenance Plans

Developing and following a maintenance plan enhances and extends the safety, function, and life cycle of a bikeway. Maintenance plan tasks include, but are not limited to, the tasks listed in Table 9-2 whether maintenance is conducted by the jurisdiction of ownership, a contractor, or through another entity through a maintenance agreement. If the bicycle facility is a shared use path, the tasks listed in Table 9-2 apply except for the task listed as “Shoulders.”

Each bicycle facility should have a maintenance schedule and should be determined in its scoping and planning. Shared use paths are used by both bicyclists and pedestrians, so the needs of pedestrians must also be included in the maintenance plan. As some road shoulders can be used by pedestrians, pedestrian needs should to be addressed as well.

Table 9-2: Maintenance Plan Tasks

Item	Tasks
Overall Inspection	Inspect for obstructions and remove any fallen tree and shrub limbs or right-of-way encroachments in the path’s clear zone and within 1.8 m (6 ft) of the path edge.
Pavement Surface	Pavement surface should be kept reasonably clear of debris and limbs that would constitute tripping hazards for pedestrians or bicyclists. Check and correct as necessary for cracking, raveling, corrugations, potholes, and bridge approach settlement. See Surface Quality section 9-2.0.
Signs and Markings	Traffic signs and pavement markings (striping) should be maintained as originally installed. This includes signing and marking (striping) on both the shared used path and signing and marking (striping) for path crossing roadways, and signing and markings directed at motorists. All devices, signs, and markings (striping) shall be in conformance with the *Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD)*.
Curb Ramps	Check that curb ramps are in proper position and that detectable warnings have not deteriorated.
Signals and Lights	Damaged or malfunctioning traffic warning signals should be promptly repaired or temporary corrections made until permanent repairs can be made. Luminaires and fixtures for illuminated signs not essential for traffic safety should be routinely scheduled for repair or replacement. Report malfunctions promptly to the jurisdiction that has authority over lighting and signals.

Table 9-2: Maintenance Plan Tasks (Continued)

Item	Tasks
Vegetation Management	Safety, aesthetics, and compatibility with adjacent land use are the prime considerations in proper vegetation control. Trees, shrubs, and tall grass should be trimmed to provide a minimum 0.6 m (2 ft) clear zone from the edge of the pathway and a minimum of 3.0 m (10 ft) overhead clearance. Also, vegetation at intersections should be kept cleared to provide an acceptable sight triangle. See Vegetation Management section 9-3.0.
Shoulders	Shoulders should be free of debris and properly sloped to ensure adequate drainage. Paved shoulders should be free of debris, surface irregularities, and potholes. Unpaved shoulders should be free of ruts. Care should be taken on shoulders with rumble strips which may force bicyclists farther out from the right edge of the shoulder which is typically debris-free. Sweeping of shoulders with rumble strips helps to remove debris and accommodate bicyclists. See Surface Quality section 9-2.0.
Safety Railings and Fencing	Safety railings on bridges and approaches should be maintained approximately true to line, grade, and functional height. Damaged railings should be repaired or replaced.
Drainage	Culverts, ditches, and gutters should be kept open and in a state of good repair. Erosion should be kept to a minimum.
Encroachments	If right-of-way encroachments, such as advertisement signs, are not approved and/or warranted, they should be removed.
Structures	Bridges and tunnels/underpasses should be thoroughly inspected by a qualified professional at approximately two-year intervals. In addition, the following items should be checked for routine maintenance: ● Approach safety railings and bridge railings ● Settlement of approach fills ● Condition of deck (see Pavement Surface) ● Slope paving or rock slope protection. ● Deck drains and oversized drains ● Debris plugging channels ● Retaining walls ● Appurtenances, such as benches, restrooms, water fountains, and kiosks

Table 9-2: Maintenance Plan Tasks (Continued)

Item	Tasks
Snow and ice control	Remove snow and ice from paths, bike lanes, shoulders and pedestrian ramps and clear snow on roads from curb to curb and along the path. See section 9-4.0.
Temporary traffic control	See *Minnesota Manual on Uniform Traffic Control Devices (Mn MUTCD)* for requirements in setting up temporary traffic control. See section 9-1.0.
Seal Coating	● Provide temporary warning sings for bicyclists ● If possible, provide alternative bicycle route ● Use fine aggregate (FA1 or FA2) for bicycle safety ● Remove excess aggregate as soon as possible

Appendix A - Glossary

AASHTO: American Association of State Highway and Transportation Officials

ACCESSIBLE: A facility that provides access to people with disabilities using the design requirements of the ADA.

ADA: The Americans with Disabilities Act; Civil rights legislation passed in 1990 and effective July 1992. The ADA sets design guidelines for accessibility to public facilities, including sidewalks and trails, by individuals with disabilities.

ADAAG: Americans with Disabilities Act Accessibility Guidelines. ADAAG contains scoping and technical requirements for accessibility to buildings and public facilities by individuals with disabilities under the Americans with Disabilities Act (ADA) of 1990.

ADT OR AADT: Average Daily Traffic or Annual Average Daily Traffic. The average number of vehicles passing a certain point each day on a highway, road or street.

AVERAGE BICYCLISTS: The Design Bicyclists, comprised of both Group B (Basic Bicyclists) and Group C (Children).

BICYCLE: Every device propelled solely by human power upon which any person may ride, having two tandem wheels, except scooters and similar devices, and including any device generally recognized as a bicycle though equipped with two front or rear wheels (MN 169.01 Subd. 51). A bicycle is considered a vehicle by MN Statute 169.01 Subd. 2, MN 169.222 Subd. 1.

BICYCLE FACILITIES: A general term denoting improvements and provisions made by public agencies to accommodate or encourage bicycling, including parking facilities, bikeways, bikeways maps, and shared roadways not specifically designated for bicycle use.

BICYCLE LANE (BIKE LANE): A portion of a roadway or shoulder designed for exclusive or preferential use by persons using bicycles. Bicycle lanes are distinguished from the portion of the roadway or shoulder used for motor vehicle traffic by physical barrier, striping, marking, or other similar device. (MN 169.01 Subd. 70)

BICYCLE NETWORK: A continuous system of bikeways and roadways in a region or municipality.

BICYCLE-PEDESTRIAN PATH (SHARED-USE PATH): A path designated for the preferential or exclusive use of bicycles and pedestrians.

BICYCLE ROUTE SYSTEM: A roadway or shoulder signed to encourage bicycle use (MN 169.01 Subd. 62). It is desirable that a bicycle route establish one continuous routing, however, a combination of Mn/DOT defined bikeways is acceptable.

BIKEWAY: A bicycle lane, bicycle path, or bicycle route, regardless of whether it is designed for the exclusive use of bicycles or is to be shared with other transportation modes. (MN 169.01 Subd. 72)

CROSSWALK: That portion of a roadway ordinarily included with the prolongation or connection of the lateral lines of sidewalks at intersection or any portion of a roadway distinctly indicated for pedestrian crossing by lines or other markings on the surface. (MN 169.01 Subd. 37)

DESIGNATED SHARED STREET OR HIGHWAY: Any street or highway designated as a bikeway and recommended for use by bicyclists and characterized by basic signage and the absence of striping or marking for bicyclists. Traffic calming measures may be implemented to maximize their usefulness and safety.

GRADE: A measure of the steepness of a roadway, bikeway or walkway, expressed in a ratio of vertical rise per horizontal distance, usually in percent.

GRADE SEPARATION: The vertical separation of conflicting travelways with a structure, such as an interchange, overpass or underpass.

GROUP A — ADVANCED OR EXPERIENCED BICYCLISTS: The FHWA Design Bicyclists comprised of advanced or experienced riders who can operate under most traffic conditions.

GROUP B — BASIC BICYCLISTS: The FHWA Design Bicyclists comprised of casual or new adult and teenage riders who are less able to operate in traffic without provisions for bicycles.

GROUP C — CHILDREN: The FHWA Design Bicyclists comprised of pre-teen riders whose roadway use is initially monitored by parents and eventually are accorded independent access to the roadway system.

HIGHWAY: A general term denoting the public way for purposes of vehicular travel, including the entire area within the right-of-way.

INTERSECTION: The crossing of two or more highways or bikeways at the same grade.

MUTCD: The "Manual on Uniform Traffic Control Devices," approved by the Federal Highway Administration as a national standard for placement and selection of all traffic control devices on or adjacent to all highways open to public travel.

MN MUTCD: Similar in nature to the "Manual on Uniform Traffic Control Devices," this document contains the standards as adopted by the Minnesota Commissioner of Transportation for traffic control devices that regulate, warn, and guide road users along all roadways within the State of Minnesota.

NON-MOTORIZED: Pedestrian, bicycle and other types of traffic propelled by human power.

PATH: A bikeway or walkway, typically paved, that is physically separated from motor vehicle traffic by on open space or barrier.

PEDESTRIAN: Any person afoot or in a wheelchair. (MN 169.01 Subd. 24)

RIGHT-OF-WAY: A general term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to transportation purposes. "Right-of-way" also may mean the privilege of the immediate use of the highway. (MN 169.01 Subd. 45)

ROADWAY: That portion of a highway improved, designed, or ordinarily used for vehicular travel, exclusive of the sidewalk or shoulder. In the event a highway includes two or more separate roadways, the term "roadway" as used herein shall refer to any such roadway separately but not to all such roadways collectively. (MN 169.01 Subd. 31)

RUMBLE STRIP: A band of raised material or indentations formed or grooved in the pavement that transmits sound and vibration through the vehicle, alerting inattentive drivers.

RURAL SECTION (RURAL CROSS SECTION): A highway design that has wide rights-of-way, open ditches for drainage, and a clearway of usually 9 m **(30 ft)** from the edge of the outside line. The terminology refers only to the typical roadway cross section, regardless of its location, and does not pertain to land use adjacent to the roadway.

SHARED LANE: Any roadway or travel lane upon which a separate bicycle lane is not designated and which bicycles may legally use, whether or not such facility is specifically designated as a bikeway or bike route.

SHARED-USE PATH: A bikeway that is physically separated by a roadway or shoulder by the use of an open space buffer or physical barrier. A shared-use path can also be used by a variety of non-motorized users such as pedestrians, joggers, skaters and wheelchair users.

SHOULDER: That part of a highway which is contiguous to the regularly traveled portion of the highway and is on the same level as the highway. The shoulder may be pavement, gravel, or earth. (MN 169.01 Subd. 73)

SIDEWALK: That portion of a street between the curb lines or the lateral lines of a roadway and the adjacent property lines, intended for the use of pedestrians. (MN 169.01 Subd. 33)

STREET OR HIGHWAY: The entire width between boundary lines of any way or place when any part thereof is open to the use of the public, as a matter of right, for the purposes of vehicular traffic. (MN 169.01 Subd. 29)

TRAIL: There are several different types of trails, which may accommodate different groups of non-motorized and motorized users, including all-terrain vehicles, bicyclists, cross country skiers, equestrians, hikers, in-line skaters, skiers, snowmobiles, snowshoes and wheelchair users. In general usage, but not in this manual, shared-use paths or bike paths are sometimes referred to as multi-use trails or bike trails. A designated trail may or may not meet all of the criteria for a bikeway.

TRAVELED WAY: The portion of the roadway for the movement of vehicles, exclusive of the shoulders.

URBAN SECTION (URBAN CROSS SECTION): A roadway design that includes curbs and gutters. The terminology refers only to the typical roadway cross section, regardless of its location, and does not pertain to land use adjacent to the roadway.

VEHICLE: Every device in, upon, or by which any person or property is or may be transported or drawn upon a highway, excepting devices used exclusively upon stationary rails or tracks. (MN 169.01 Subd. 2)

WIDE OUTSIDE LANE: The right-most through traffic lanes that are wider than 3.6 m (12 ft). Also called a wide curb lane in some cases.

Appendix B – Federal Funding Programs that may be used for bicycle and pedestrian activities

Table B-1: Federal Highway Administration programs that may be used for bicycle and pedestrian activities	
Federal Highway Administration Programs	
Program/Primary Purpose	**Eligible Pedestrian and Bicycle Activities**
Metropolitan Planning (23 USC 104(f))	
Transportation planning in urbanized areas in accordance with 23 USC 134 and 49 USC 5303.	Bicycle and pedestrian planning as part of the metropolitan planning process.
Statewide Planning (23 USC 505)	
Statewide transportation planning in accordance with 23 USC 135 and 49 USC 5304.	Bicycle and pedestrian planning as part of the statewide planning process.
National Highway System (NHS) (23 USC 103)	
Improvements to rural and urban roads that are part of the NHS or that are NHS Intermodal connectors.	Construction of pedestrian walkways and bicycle transportation facilities on land adjacent to any highway on the NHS.
Surface Transportation Program (STP) (23 USC 133)	
Construction, reconstruction, rehabilitation, resurfacing, restoration, and operational improvements for highways and bridges including construction or reconstruction necessary to accommodate other transportation modes.	Construction of pedestrian walkways and bicycle transportation facilities; nonconstruction projects for safe bicycle use; modify public sidewalks to comply with the Americans with Disabilities Act. Projects do not have to be within the right-of-way of a Federal-aid highway.
Surface Transportation Program Transportation Enhancements Set-aside (TE) (23 USC 133(d)(2))	
12 specific activities included in the definition of Transportation Enhancement Activities in 23 USC 101(a)(35).	3 of the 12 eligible categories are pedestrian and bicycle facilities, safety and education for pedestrians and bicyclists, and rail-trails.

Interstate Maintenance (IM) (23 USC 119)	
Resurfacing, restoring, rehabilitating, and reconstructing most routes on the Interstate system.	No specific eligibility, but funds may be used to resurface, restore, rehabilitate, and reconstruct pedestrian and bicycle facilities over, under, or along Interstate routes.
Highway Bridge Replacement and Rehabilitation (HBRRP) (23 USC 144)	
Replace and rehabilitate deficient highway bridges and to seismically retrofit bridges located on any public road.	Pedestrian walkways and bicycle transportation facilities on highway bridges. If a highway bridge deck is replaced or rehabilitated, and bicycles are permitted at each end, then the bridge project must include safe bicycle accommodations (within reasonable cost). (23 USC 217(e))
Highway Safety Improvement Program (HSIP) (23 USC 148)	
To achieve a significant reduction in traffic fatalities and serious injuries on public roads.	Improvements for pedestrian or bicyclist safety. Construction and yellow-green signs at pedestrian-bicycle crossings and in school zones. Identification of and correction of hazardous locations, sections, and elements (including roadside obstacles, railway-highway crossing needs, and unmarked or poorly marked roads) that constitute a danger to bicyclists and pedestrians. Highway safety improvement projects on publicly owned bicycle or pedestrian pathways or trails.
Congestion Mitigation and Air Quality Improvement Program (CMAQ) (23 USC 149)	
Funds projects in nonattainment and maintenance areas that reduce transportation related emissions.	Construction of pedestrian walkways and bicycle transportation facilities; nonconstruction projects for safe bicycle use. Projects do not have to be within the right-of-way of a Federal-aid highway, but must demonstrate an air quality benefit.

National Scenic Byways Program (NSBP) (23 USC 162)	
8 specific activities for roads designated as National Scenic Byways, All-American Roads, State scenic byways, or Indian tribe scenic byways. The activities are described in 23 USC 162(c). This is a discretionary program; all projects are selected by the US Secretary of Transportation.	Construction along a scenic byway of a facility for pedestrians and bicyclists and improvements to a scenic byway that will enhance access to an area for the purpose of recreation. 23 USC 162(c)(4-5). Construction includes the development of the environmental documents, design, engineering, purchase of right-of-way, land, or property, as well as supervising, inspecting, and actual construction. Construction of the recreation facility is not eligible.
Federal Lands Highways Program (FLHP) (23 USC 204)	
Coordinated program of public roads and transit facilities serving Federal and Indian lands. Funding is broken into 4 discrete sources: Indian Reservation Roads (IRR)Public Lands Highway - Discretionary & Forest Highways, Parkways & Park Roads, Refuge Roads	Construction of pedestrian and bicycle transportation facilities.
Recreational Trails Program (23 USC 206)	
Develop and maintain recreational trails and trail-related facilities for both nonmotorized and motorized recreational trail uses.	Nonmotorized or mixed use (motorized and nonmotorized) trails. Eligible categories are trail maintenance and rehabilitation, trailside or trailhead facilities, construction and maintenance equipment, trail construction, trail assessments, and trail safety and environmental protection education.
Transportation, Community, and System Preservation Program (TCSP) (S-LU Sec. 1117, formerly TEA-21 Sec. 1221)	
Provides funding for a comprehensive program including planning grants, implementation grants, and research to investigate and address the relationships among transportation and community and system preservation plans and practices and examine private sector based initiatives	Pedestrian and bicycle projects meet several TCSP goals, are generally eligible for the TCSP program and are included in many TCSP projects.

Coordinated Border Infrastructure Program (S-LU Section 1303)	
To improve the safe movement of motor vehicles at or across the border between the United States and Canada and the border between the United States and Mexico.	Eligible as part of an overall project.
Safe Routes to School (SRTS) (S-LU Sec. 1404)	
To enable and encourage children, including those with disabilities, to walk and bicycle to school; To make bicycling and walking to school a safer and more appealing transportation alternative, encouraging a healthy and active lifestyle from an early age; and to facilitate the planning, development, and implementation of projects and activities that will improve safety and reduce traffic, fuel consumption, and air pollution in the vicinity of schools	Infrastructure projects including planning, design, and construction of infrastructure-related projects to improve the ability of students to walk and bicycle to school, including sidewalks, traffic calming and speed reductions, pedestrian and bicycle crossing improvements, on-street bicycle facilities, off-street bicycle and pedestrian facilities, secure bicycle parking, and traffic diversion in the vicinity of schools. Noninfrastructure activities including public awareness campaigns and outreach to press and community leaders, traffic education and enforcement, student sessions on bicycle and pedestrian safety, health, and environment, and funding for training, volunteers, and managers of safe routes to school programs
Nonmotorized Transportation Pilot Program (NTPP) (S-LU Sec. 1807)	
To demonstrate the extent to which bicycling and walking can carry a significant part of the transportation load, and represent a major portion of the transportation solution, within 4 communities (Marin County, CA; Sheboygan County, WI; Columbia, MO; and Minneapolis-St Paul, MN).	Construction of nonmotorized transportation infrastructure facilities, including sidewalks, bicycle lanes, and pedestrian and bicycle trails, that connect directly with transit stations, schools, residences, businesses, recreation areas, and other community activity centers. Educational programs; promotion; planning; data collection, analysis, evaluation, and results reporting.
Source: *FHWA 2006*	

Table B-2: Federal Transit Administration programs that may be used for bicycle and pedestrian activities

Federal Transit Administration Programs	
Program/Primary Purpose	**Eligible Pedestrian and Bicycle Activities**
Metropolitan Planning Program (MPP) (49 USC 5305(d))	
To carry out the metropolitan transportation planning process under 49 USC 5303.	Bicycle and pedestrian planning as part of the metropolitan planning process.
Statewide Planning & Research (SPR) (49 USC 5305(e)	
To carry out the provisions of 49 USC sections 5304, 5306, 5315, and 5322.	Bicycle and pedestrian planning as part of the statewide planning process.
Urbanized Area Formula Grants (49 USC 5307)	
Transit capital and planning assistance to urbanized areas with populations over 50,000 and operating assistance to areas with populations of 50,000 - 200,000.	Improve bicycle and pedestrian access to transit facilities, including bike stations.
Urbanized Area Formula Grants Transportation Enhancements Set-aside (49 USC 5307(k))	
A one percent set-aside of section 5307 funds for areas with population over 200,000 population for 9 specific activities included in the definition of Transit Enhancement Activities in 49 USC 5302(a)(15).	Pedestrian and bicycle access, bicycle storage facilities, and installing equipment to transport bicycles on mass transportation vehicles.
Job Access and Reverse Commute Program (49 USC 5316))	
To provide transportation to connect welfare recipients and low-income residents to jobs and employment support services such as childcare and training.	To provide transportation to connect welfare recipients and low-income persons to jobs and employment support services such as childcare and training.
Alternative Transportation in Parks and Public Lands (49 USC 5320)	
To enhance national parks and public lands protection and increase the enjoyment of those visiting the parks and public lands.	Definition of “Alternative Transportation” includes “a nonmotorized transportation system (including the provision of facilities for pedestrians, bicycles, and nonmotorized watercraft)”.
Source: *FHWA 2006*	

Appendix C: Planning and Design Checklists

Table C-1: Planning Checklist for Bicycle Accommodation		
✓	**Task**	**Comments**
	Visit project site.	
	Review the project with Traffic Office.	
	Review the area crash history, including motor vehicle, bicycle, and pedestrian crash reports. Check police reports for other incidences in project area.	
	Determine current and future motor vehicle ADT and posted and design speed.	
	Research current and future land use. Check plats and plans.	
	Review and/or conduct pedestrian and bicycle traffic counts, conduct field observations, consult with local government and citizen groups and review survey results to estimate demand. Determine other user types that need greater operating space.	
	Review project with Mn/DOT's Bicycle and Pedestrian Section.	
	Review local government transportation and corridor plans, comprehensive plan, and bicycle network plan and gap maps.	
	Review Highway Project Development Process including Bikeways and Pedestrians section.	
	Review project with State Aid Office.	
	Meet each local government agency involved or affected by project.	

Table C-1: Planning Checklist for Bicycle Accommodation

✓	Task	Comments
	Review the Mn/DOT Road Design Manual Chapter 11, Section 3 & 4.	
	Review the Mn/DOT Bikeway Facility Design Manual.	
	Review the Mn/DOT Bicycle Modal Plan.	
	Check transit service in project area, including bus stops, routes, and transit hubs and park and ride locations.	
	Determine whether schools and parks (within 2 miles) have quality bicycle and pedestrian access.	
	Identify entities with typical high bicycle demand, including residential areas, shopping and employment centers, libraries, public housing, schools, colleges, playgrounds, and parks in project area. Check for worn paths along roads.	
	Identify parking zones (parking on paved shoulders) and potential bicycle/pedestrian potential conflicts.	
	Determine if adequate crossing opportunities exist and type of crossing needed.	
	Determine bicycle or pedestrian facilities that need improvement, for example: sidewalks, shoulders, signing or pavement markings, ADA compliance, curb ramps, lighting, etc.	
	Determine whether intersections accommodate bikes & pedestrians safely.	

Table C-2: Design Checklist for Bicycle Accommodation		
✓	**Task**	**Comments**
	Determine bikeway type and select appropriate section widths. Coordinate selection with pedestrian accommodation.	
	Provide acceptable alignment curvatures and profiles.	
	Meet State Aid or Federal standards.	
	Check for appropriate sight distance and widths at sharp corners.	
	Review appropriate design of pedestrian refuges, raised islands and medians at shared use path crossings.	
	Determine appropriate signing and striping, and traffic control	
	Meet ADA requirements.	
	Provide needed overhead clearance.	
	Provide adequate lighting at path crossings, along paths, and at intersections.	
	Check for proper drainage of bikeway including underpasses, shoulders, intersections, and shared use path crossings.	
	Provide bicycle safe drainage grates as needed.	
	Provide landscaping, pavement texturing, as needed.	

Table C-2: Design Checklist for Bicycle Accommodation		
✓	**Task**	**Comments**
	Review rumble strip type and placement for compatibility with bicycle accommodation.	
	Incorporate shared use path or trail, rest area, or transfer facility needs (parking, both bicycle and motor vehicle, shelters) as needed.	
	Establish temporary traffic control plan and/or determine alternative route for construction.	
	Review project with Maintenance.	
	Provide Municipal Agreement if needed.	
	Provide Maintenance Agreement if needed.	

Minnesota State Department of Transportation

Transit Office
395 John Ireland Boulevard
St. Paul MN 55155-1899
www.dot.state.mn.us/bike