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Section 1
Introduction

1.1 Purpose of This Handbook

The purpose of this handbook is to provide guidelines and criteria for planning, design, construction, operation and maintenance of safe on-road bicycle facilities and shared use paths.

This handbook is intended to serve as an aid to engineers, designers, planners, architects, landscape architects, citizens and others interested in improving Florida's bicycling environment. Information found in this handbook can be useful for private, local, state or federal projects.

This handbook is intended to be used for the following:

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

This handbook contains information from numerous sources in a attempt to provide planners and designers information to develop the safest most efficient facilities possible.

This handbook is not intended to replace any official Department or local standards. This document is periodically updated to incorporate changes in Federal guidance, state or local standards. On occasion, the updates to this Handbook may lag behind other updates. Any approved Department or local standards overrule this document.

Above: A Place for Cars, Not for People. *Older roadways, built solely for auto transport, created discomfort and unsafe conditions for motorists, bicyclists and pedestrians.*

Below: A Place for Everyone. *In contrast, modern highways are being designed as shared use facilities. Such designs are increasing the comfort and safety of all roadway users.*

1.2 Principles, Policies, Guidance

The handbook offers general principles and policies followed by The Florida Department of Transportation (FDOT, also referred to as the Department). It also offers guidance to cities, counties, citizens and private groups for the development of local plans and projects.

In some cases the Department's standards are different from the requirements for local facilities. Also, both may vary from national guidelines. A brief explanation of the various documents which give design criteria or standards and their application is given in **Section 1.14 Federal Guidance, State and Local Requirements**.

1

(1) U.S. A-1-A in Ft. Lauderdale *was modernized to encourage walking, following older FDOT policy to build wide curb lanes, (2) novice bicyclists chose to use the sidewalks instead. (3) With the installation of bike lanes (below) most bicycling now occurs in the roadway. This discovery that novice bicyclists need bike lanes has sped up State policies toward widespread use of bike lanes. Pedestrians and motorists benefit when bicyclists are included in highway design. This 1 m (3.5 foot) bike lane is to be widened in a*

2

3

1.3 Department Policy

The Department incorporates the needs of bicyclists into all appropriate construction and RRR (resurfacing, restoration and rehabilitation) projects. In some instances, right-of-way constraints and safety considerations may limit the extent facilities and treatments can be applied in a given section. Considering these limitations, projects are to incorporate the needs of bicyclists to the maximum extent practicable.

1.4 Roadways Promoting Predictable Behavior

This handbook provides information to help planners and designers accommodate bicycle traffic in all riding environments and encourage predictable bicyclist behavior. Bicyclists can be expected to ride on all roadways except limited access highways. A lack of safe, convenient and appropriate facilities often leads to bicyclists riding in unsafe locations, such as on commercial district sidewalks. Sometimes they ride against traffic.

The information in this handbook flows progressively from general concepts through the planning process to actual design. Samples of design details, specifications and photographs are included whenever possible.

The handbook provides essential background on planning procedures and design.

Key information on crash types, categories of bicyclists, the design bicyclist, and the design bicycle is presented in Section 3 on safety. Please take time to become familiar with these concepts, since such information is rarely offered in planning, engineering or design schools. This information is key to understanding the design portion of this text.

This handbook is not meant to act as a stand-alone document. Designers should use this handbook for background.

This handbook also serves as a supplement to Chapter IX of The *Florida Manual of Uniform Minimum Standards for Design, Construction and Maintenance For Streets and Highways* (the Florida Green Book).

When designing projects for the Florida State Highway System, designers must comply with the *Plans Preparation Manual* (PPM). Should a discrepancy occur between this handbook and the *Plans Preparation Manual,* the PPM applies.

1.5 Criteria Definitions

To further clarify the use of this handbook for state roadway projects, definitions of roadway design criteria and project standards are offered here:

1.5.1 Roadway Design Criteria

The criteria for design of new roads or major reconstruction projects on the Florida State Highway System are found in Chapter 2 of the *Roadway Plans Preparation Manual.* Design criteria for resurfacing, restoration, and rehabilitation (RRR) are presented in Chapter 25 of the *Plans Preparation Manual.*

1.5.2 Design Standards

The specific values selected from the roadway design criteria become the design standards for a design project. These standards will be identified and documented by the designer.

The provisions for bicycle travel are consistent with and similar to standard highway engineering practices. Signs, signals, and markings for bicycle facilities which are presented in the *Manual on Uniform Traffic Control Devices* (MUTCD), Part IX, should be used in conjunction with this handbook.

Key to Success. *Bicycling activity results from a concerted effort by a community to provide transportation choices. In this Davis, California scene two autos moving 3 people are dwarfed by more than 20 people being moved by an equivalent number of bicycles.*

1.6 Background

There is a growing need for designers, citizens and others to have a common vocabulary, common concepts and common knowledge of successful bicycling systems and facilities in different places. This handbook serves as a "convenience store" of the most commonly referenced concepts, practices, policies, issues and laws.

This handbook also provides information missing in other publications, such as an explanation of behavior of bicyclists, common crash types, bicycling laws, and working definitions.

Bicycling facilities planning and design is still not offered in most college and university curricula. This omission results in a wide variance in planning and design concepts, facilities placement and final designs by individual designers.

Finally, we have become such a nation of specialists, many designers lack the opportunity to see a project from concept to concrete. This lack of continuity is complicated by the tendency of designers to be assigned a vast territory, which means they rarely live in the neighborhood, sector of town, or even in the town they are helping to design. A consultant in Atlanta, Georgia, may be completing a plan for a project in Ft. Myers, Florida. This handbook attempts to bridge the gap by urging every citizen, planner and designer to become familiar with each phase of a project. The ultimate goal of this handbook is to allow all of us to have a common general knowledge of how bicycling facilities work. In this way specific projects are more likely to do what they are intended to do - serve the public with well conceived, well located, affordable, safe, secure, and friendly environments.

Gainesville's vision saves lives. *Gainesville's bicycle friendly spaces started later than Davis, but the results are equally convincing. Near campus over 40% of all travel is non-auto. Meanwhile, the construction of 100 miles of bicycle lanes and paved shoulders has resulted in an 80% drop in bicyclist fatalities.*

We are running out of right-of-way *for affordable highways. As trip times increase there is increased demand for alternative transportation. Yet, until planners and designers build safe, convenient, efficient, comfortable places to bicycle, the public is not likely to switch to other modes. People need places to ride their bikes in the same way they need places to drive their cars.*

1.6.1 Why Bicycling?

Increasingly, transportation officials throughout the United States recognize bicycles provide a viable mode of transportation. Since the early 1970's, bicycling for commuting, for recreation, and for other travel purposes has increased in popularity. Nationwide, people are increasingly recognizing the energy efficiency, economy, health benefits, pollution-free aspects, and the many other advantages of bicycling.

Recent legislation such as federal transportation legislation, the Clean Air Act Amendments and other initiatives now require governments to give full consideration to all modes of transportation. Special emphasis is put on clean, energy-efficient, socially responsible modes, such as bicycling.

1.6.2 A Better System

Bicycling can help us create a better, transportation system as follows:

- Achieving intermodal links with transit.
- Creating safe and effective links between neighborhoods, i.e. link neighborhoods to destinations where people go for their daily needs.
- Reducing complex and costly parking problems.
- Allowing employers to offer choices in mode of transportation for their employees.
- Incorporating greenways development, urban redevelopment and resource preservation.
- Rail bank with rails-to-trails conversions.
- Achieving other timely, sensible and sensitive urban and rural land use practices.

Bicycling is for people of all ages. Along with walking, bicycling is more affordable than auto transport, and most people are physically capable of bicycling. Bicycling is more efficient than walking. It is the most efficient means of assuring independent travel for children, elder adults, many people with disabilities and those with reduced incomes. Bicycling gives all people mobility at an affordable cost. Bicycling helps keep them fit and improves health. However, bicycling does not replace the car or transit options for longer trips.

Local, state and federal agencies are responding to the increased use of bicycles by implementing a wide variety of bicycle-related projects and programs. The emphasis now being placed on bicycle transportation requires an understanding of bicycles, bicyclists, and bicycle facilities. With adequate planning and facilities development, the bicycle can play an important role in the overall transportation system. Bicycling promotes important land use and conservation policies, which call for compact and integrated land use patterns. These patterns provide reduced parking needs, urban infill, keeping destinations within bicycling distances, mixed use development and more balanced and efficient land use for transport systems.

1.7 Research

Research is currently underway in Florida and elsewhere to develop additional criteria for the design of bicycle facilities. Specifically, additional information is under development regarding the selection of appropriate types of bicycle facilities. Such selections may depend on vehicular and bicycle traffic characteristics, adjacent land use and expected growth patterns, as well as other factors.

Should future research provide improved selection criteria, that information will be included in subsequent editions of this handbook.

Planning goals *in Boulder, Colorado lead to objectives and strategies that increase bicycling. A simple strategy to connect cul-de-sac streets increased local bicycling twofold.*

1.8 Training Courses

The Department recognizes that much of this information is new to many readers. However, roadway designers are now expected to understand and apply these principles on all future transportation, maintenance and operations projects. Although no training is required to receive this handbook, the Department is making available, at no charge, one-day training courses throughout the state. The training courses will cover the material in the handbook, what is being done in other parts of the country and provide opportunities to work through example problems. Consult your local Pedestrian/Bicycle Coordinator for details on when the next course is scheduled in your area, or call the Florida Pedestrian and Bicycle program staff at (850) 487-1200, SUNCOM 277-1200 or FAX (850) 922-2935.

1.9 Handbook Overview

SECTION 2 - Planning...

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

SECTION 3 - Safety...

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

SECTION 4 - On-Road Design...

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

SECTION 5 - Shared use Paths...

incorporates the needs of bicyclists to the maximum extent practicable.

Sidewalks Risky. *Below: The discouragement and danger of mixing bicycling and sidewalks is made evident in this existing Key West scene.*

Which Side Is Safe? *(1) The shops and lodgings are on one side, the bike path on the other. Key West's North Roosevelt Boulevard scramble lane offers too little safety for crossings. (2) Meanwhile, bicyclists stay on the service side, darting in and out, or use the sidewalks when available. This behavior creates high potential for crashes. A true boulevard-style raised median will simplify roadway crossings and increase safety by providing a safe haven midway.*

1

2

Policies are backed by research. *(3) New research by FDOT in seven cities reveals that presence of bike lanes creates more predictable movement and less displacement of motorists and bicyclists while passing.*

3

SECTION 6 - Supplemental Topics...

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

SECTION 7 - Appendix...

provides supplemental data for the handbook.

1.10 Comprehensive Program

Facilities are only one of the several elements essential to a community's overall bicycle program. A comprehensive community approach to bicycle use also includes bicycle safety education and training, bicycle use encouragement, and the application and enforcement of the Rules of the Road as they pertain to interactions between bicyclists, motorists and pedestrians. This handbook provides information on facilities. Information on other elements of an overall bicycle program can be found in other publications (see Reference section).

1.11 Authority

F.S. 335.065 SPECIFIES:

"*Bicycle and pedestrian ways along state roads and transportation facilities. --*

(a) Bicycle and pedestrian ways shall be given full consideration in the planning and development of transportation facilities, including the incorporation of such ways into state, regional, and local transportation plans and programs. Bicycle and pedestrian ways shall be established in conjunction with the construction, reconstruction, or other change of any state transportation facility, and special emphasis shall be given to projects in or within one mile of an urban area.

(b) Notwithstanding the provisions of paragraph (a), bicycle and pedestrian ways are not required to be established:

(1) Where their establishment would be contrary to public safety;

(2) When the cost would be excessively disproportionate to the need or probable use;

(3) Where other available means or factors indicate an absence of need."

An absence of need could be argued along a limited access roadway. However, in some areas, including one path in Florida, facilities are being built along freeway corridors.

1.12 Supporting Florida References

The following Florida documents also urge improvements to bicycling to achieve agency goals:

- *Florida Transportation Plan*
- *Long Range Transportation Systems Plan*
- *Safety Management Systems Plan*
- *Congestion Management Systems Plan*
- *Intermodal Systems Plan*
- *Transit Systems Plan*
- *Florida Bicycle 2000*
- *Plans Preparation Manual*
- *Roadway Standard Index*

Local Comprehensive Plans and Transportation Improvement Plans can also support bicycling.

1.13 Definitions

AASHTO - American Association of State Highway and Transportation Officials.

ACCESS MANAGEMENT - The principles, laws and techniques used to control access to highways.

ADA - The *Americans with Disabilities Act;* civil rights legislation passed in 1990, effective July 1992.

ADT - Average Daily Traffic. The measurement of the average number of vehicles passing a certain point each day on a highway, road, street or path.

ARTERIAL (ROAD) - Divided or undivided, relatively continuous routes that primarily serve through traffic, high traffic volumes and long average trip lengths. Traffic movement is of primary importance, with abutting land access of secondary importance, with land access of secondary importance. Arterials include expressways without full control of access, US numbered routes and principal state routes. May be classified as urban or rural.

BACKCOUNTRY TRAILS - Any multi-use trails that are not hard surfaced, commonly used for mountain bike or "off-road" riding and joint hiking uses.

BICYCLE - A vehicle having two tandem wheels, either of which is more than 16 inch (0.4 m) in diameter, or having three wheels in contact with the ground, any of which is more than 16 inch (0.4 m) in diameter, propelled solely by human power, upon which any person or persons may ride.

BICYCLE ADVISORY COMMITTEE - Most Metropolitan Planning Organizations (MPO's) and some counties have a politically appointed group of citizens and technicians who oversee bicycle planning and provide technical review of local bicycling facilities. These groups are known as Bicycle Advisory Committees (BAC's).

BICYCLE BOULEVARD - A system of roadways and connections between neighborhoods or areas in a community

What is a bicycle? *A tandem bicycle pulling a trailer is legally defined as a bicycle. Wheel diameter, tandem wheels, and self-propulsion are criteria for defining a bicycle. This vehicle can move three or even four people.*

An adult trike is still a bike according to law. Handling characteristics are different. Tricycles have greater problems dealing with roadway cross slopes than conventional two-wheelers.

Fog and early morning light *lead to high crash rates. Bike lanes work best when conditions are worst. It is the presence of these facilities that has led to Gainesville's remarkable decline in serious car/bike crashes.*

1

Bicycle facilities and roadways *vary in dimensions according to traffic and safety needs. (1) The bike lane above is large enough to permit buses to pass bicyclists comfortably. (2) This roadway purposefully slows motorist speeds with use of a median. (3) In this private development a nine foot travel lane with median slows cars to 12-18 mph (bicycling speed).*

2

3

that forms a bicycling throughway, but discourages through and higher speed motor vehicle movement.

BICYCLE FACILITIES - A general term denoting improvements and provisions made by public agencies to accommodate or encourage bicycling, including bicycle paths, bike lanes, parking and storage facilities, lockers and showers, maps of bikeways, marked routes and shared roadways not specifically designated for bicycle use.

BICYCLE LANE (BIKE LANE) - A portion of a roadway (typically 4 - 5 ft.) which has been designated by signing and pavement markings for the preferential or exclusive use by bicyclists (Also see "Undesignated Bicycle Lane").

BIKE ROUTE - A system of roads and ways that are linked by signs to aid bicyclists. Bike Routes are ineffectual unless signs are highly specific, giving a clear indication of destination.

BIKEWAY - Any road, path, or way which in some manner is specifically designated as open to bicycle travel, regardless of whether such facility is designated for the exclusive use of bicycles or is to be shared with other transportation modes.

CLEARANCE, LATERAL - The width required for safe passage of a bicyclist as measured in a horizontal plane.

CLEARANCE, VERTICAL - The height necessary for the safe passage of a bicyclist as measured in a vertical plane.

CLEARANCE INTERVAL- The amount of time a traffic signal provides to allow a type of traffic to clear the intersection before releasing conflicting traffic.

COLLECTOR (ROAD)- A road designated to carry traffic between local streets and arterials, or from local street to local street.

CROSS SECTION , "TYPICAL CROSS SECTION" or "TYPICAL" - Diagrammatic presentation of a highway or path profile which is at right angles to the centerline at a given location.

DESIGN STANDARDS - The specific values selected from the roadway design criteria become the design standards for a design project. These standards will be identified and documented by the designer.

EDGE LINE - A painted or applied line to designate the edge of the road (150-200 mm, 6-8 inches wide)

ENHANCEMENT FUNDS - Under ISTEA, set aside funds for ten categories of projects including bicycling and pedestrian facilities and paths.

FRONTAGE ROAD - A road designed and designated to serve local traffic parallel and adjacent to a highway or arterial

street.

GRADE - A measure of the steepness of a roadway, bikeway or walkway, expressed as a ratio of vertical rise per horizontal distance, usually in percent. For example, a 5% grade equals 5 foot of rise over a 100 foot horizontal distance.

GRADE SEPARATION - The vertical separation of conflicting travelways with a structure. An overpass or tunnel are examples of common grade separations used to avoid conflicts.

HIGHWAY - A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.

ISTEA - The Intermodal Surface Transportation Efficiency Act enacted in 1991. Federal legislation guiding the expenditure of federal highway funds.

LATERAL CLEARANCE - The distance between the edge of a travelway and a fixed object. Also, the separation distance a roadway user needs to feel safe operating near a fixed object.

LIMITED ACCESS - A street or highway especially design for through traffic and over, from, or to which owners or occupants of abutting land or other persons have no or limited rights of access. Interstates and freeways are limited access roadways. In Florida bicycles and pedestrians are prohibited from operating on a limited access facility.

PRINCIPAL ROADWAY - Roadways serving as the popular route through and area. Usually, these will be collector or arterial roadways.

RAIL TRAIL - A shared use path built within the right-of-way of and existing or former railroad. These may be either paved of unpaved.

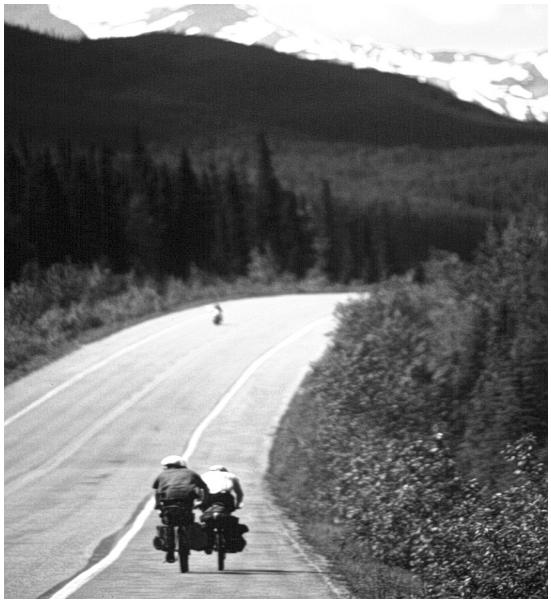
RIGHT-OF-WAY - A general term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to transportation purposes. This term also applies to the right of one vehicle or pedestrian to proceed in a lawful manner in preference to another vehicle or pedestrian.

ROADWAY - That portion of the highway, including shoulders, for vehicle usage.

ROADWAY DESIGN CRITERIA - Criteria for the design of new or major reconstruction projects on the Florida State Highway System. These criteria are found in Chapter 2 of the *Roadway Plans Preparation Manual (PPM)*. Design criteria for resurfacing, restoration, and reconstruction (RRR) are presented in Chapter 25 of the manual.

RRR PROJECTS - Specific roadway improvement projects that include resurfacing, restoration and rehabilitation of

Specialized customers. *The two mobility impaired travelers above use bicycle facilities in Davis, California (shared use path) and in a Manhattan bike lane. Below: When forced by law onto sidewalks, in-line skaters bring danger to pedestrians. Bike lanes and quiet streets may be safer places. Further research is required for in-line skate facilities.*



Shoulder width provides separation, allows free movement of motorized vehicles and promotes tourism. Top: No shoulders on U.S. Alt 19 hold back motorists. Middle: U.S. 41 has 4 foot (1.2 m) paved shoulders and allows low speed passing. Bottom: Many northern roads (Banff National Park) have ample 10 foot (3.0 m) wide shoulders.

roadways. These projects use a different pot of funds than new construction.

RULES OF THE ROAD - That portion of a motor vehicle law that contains regulations governing the operations of vehicular and pedestrian traffic.

SHARED ROADWAY - Any roadway upon which a bicycle lane is not designated and which may be legally used by bicycles regardless of whether such facility is specifically designated as a bikeway.

SHARED USE PATH - A bikeway physically separated from the motorized vehicular traffic by an open space or barrier and either within highway right of way or within an independent alignment. Shared us paths will be used by pedestrians, skaters, bicyclists, joggers as well as bicyclists.

SHOULDER (PAVED) - That portion of a highway which is contiguous to the traffic lanes, allowing use for emergencies of motor vehicles, for specialized use of pedestrians and bicyclists, and for lateral support of base and surface courses.

SIDEWALK - That portion of a highway designed for preferential or exclusive use by pedestrians.

SIGHT DISTANCE - The distance required to bring a bicycle to a complete controlled stop. This is a function of the bicyclists perception and brake reaction time, the initial speed of the bicycle, the coefficient of friction between the tires and the pavement and the braking ability of the bicycle.

UNDESIGNATED BIKE LANE - A bike lane which is not designated with the diamond, bike, and arrow pavement markings. It is striped as a regular bike lane on the approaches to intersections.

WIDE CURB LANE OR WIDE OUTSIDE LANE - A minimum roadway improvement where the curbside lane is typically widened to 14 ft. (4.2 m). This treatment is generally being replaced in Florida with a designated or undesignated bike lane.

1.14 Federal Guidance, State and Local Requirements

This Handbook quotes many standards for the design of bicycle facilities. It does not create any standards. To users of this handbook in sorting through the various levels of guidance and standards, their application is summarized in the following sections.

1.14.1 *A Policy on the Geometric Design of Highways and Streets, AASHTO*

The American Association of State Highway and Transportation Officials, AASHTO, produces this document which is

usually referred to as simply the *Greenbook*. The *Greenbook* contains recommended criteria for roadway geometrics: widths, cross sections elements, horizontal and vertical alignment, etc. It is intended to provide guidance to designers by referencing a recommended range of values for critical dimensions. It does contain some flexibility to allow for tailoring designs to particular situations.

Although the *Greenbook* contains guidelines, it is the basis of most FDOT and local standards.

1.14.2 *Guide for the Development of Bicycle Facilities, AASHTO*

This document , sometimes referred to as the AASHTO *Bikek Guide,* contains planning and design guidance related specifically to bicycle facilities. The design section includes mostly information on geometric criteria but does include some signing, striping and signalization issues. It addresses both in-street facilities as well as shared-use paths.

Like the *Greenbook*, this document contains guidelines; and like the *Greenbook,* it serves ad the basis for most of our state or local standards.

1.14.3 *Manual on Uniform Traffic Control Devices*, FHWA

This manual addresses the required and permitted uses of traffic control devices. Traffic control devices include such things as signs, pavement markings, signals, and in some cases islands.

The standards set for in this manual have been adopted by FDOT as the states requirements and are required to be followed in Florida. They apply to the roadway and paved shared-use paths.

1.14.4 *Plans Preparation Manual*, FDOT

This document, know as the *PPM*, is produce by the Florida Department of Transportation. It sets forth geometric and other design criteria, as well as procedures, for FDOT projects. Unless it is adopted by a county, it applies only to FDOT projects.

1.14.5 *Manual of Uniform Minimum Standards for Design, Construction, and Maintenance for Streets and Highways,* FDOT

This document is usually referred to as the *Florida Greenbook*. Although printed by FDOT , it is developed by a committee which includes engineers from cities, counties, the private sector and FDOT.

The standards established in by this Manual are intended for use on all new construction projects off the state highway and federal aid systems.

Ponding on pathways, overgrown sidewalks, and drainage grates in the roadway. *All of these conditions exist in many communities. Whether designing a shared use path crossing, lane, or simply improving the roadway, it is essential to treat all highway users with equal respect. Our changing world calls for new ways of thinking and designing. This handbook provides many tips for understanding and addressing the needs of this new, ever changing public demand for multi-modal highways.*

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Section 2 Planning

2.1 Bicycle Planning

Bicycle transportation planning is commonly construed as the effort undertaken to develop complete/comprehensive bicycle facilities for transportation and recreational activities. The resulting system is composed of shared use paths, improved roadways, bicycle lanes, bicycle parking, bicycle mapping and transit links. All facilities are interconnected and spaced closely enough to satisfy the travel needs of bicyclists.

2.1.1 Bicycling Uses the Existing Systems

Bicyclists have the same mobility needs as every other user of the Transportation System. They use the highway system as their primary access to goods, services, and recreational activities. Existing highways and streets, often with relatively inexpensive improvements, must serve as the base system to provide for the travel needs of bicyclists. Shared use paths and path connectors can augment this existing system in scenic corridors, greenways or places where access is limited. Water and land transit are important future linkages and partners to a comprehensive bikeway system. Thus, bicycle transportation planning is more than planning for bikeways. It is an effort that should consider many alternatives to provide for safe and efficient bicycle travel.

2.2 Utilitarian and Recreational Bicycling

The wide range of bicyclists' abilities and multitude of purposes for riding must be understood before planning for bicycle transportation improvements. In general, bicycle trip purposes can be divided into two broad types, utilitarian and recreational. For a bicyclist on a utility trip, the primary objective is reaching a specific destination quickly, with few interruptions. The bicycle happens to be the chosen mode of transportation or, in some cases, the only mode available.

On the other hand, a bicyclist on a recreational trip is riding for pleasure. The timing to a destination is often of less

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***Bike planning should be pro-active and comprehensive**. Reactive, stand alone- planning does not work. Top: (1) SR. A-1-A was not initially planned for bicycling. (2) Riders took over the new wide sidewalks. Although this works fine when there are few users, at times this becomes congested and dangerous. (3) Retrofit narrow bike lanes were squeezed into the space at added cost, and results were limited. (4) More striking, the land use in the New Town portion of Key West excluded bicycle access. Today a retrofit bridge is being considered to link neighborhoods with shopping and work.*

Bicycling is often a pleasurable activity. Thus, with the exception of the top photo, it is hard to separate utility from recreational riding. Both utility and recreational riding encourage fitness, community awareness and relaxation.

importance. Of course, for many trips and bicyclists, these purposes are not absolute or mutually exclusive. New bicycle facilities, therefore, should be designed to accommodate different types of bicycle trips.

Bicyclists differ widely in their abilities and in their preferences of riding environments. Some bicyclists place high importance on directness and have the ability to ride safely and confidently in heavy traffic. They will often choose to travel on arterial roads in lieu of quieter, more aesthetically pleasing alternate routes, because arterial roads are more direct and result in perceived or actual time savings. Arterial and major collector roads also offer bicyclists increased signal and operations support, better lighting and other benefits over local and minor collector routes.

If an arterial road is not improved for bicycling, then many novice bicyclists are likely to make use of sidewalks. By doing so, especially in commercial districts, they endanger pedestrians and subject themselves and motorists to numerous conflicts that neither is prepared to handle. Thus, the Department now strongly urges the full consideration of on-road bicycling facilities on all principal roadways.

Since major attractors are often located on these roadways and rear access to properties is often limited or denied, a significant amount of bicycling should be anticipated by most age groups on all principal roadways.

In some cases, additional design support can be given on parallel roads to attract bicyclists. This shift from the arterial road will only occur, however, when bicyclists find the alternate route provides direct access and personal security, as well as traffic safety. Cooperation is sought from each community to incorporate attractive bicycle boulevards, lanes or routes on available roads that parallel principal roadways. Decisions not to fund off-system roads ultimately dictate that the best riding conditions are on the most heavily traveled principal roadways. Every effort should be made to offer financial assistance for the development, operations and maintenance of bicycle facilities on both principal roadways and quiet collectors.

Some bicyclists place more importance on the quality of the trip and are willing to go out of their way to ride on residential streets or paths. While it is important to understand that a range of bicyclists' abilities and preferences exists, it will usually be a mistake to plan or design bicycle facilities primarily or exclusively around the needs of bicyclists at either end of this spectrum. Rather, bicycle facilities should be planned and designed to accommodate a broad range of bicyclists.

2.3 Basic Principles

It is recommended that the following basic principles be considered when beginning any transportation project:

- Just as with motor vehicle support, assume every street is a bicycling street and all locations accessible to a motor vehicle should be accessible by bike.
- Involve all appropriate agencies and general public in planning corridors and communities.
- Use public funds for land use development that fully considers bicycling or mitigates the harmful effects caused by that development to bicycling.
- Transportation planning should give high priority to bicycling for all trips under four miles.
- Plans should overcome existing barriers to bicycle travel and create no new barriers.
- Roadway improvements should provide access to all destinations through the most direct or feasible route.
- Involve the public in the conceptual stage, data gathering, goals development, and all other reviews and phases of work.
- Planning should be flexible throughout the development process. Accept new design concepts and anticipate future changes to the system.

The effectiveness of the planning process will ultimately depend upon the following:

- Ensuring the integration of the final product into local policy documents by following a clearly defined process involving local elected officials, planners, engineers and the public.
- Identifying the size and nature of the area (urban center or rural locale) being considered for the provision of bicycle and path facilities or programs and tailoring the process to meet the area's needs.
- Identifying the available human, money and time resources.
- In Florida, as elsewhere, this process often involves taking a project or element through the local Bicycle Advisory Council (BAC), and then having the project reviewed through the Technical Advisory Committee (TAC), the Citizen's Advisory Committee (CAC), and then forwarded for final approval by the Metropolitan Planning Organization (MPO).
- Once a project has been approved by the MPO, it is accepted in the community Transportation Improvement Plan (TIP), and prioritized along with other roadway improvement projects.

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Balloons capture polarization. (1) *Captivia Island residents were evenly split on a bike path issue in this tight corridor. (2) Opposing sides displayed either white or black balloons.* ***The Process:*** *Engage and involve all sides(3). Give citizens the tools to collect data and insights on options. Use public process for a community solution. The result: A full 95% of residents became involved, and they approved an engineering study with a 98% approval rate.*

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Meet the People. *Planning is not something done in an office. Planning is interactive. Use the 80/20 measure. If your plan writer has not spent at least 80% of the invested time surveying, meeting with people and engaging in meetings, then the plan is likely to lack community vision and desire. Bicycle planning gains consensus as it develops. (1) William Roll interviews a Vancouver, B.C. street retailer on his vision, (2) Key West planners involved an area commissioner in their data collection; (3) Portland, Oregon's famous citizen-driven planning brings out citizens on the coldest of days.*

- In areas not large enough to have an MPO (under 50,000 population), a similar process should be followed. For instance, it is always essential to have a formal BAC or other citizen's group, a technical review committee, and then a political hearing of commissioners or others that can give final sanction and budget authority to the project.

Non-transportation projects such as Traffic-Ed Training or a Velodrome can follow a similar route of approval using other political groups such as recreation boards, school boards, or other appropriate councils or government bodies.

2.4 Model Planning Process

The best planning efforts use an integrated approach to bicycle and pedestrian facilities based on the existing roadway system and other urban visions, goals and infrastructure. Using only separate bicycle and pedestrian plans is not recommended. But an independent planning effort is a helpful step in the overall planning process. It will help focus efforts and prioritize projects. However, as stand alone plans, they often fail to integrate the various components needed to develop sustainable communities and facilities. These stand alone plans are only seen by a few and are rarely referenced. This lack of consideration of them often results in many lost opportunities. When stand alone bicycle and pedestrian plans are developed, the information within them should also be incorporated into any other comprehensive plans.

Planners and practitioners are strongly urged to build the needs of bicycling and walking into all transportation, land use, school development, utility, conservation, public access and recreation documents. Ensure planning for bicyclists and pedestrians is incorporated into any document, comprehensive plan, or policy statement guiding local and regional Metropolitan Planning Organizations (MPO's), Regional Planning Councils (RPC's) or other municipal or county officials, boards, councils or commissions. Bicycle facility plans should be included in standard municipal design specifications. By following these steps, financing bicycle facility and construction and maintenance will become a regular part of the budget process. These functions will no longer be considered separate embellishments that can be ignored.

2.5 Bike Planning Does Not Stand Alone - Comprehensive Community Planning

Planning for bicycle facilities must be concurrent with planning for other transportation modes, other public works projects and other land use planning. Often an improvement which enhances bicycle travel also benefits other modes of

travel and helps a community achieve better land use and conservation objectives. Highway improvements, through appropriate planning and design, can enhance bicycle travel as well. Plans for implementing bicycle projects must be in harmony with a community's overall goal for transportation improvements. Transportation plans, in turn, should be consistent with overall community vision and goals.

Many bicycling opportunities are missed due to ineffective and uncoordinated land use practices that create sprawl, isolated services and a fragmented community. Although there is much discussion of improved zoning and development leading to more compact and mixed land use, implementation requires commitment and major public involvement. Bicycle planners and project proponents need to remain central to these changes.

Special planning districts which promote alternative transportation, commercial management areas, and transportation exception areas each offer opportunities to promote bicycle transportation.

Additional support can be given to bicycling by regulating changes improving bicycle safety. For instance, bicycling on commercial district sidewalks, a high risk activity, can be restricted. However, such restrictions may prove unpopular and unenforceable if alternate facilities in the roadway section or on parallel streets are not provided. Locking bicycles to light poles, parking meters and other locations, where they become a tripping hazard and clutter the sidewalk, can and should also be regulated. Close cooperation with merchants, and a plan to provide public racks in appropriate locations must be established through public policy.

Above: With the development of Transportation Management Organizations, alternative transportation trips are given additional promotion.

The best planning efforts use an integrated approach to bicycle and pedestrian facilities based on the existing roadway system and other urban visions, goals and infrastructure.

2.5.1 Example community

Using Davis, California as an example, development codes serve as the genetic code for all areas of town. They determine whether or not a community is bicycle friendly. Davis is well-known for its preference for bicycles, energy conservation and slow and carefully managed growth. Its notable physical characteristics are its innovative neighborhood design, traditional downtown, absence of large scale shopping centers, rear access to all shopping centers and high density living with convenient walking or bicycling to most destinations.

While zoning ordinances and development codes can be tools to inhibit sprawl, decrease auto trips and recreate the character of urban form, they are also tools to implement site specific practices. Key decisions are needed on such practices as:

- Minimum safe and convenient bicycle access to all com-

This Davis, California path helps connect over 3000 bicyclists with their daily school and park destinations.

Through the use of a comprehensive planning approach, Davis, California's schools are well located and laced with greenways. Nearly 100% of school-aged children walk or bicycle to school.

In contrast, the Florida school below has no connections to neighborhoods. Set amidst sprawl, only about 10% of area children walk or ride their bikes to school. Resulting auto trips add to peak hour traffic and create unsafe conditions for those who do walk or ride.

In Florida an average of 1 child in 8 gets to school on his own. Such a dismal record is the result of poor coordination and planning.

merce. Access management policies, especially with commercial establishments, should be regulated to minimize the number and location of entry points. The existence of too many or poorly placed driveways, is closely linked with bicycling crashes, especially those associated with bicyclists riding commercial district sidewalks.

- Minimum and desired levels of secure and convenient bicycle parking for commercial and public buildings. There is ample opportunity to initiate positive language in support of public bicycle parking facilities. Many times such facilities can be installed as a trade with the merchant or land owner through a variance or change in parking requirements.
- Minimum thresholds for shower/locker provisions at all large employment centers with at least 50-100 employees.
- Required connections between cul-de-sacs with paths, schools and public transit in new and retrofitted neighborhoods. Often the public supports non-motorized connections while disapproving motorized connections.
- Greenways development. A major opportunity for future bicycling is to support the preservation of open space or undeveloped land as the greenway. For new developments, (especially in low lands) drainage areas, wetland habitats, and other natural areas should be preserved. These areas can be sensitively designed for paths, perhaps using boardwalks, and serve as the backbone for a bicycle recreation and transportation network. Davis, California now has over 50 miles of greenways. It is difficult to find a neighborhood in Davis that lacks the green canopy that connects all cul-de-sacs to minor and major paths.

2.5.2 Site Plan Agreements

Proposals for development or redevelopment of residential, commercial and industrial projects often involve site plan agreements. The agreements provide the ideal opportunity to negotiate the inclusion of bicycling facilities into the overall design. The agreements can address access, parking, internal roadways (bicycle boulevards or lanes) and the location of structures on the land to be developed or redeveloped.

2.5.3 New Subdivision Amendments

Many of the items mentioned in the planning concepts section should also be considered here. Law enforcement should be consulted on proposed circulation patterns. Public notification can assist in developing a mutually acceptable final design. The planning process should examine road patterns and connections with existing transportation routes so that residents of the subdivision will be able to use their bicycles for commuting or other purposes. Main bicycle routes to work

places, shopping areas, connecting transit station stops and terminals or other destinations should also be considered. For example, the internal road network should ensure that short trips to schools, recreation centers or parks and local shops are easily reached through low volume streets or paths. A return to traditional neighborhood design concepts, where there are many links into and out of neighborhoods, to nearby stores, and schools, are all key to a successful neighborhood.

2.5.4 Dedication of Land

Many municipal governments require dedication of land for parks, schools and other public needs. The location of these lands in a central part of the development, or with a perimeter that permits greenways, is key to the success of associated bicycle facilities. Such planning keeps trip distances within range of a bicycle ride.

2.5.5 Redevelopment

As environmental issues force reconsideration of formerly underdeveloped lands, opportunities abound for urban infill. Greatly improved bicycling can result from sensitive design, proper increases in density, addition of new links between formerly closed roadways, and the location of schools, parks and other infrastructure.

2.5.6 Road Reconstruction

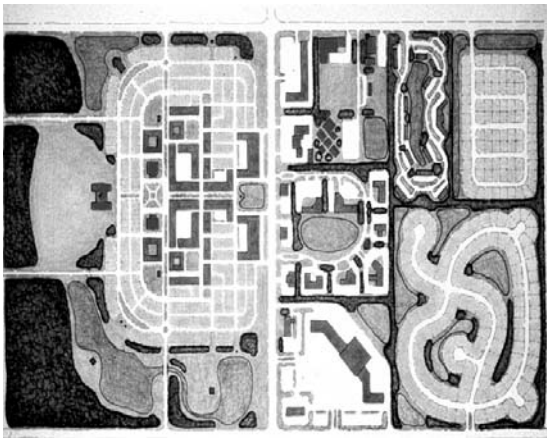
New highways are rarely built. The majority of opportunities to improve conditions for bicyclists are found on roadways bursting at the seams. Often these roadways can and should be improved to provide safer travel for everyone, including bicyclists. These improvements can and should be included on every project, regardless of scale, so that eventually a corridor can provide a continuous facility for bicycling. It is estimated that during the 1980's, project-by-project bicycle sensitive designs increased the total supportive lane mileage from 5% to 40-60% of the urban state system in some districts.

2.5.7 Major Urban Infrastructure

Planning and design for bicycles must be incorporated into the fabric of any development project. The bicycle facility is not to be viewed as a separate entity any more than a new arterial road or industrial area is viewed in isolation. The integration of bicycles into the overall transportation network must be dealt with at the base level within the context of the larger urban area, if it is to be cost-effective, efficient and ultimately successful. The overall concept of an urban design is often lost in the details of many individual projects. Planning for changes to the urban infrastructure is both feasible and practical.

Photo Above: New urbanism in a nutshell. *Current zoning and development codes, banking and other regulations dictate that most development must take the pattern of the above drawing. People living in these common suburban developments generate ten auto trips per family each day. These practices fill our highways and consume nine parking places for each car. This style of development makes walking or bicycling to a destination lengthy, challenging or impossible.*

In contrast, New Urbanism, depicted below, places shops, stores, schools, recreation and most other needs within easy walking and bicycling distances of residential communities. Note the lot sizes are the same. Parking spaces are greatly reduced since fewer people choose to drive such short distances. Bicyclists fare better in either New Urbanism development, or in older (pre-1950's) developments that typically followed a grid or highly interlaced pattern.



Credit: Victor Dover & Associates

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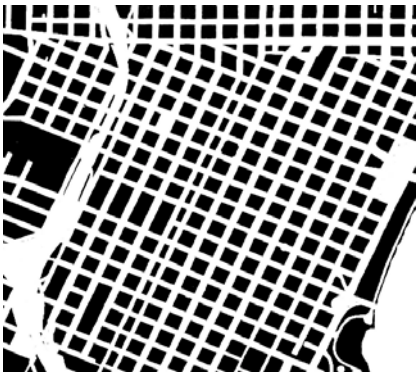

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Same Scale, different cities. *(1) The City of Portland, top grid, has the markings of a successful city. Bicycling works best when there are many choices for routing. With many links, traffic is less likely on any one road, and speeds remain sensible. New Urbanism and pre-1950's development have fine grained roadway patterns.* ***(2) Less is not better.*** *As society moved toward auto trips, fewer intersections allowed for higher speeds. Bicyclists have a tough way to go in Irvine, California, and most suburban sectors of any town. There are few choices. Any road that goes any place seems to be a main road.*

The aspect of budget considerations is of equal importance in the pre-planning stage. The costs of bicycle facilities when they are incorporated into the budget of the project is minor compared to the cost of undertaking such a project separately.

2.5.8 Land Exchange

Often developers or land owners are willing to trade part or all of their land for a more favorable site. In this way, municipalities and departments can acquire lands that can be used for the development of bicycle facilities. Such parcel trades can simplify the design and eliminate conflicts by developing a path where conflicts are low and service is high.

2.5.9 Easements

An effective tool for improved bicycling and walking is the acquisition of easements. Easements can:

- be low costs compared to market value purchase
- have no management responsibility
- have the ability to use land and preserve scenic views
- provide an option to purchase in the future.

2.5.10 Other Opportunities

Florida land use policies and practices are being constantly upgraded at both state and local levels. It is essential that all bicycling proponents look to the future by staying involved and alert to community developments. Many practices in the past, such as building major arterial traffic corridors through residential areas near downtown in order to get traffic out to the suburbs as fast and efficiently as possible are no longer deemed socially responsible.

There are many inner areas of cities that should be redesigned or refocused for livable, secure and convenient move-

(3)(4) Contours of Farming become Contours of Development. *Under current development practices, the land on the left will soon be converted to the development on the right, furthering sprawl, auto trips and reducing this community's chance to be sustainable.*

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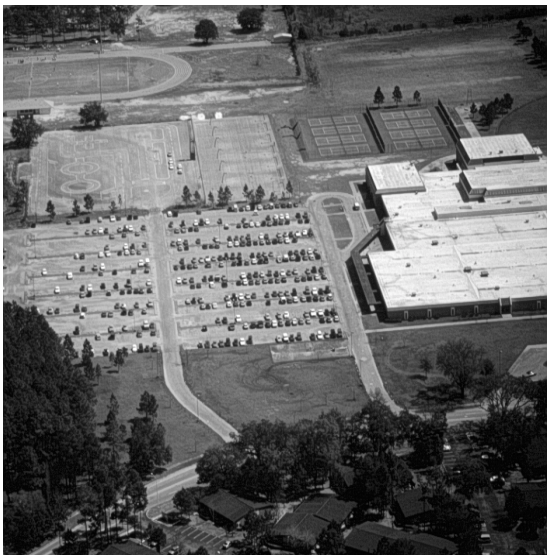
ment of people. Town and city planners should step back and take a broader view of conditions that affect their citizens. Cities designed for people work far better than cities designed for cars. With such a view, town planners will be able to make transportation decisions that make sense to everyone. This concept will result in more interactive, efficient and sustainable cities. It will also enrich the lifestyles of its people.



Above: Some Florida high schools have more space for automobile parking than for student's classes. If other modes are to compete, incentives for bicycling must be equally strong.

2.6 Planning Checklist

There are ten steps to be considered as an action checklist. Public involvement is a must throughout the process.

1 Staff conceptual stage
2 Budget and schedule for planning process
3 Development of goals and objectives
4 Bicycle Facilities Inventory
5 Bicycling background and research analysis
6 Examination of opportunities and constraints
7 Development of options
8 Selection of preferred options
9 Development of implementation strategy
10 Assessment

2.7 Ongoing Public Involvement

Ongoing public involvement is crucial to the success of any planning work. Any changes occurring during the planning phases must be communicated to those who have expressed interest in the project. Reasons for the changes should also be clearly explained so that the cooperation between the different groups is not lost.

The following techniques and processes are recommended to involve the public, interest groups and staff in a productive team effort.

Public Involvement. *The public has become an integral part of the transportation planning process. On a given project the public can and should be involved in all planning steps. Below: This Gainesville 26 and 26A road project involved the public in 48 hours of meetings, over a period of one year. Bicycle facilities were built into the corridor design.*

2.7.1 Bicycle Advisory Committees

Throughout the planning process, every effort should be made to involve the public and bicycle user groups. This is most efficiently done by forming and making use of local Bicycle Advisory Committees (BAC's). These committees can simultaneously review pedestrian plans as well. If they serve both functions, they are called Bicycle/Pedestrian Advisory Committees (BPAC's). The public should be involved at the beginning of and throughout all public works, land use and transportation projects. Too often errors are made by well-intentioned public officials who have not heard from the public until it is "too late". This public involvement process can save costly mistakes. Public involvement must go well beyond traditional bicycle groups. Public participation should

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Engage the public early and often. *Engaging the public early and often in each step of the plan will reap huge benefits. (1) Using a highly compressed charrette style plan, Elizabeth Plater-Zyberk leads a discussion of West Palm Beach neighborhood leaders on their community vision. (2) Technicians check out routing possibilities into downtown West Palm Beach. (3) District Four Transportation Secretary Rick Chesser confers with staff on placement of bicycles in the new Lake Worth downtown plan.*

include social services, schools, neighborhood groups, employers, retailers, and others.

2.7.2 Preliminary meetings

On large projects, meet with key groups and individuals so that opportunities for advisory assistance, issues and constraints and perceived needs of the various users can be identified. These groups would include Bicycle/Pedestrian Advisory Committees, Greenway Committee and Councils, and Neighborhood Organizations.

2.7.3 Open houses

Have additional informal meetings to involve the general public, to publicize the process and to allow staff and elected officials a chance to appreciate the concerns the community has regarding the provision of bicycle facilities in their area. These open houses can have multiple presentations, copies of planning documents and staff to answer questions.

2.7.4 Surveys

Questionnaires, properly administered to solicit reactions to and suggestions for a proposed project, can be used to document public opinion during the planning process. They are also effective follow-up after a facility has been built.

2.7.5 Other Advisory Committees

A special committee for a specific project can be created to help communicate the process to the public. The committee can present issues for consideration. Such committees can consist of staff and elected officials as well as members of the public. For instance, for a path development, representatives of area schools, safety organizations, garden clubs, neighborhood associations, merchants, conservation groups, and outdoors clubs or organizations should all be involved.

2.7.6 Ongoing Liaison

In some communities, bicycle program newsletters are published and circulated widely to keep all interested members of the public and press involved and sensitized to key issues. The Friends of the Pinellas Trail, for example, publish a quarterly newsletter that has been an effective communication tool for nearly five years.

2.8 Goals and Objectives

It is important to measure the success of planning and developing bicycling facilities and programs. The state bicycle program and each community should have clear goals and objectives. These goals and objectives should be obtainable both financially and in the allowed time frame. A project should then be evaluated to determine if it adds to or fails to satisfy these measurable objectives. Local and regional goals

and objectives must be set to help achieve continuous state system. The following community goals and objectives are given as examples:

- Level and rate of growth in bicycling as a transportation mode should increase. By the Year 2010, bicycling should comprise 4% of commute trips and 30% of city-wide, school-related travel. (Current rates are <2% for commuting and <10% for school trips).
- Bicycling should increase as a transportation mode to key employment centers (level and rate of growth). Each metropolitan area should select key employment centers (100+ employees) and increase bicycling to a 15%+ share of the total commute trips.
- Bicycling should increase as a transportation mode for errands and non-work trips (level and rate of growth). By 2005, bicycling should comprise 15% of short errand trips (currently less than 5%).
- Bicycling should have increased access to public transit. By the Year 2010 bicycling/bus trips should comprise 10% of urban area bus/transit trips. (Current rates are <1%). By the Year 2010, all buses should have bike racks and all transit hubs/centers and all express bus stops should have secure and convenient bicycle parking. By the Year 2005, accommodation should be included on all public rail routes.
- Bicycle crashes should decrease by 10% by 2010.
- Bicyclists injuries and fatalities should be reduced yearly.
- Bicycle proportions of total traffic should increase within certain corridors. An increase from current levels of 2-3% at key intersections to over 15% at the same sites is desired. Identify 10 key locations for an annual count of bicycling/traffic percentages. Measurements will be for daylight hours.
- Bicycle-friendly designs should be incorporated on roadway projects in urban/ rural areas, comprising at least 90% of all local and state roads (limited access roads excepted).
- By 2005 at least 50% of all staff, state, district, regional and local transportation planning and engineering design, construction, PD&E, right-of-way, permits, safety, operations, and maintenance staff, and representatives from all FDOT transportation project consulting firms, will be trained in bicycle facilities design.

Other measures that could be considered as goals to be achieved by locals by the year 2010:

- 10% of all parking within a city should be for bicycles
- 100% of all non-limited access bridges should be accessible and safe for bicyclist.

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Where do people want to live? *(1) Contrary to popular myth a great majority of Americans vote to live in places depicted in these scenes. Nearly 80% of Americans want to live in cities or towns encouraging neighbors to interact with sidewalks and porches (Crystal Beach, Florida) (2) or on narrow, quiet streets like Espanola Way's one-way one lane road (South Beach Fl.). (3) Fifth Avenue in Naples, Florida has a small scale and pleasant deli, outdoor cafe and grocery. The trend and desire of many Americans is to have interactive neighborhoods and communities such as those depicted here. Community goals should reflect the citizens' desire.*

Rolling through public space. *Our roadways, walkways and bikeways constitute much of what is left of urban public space. Neighborhood leaders, advocates for beautiful cities and roadways, pedestrians, bicyclists and others are taking a stand. Single use roadways, vacuous open space, sprawl and noxious fumes are stressful and debilitating. Citizens and planners can take new inspiration from dozens of cities that have gotten their feet back on the ground.*

- 90% of all non-limited access urban roadways should be rated as bicycle friendly.

2.9 Inventory of Existing Conditions

Planning for bicycle facilities begins with observing and gathering data on the existing conditions affecting bicycle travel. Problems, deficiencies, safety concerns, and bicyclists' needs must be identified. The existing bicycling environment should be observed. Bikeways, roadways where bicyclists ride and roadways where bicyclists do not ride should be examined for their suitability for bicycling.

Obstructions and impediments on existing highways, such as unsafe grates, debris, shoulder rumble strips, narrow lanes, driveways, rough pavement, high-speed or high-volume traffic, high truck volume, curbside auto parking, lighting, railroad crossing flanges, bridge expansion joints, metal grate bridge decks, and traffic signals that are not responsive to bicycles should be considered for their effect on bicycling. The existing bicycle parking situation should be examined for its adequacy.

Areas near probable bicycle traffic generators, such as major employment centers, schools, parks and shopping centers, should be reviewed to identify existing or potential bicycle travel. Convenient access to mass transit stations and other intermodal transfer points for bicyclists should be checked. Barriers such as rivers and freeways should be identified and examined for their effects on bicycling. The existence of bicycle parking, lockers, showers and other services should be noted.

Bicycle crash locations should be investigated to identify any physical obstructions which may contribute to crashes. Data should be collected on the amount of recreational versus utilitarian riding and on the ages and experience of bicyclists.

Public participation is essential during the inventory of existing conditions or physical factors affecting bicycle transportation. Observations and surveys of active and potential bicyclists will be useful, as will the views of the non-bicycling public. The attitudes and needs of destination-oriented, traffic-tolerant bicyclists greatly differ from those of casual, traffic-intolerant bicyclists. Thus, a wide variety of views should be sought. The views of various groups should be weighed against each other and tempered with sound professional judgment.

A comprehensive inventory would include all the following:

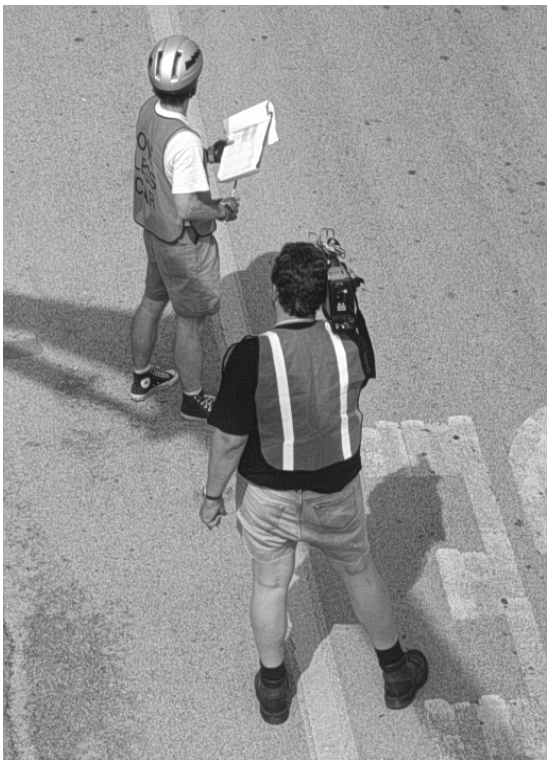
- Traffic volumes and speeds,
- Parking
- Continuity
- Directness
- Access
- Attractiveness
- Security
- Barriers
- Crashes
- Delays
- Facility Conflicts
- Sight Distances
- Maintenance
- Bridges
- Conditions at intersections
- Traffic laws and ordinances

Florida bike planners and others from around the nation joined with Key West citizens to devote 3000 person hours to analyze bicycling and pedestrian conditions. The 10-day effort has resulted in a detailed listing of problems and opportunities facing Key West as it makes its decisions for transportation for the next decade.

2.10 Background Report

The information gathered during the inventory should be included in the background report. Additional information which should be considered when preparing a background report include:

- Demographics
- User surveys, questionnaires
- Existing standards (design, engineering)
- Existing safety programs
- Existing enforcement programs
- Known or proposed projects affecting bicyclists (i.e. new subdivisions, new or reconstructed roads, bridges, sewers, greenways, utility corridors, etc.)
- Current planning policy documents
- Forthcoming revisions to existing planning, policy documents
- Jurisdictions
- Resource groups or individuals
- Funding sources



2.11 Selection and Development of Options

With goals and objectives set, an inventory completed, and a background report written, inadequacies in the system can be addressed. The inventory of existing conditions provides an opportunity to modify and/or refine bicycle-use goals and objectives. Programs and projects for bicycle user encouragement, enforcement, education, and improvements complement each other and are all options that should be considered.

Poor design creates problems. *Note the presence of signs , posts and trees in the area cyclists are expected to ride. Sidewalk bikepaths are universally ignored, while rough shoulder pavement forces bicyclists to adjacent lanes. Attention to basic needs must be foremost.*

This popular, shaded bike route in Palo Alto, California connects numerous quiet neighborhood streets with the downtown. Bike Routes and bike boulevards provide links to bike lanes and shared use paths.

2.11.1 Traffic Volumes and Speeds

For facilities on roadways, traffic volumes and speeds must be considered along with the roadway width. Commuting bicyclists frequently use arterial streets because they minimize delay and offer continuity for trips of several miles. It can be more desirable to improve heavily traveled high-speed streets than adjacent streets, if there is adequate width for all vehicles is available on the more heavily traveled street.

When this improvement is not possible, a nearby parallel street may be improved for bicycling. Stops must be minimal and other route conditions adequate. When such a parallel facility is improved, care must be taken that motor vehicle traffic is not diverted to the improved facility.

This discouragement can often be accomplished with traffic calming techniques, such as an occasional diagonal diverter which still permits bicycle and pedestrian flow. In general, inexperienced bicyclists will not ride on heavily traveled, high-speed arterials but will prefer quieter streets. Thus, cyclists' preferred routes may change over time as their skills change, or as traffic volume continues to increase.

2.11.2 Traffic and Parking Factors

The turnover and density of on-street parking can affect bicyclist safety (e.g., opening car doors and cars leaving angle parking spaces).

High-speed trucks, buses, motor homes, and trailers, because of their aerodynamic effect and width, can cause special problems for bicyclists. Where bus stops are located along a route, conflicts with bus loading and discharging may pose problems. Pavement damage caused by large vehicles may also cause problems for bicycle use.

2.11.3 Continuity

Continuity of a bicycle facility system is important to the convenience and safety of bicyclists. When constructing bicycle facilities, provide connections to other facilities. When it is not possible to make a connection the isolated facility should still be constructed and adjacent connecting facilities added on future projects. It is possible to provide width for bike lanes in the highway, or provide undesignated bike lanes, and hold off on marking them as designated lanes until there is sufficient length.

2.11.4 Directness

For utilitarian bicycle trips, facilities should connect traffic generators and should be located along a direct line, convenient for users. To encourage bicycling, bicyclists should have equal access to all corridors and attractions, especially for short trips within a neighborhood or between neighborhoods.

Within a neighborhood, links should be considered through cul-de-sacs, making use of greenways and other open ways.

2.11.5 Access

In locating a bicycle path, consideration should be given to the provision for frequent and convenient bicycle access, especially in residential areas. There should be many links to the places people live, shop, attend school and work, and connect to transit. Adequate access for emergency, maintenance and service vehicles should also be considered. Too often bicyclists are denied convenient access to major destinations, including airports, bus/rail stations and seaports. Planners and policy makers must ensure that bicycling access is provided to every public facility and across all waterways where other transportation is being provided. When a corridor formerly accessible to bicyclists becomes a freeway, planners must assure that some alternative access along the route is provided to non motorized users.

2.11.6 Attractiveness

Scenic value is particularly important along facilities intended to serve primarily recreational purposes. Facilities should add to rather than reduce the character of the surroundings. When a facility is attractive, longer bicycling distances and greater use will be achieved.

2.11.7 Security

The potential for criminal acts against bicyclists, especially along remote bicycle paths, and the possibility of theft or vandalism at parking locations should be considered. High levels of use, lighting, and environmental design are key factors in assuring a high level of security. During low light hours, lone bicyclists may prefer to travel on roadways which have more pedestrian and vehicular traffic than an adjacent path.

2.11.8 Barriers

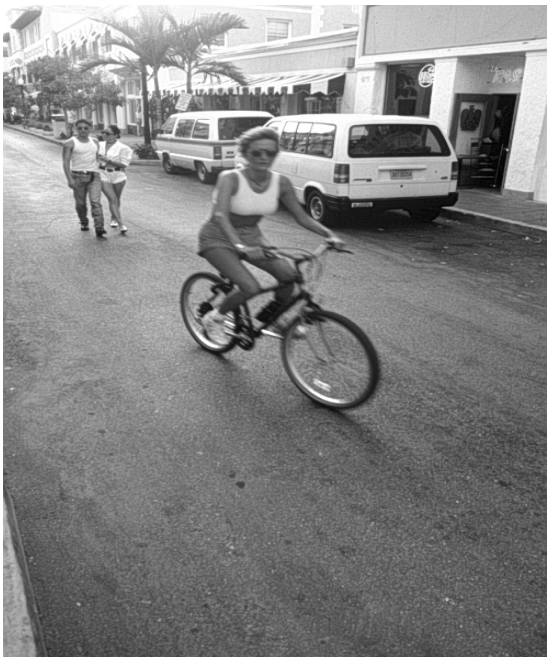
In some areas, there are physical barriers to bicycle travel, caused by lack of accessible bridges, topographical features, freeways, high speed roadway sections, intersections or other impediments. In such cases, providing a facility or bike on transit service to overcome a barrier can create new opportunities for bicycling.

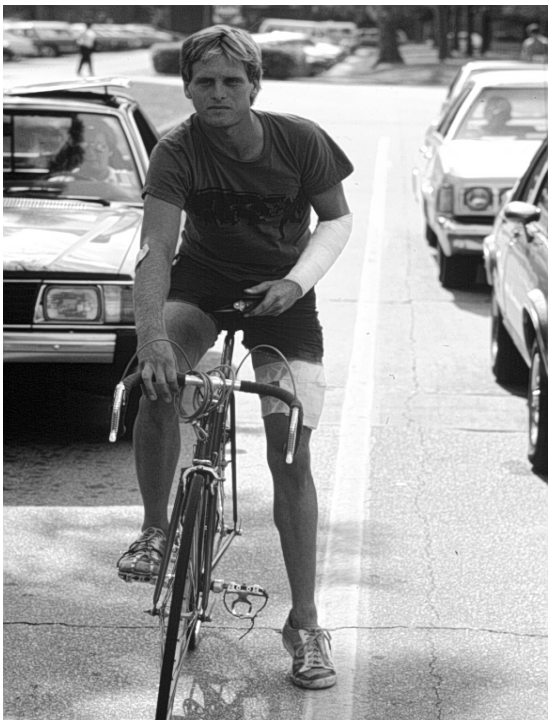
2.11.9 Crashes

The reduction or prevention of bicycle crashes (i.e., bicycle/motor vehicle, bicycle/bicycle, bicycle/pedestrian and single bicycle crashes) along routes is important. The potential for alleviating crash problems through the improvement of a facility should be assessed. During the 1980's and early 1990's, Florida had the highest rate of bicycle crashes per

Directness and Access. *This special traffic diverter prohibits cars but remains a connection for pedestrians and bicyclists into and out of this neighborhood. Convenience wins as bicycles are chosen instead of motor vehicle trips. A 10 minute advantage on a 30 minute trip increases those willing to bicycle by as much as 50%.*

Attractiveness and Security. *Espanola Way in South Beach recently underwent an $80,000 face lift. This street now serves as an attractive connector from the beach to the far west side of the island. By designating every 5th or 6th street as a "Green Street" it is possible to add both attractiveness and security to travel. Increased pedestrian and bicycling traffic leads to higher levels of security for everyone.*





Safety must come first. *This Gainesville bicyclist has no other transportation. Providing choices in safe, convenient and accessible transportation is an essential goal of all communities.*

capita in the nation. The conditions leading to these crashes (i.e. high urban motorist speeds, narrow roads, poor lighting, few alternative bicycle path routes, etc.) continue to dominate. Plans should be reviewed on all proposed roadway and transportation improvements including resurfacing projects to avoid introducing new bike crash problems, and to reduce/ eliminate existing problems.

2.11.10 Delays

Bicyclists have a strong inherent desire to maintain momentum. If bicyclists are required to make frequent stops, they may tend to avoid the route or disregard the traffic controls. Total trip time is important to utilitarian bicyclists. If system delays are substantial, the potential bicyclist is likely to seek some other form of movement. Thus, both point source delays and corridor-long delays should be weighed and measured.

Bike lanes often reduce delays to motorists and bicyclists. This is especially true on crowded arterial and major collector roads. Bicyclists have the opportunity legally and conveniently to move to the head of the queue at each intersection. Motorist may more easily pass a bicycle. Department research found fewer motorist encroach upon adjacent lanes when passing a bicyclists if bike lanes are present. Consequently, fewer motorists are having to wait for a gap so they can pass safely.

2.11.11 Facility Conflicts

Different types of facilities introduce different types of conflicts. Facilities on the roadway can result in conflicts

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Barriers. *(1) For years bicyclists were denied access to this southern Florida bridge. Today the prohibition is removed. All future non-limited access bridges are to have paved shoulders accessible to bicyclists.*
(2) *Developers often provide sidewalks only to the end of their projects. It is then the responsibility of area government to make the connections. Public officials must assure that funds are programmed or developers complete the connections.*

between bicyclists and motorists. Shared use paths conflicts can involve bicyclists, moped operators, roller skaters and pedestrians on the facility. Conflicts arise between bicyclists and motorists at highway and driveway intersections as well.

Facilities should be designed and located to minimize conflicts with cross traffic, especially through access management, use of raised medians, regulatory control of turning movements in commercial districts, and other measures.

2.11.12 Sight Distances

Adequate sight distances must be maintained, especially to aid bicyclists and motorists in detecting each other at key conflict locations. A complete discussion of sight distance is provided in section 5.11.

Sight Distances & Conflicts. *Above: This sight restricted sidewalk style bike path creates high risk and discomfort for bicyclists.*

2.11.13 Maintenance

Maintenance-sensitive design and constant attention to maintenance are important. An improperly maintained bikeway will often be shunned by bicyclists in favor of a parallel roadway. Regularly scheduled sweeping of roadways and bike lanes is essential, especially on popular routes and bridges.

Bicycles are disproportionately affected by roadway maintenance. Bikeways must be free of bumps, holes and other surface irregularities if they are to attract and satisfy the needs of bicyclists. Utility covers and drainage grates should be at grade and, if possible, relocated to outside the expected area of travel.

Below: A 13 year old child lost his life at this intersection when he could not see the car about to hit him.

Approaches to railroad crossings should be improved as necessary to provide for safe perpendicular bicycle crossings. Bridge decks should be designed to minimize the effect of expansion joints and deck surfaces on bicyclist stability.

2.11.14 Bridges

Bridges serve an important function by providing bicycle access across barriers. However, some features found in bridges can be unsuitable where bicyclists are to be accommodated. The most common of these are curb-to-curb widths that are narrower than the approach roadways (especially where combined with relatively steep grades). Open grated metal decks found on many movable spans, low railings or parapets, and certain types of expansion joints can cause bicyclists steering difficulties or swallow a narrow wheel.

2.11.15 Conditions at Intersections

A high proportion of bicycle accidents occur at intersections. Facilities should be selected so as to minimize the number of crossings, reduce turning speeds of motorists, provide responsive side street signal detection for bicyclist

Maintenance and Design. *Above: A simple overlayment of 10 yards of an asphalt apron would eliminate this ongoing maintenance and safety problem.*

Bridge surface conditions *impact bicyclists. Below: FDOT tests confirmed the advantage of a newly designed decking surface for bascule bridges.*

Wheel's eye view. *This "homemade" drainage grate existed for more than a decade on the principal route to an elementary school. Adults often overlook such obvious hazards to their children.*

entry, provide adequate night lighting, and make certain that the clearance interval accommodates bicycle crossing speeds.

2.11.16 Traffic Laws and Local Ordinances

Bicycle programs must reflect local laws and ordinances. Bicycle facilities must not encourage or require bicyclists to operate in a manner inconsistent with the adopted Rules of the Road. Lack of adequate facilities may encourage unlawful behavior such as:

- Wrong way riding
- Running stop signs and signals
- Commercial district sidewalk riding
- Erratic riding when lanes are too narrow or the road is bumpy.

2.12 Analysis of Improvements

Bicycle-use goals and objectives must be in harmony with the overall transportation, land use, urban design and environmental policies of the community and state. The end result is a plan of proposed improvements for bicycle travel. The following types of improvements should be considered:

- Facility improvements, such as roadway improvements, maintenance and operations improvements, bikeways, and bicycle parking facilities, transit links and other elements can be implemented as part of normal processes..
- Reduce conflicts between pedestrians, bicyclists and motorists through separate facility types, and correct conditions unsafe for bicycle riding.
- Improvements to drainage grates, speed humps, utility caps, railroad grade crossings, pavement surfaces, traffic signals, signing and markings will be beneficial.
- Bicycle routes can provide continuity to other bicycle facilities or designate preferred routes.
- Bicycle boulevards can provide continuity and direct links to key destinations within a community along preferred routes.
- Bicycle lanes, together with signs and pavement markings, can improve conditions in corridors where there is significant or potential bicycle demand. They delineate the intended or preferred path of travel and encourage the separation of bicycles and motor vehicles. Bicycle lanes also help increase total capacities of highways carrying mixed bicycle and motor vehicle traffic.
- Shared use paths can provide enjoyable recreational opportunities as well as desirable commuter routes. Paths can create opportunities not provided by the road system. Many paths can be used to help form and preserve a

network of greenways through a bicycling community. Shared use paths can sometimes provide shortcuts to roadway routes, thus providing incentives to bicycle use instead of auto use.

- Sidewalks are generally not acceptable for bicycling. However, in a few limited situations, they may complete the bicycle system, such as on long and narrow bridges or where sidewalks are uninterrupted and have the same characteristics as one-way bicycle paths. In such situations bicyclists must be incidental or infrequent users. Recognition that the sidewalk will be used for bicycling can be beneficial, but they should not be designated as facilities.
- Bicycle parking facilities are essential to encourage all types of bicycling: cycling to the park, library, ball fields, dance class or commuting. In particular, the provision of parking facilities promotes utilitarian bicycling by giving bicyclists the same priority as cars with respect to end of trip facilities. To be effective, bicycle parking must offer protection from theft and vandalism. Bicycle parking should be clearly labeled and located as close to a building entrance as possible. It should be convenient with no stairs to negotiate. It should be covered or sheltered from the elements. Parking is most effective located where there are people or security personnel present and not interfere with pedestrian traffic. Good lighting is essential. Showers are essential for commuters. Bicycle parking should be separated from automobile parking by a barrier or sufficient distance to prevent possibility of damage to parked bicycles by automobiles. In general, bicycle parking should be provided at all major traffic generators, especially where motor vehicle parking is provided at mass transit stations. Bicycle parking encourages two intermodal forms of travel.
- Bicycle racks on buses and water taxis and bicycle parking at transit stops can increase transit use. It can also increase intermodal trips to schools and key employment and commercial districts.

2.13 Selection of Projects

Selection is based on the evaluation of the options developed in the planning process step. Each option is evaluated further with respect to goals, objectives and benefit/cost analysis. There are five basic factors to consider:

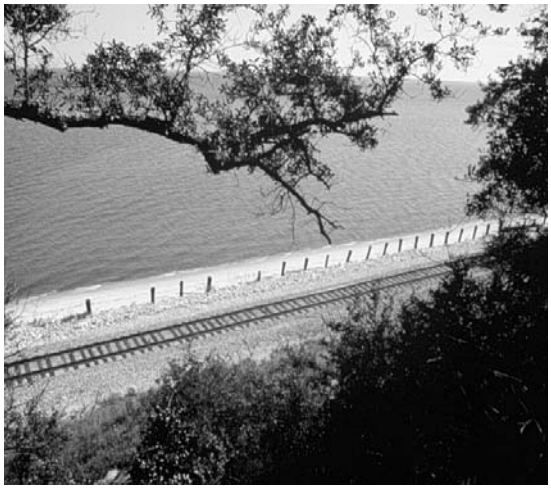
- Community vision, transportation goals
- Roadway design criteria
- Bicyclists' needs
- Other users' needs
- Cost

1

Public risks, *such as this uneven sidewalk, remain undocumented for years since many adult transportation or safety specialists make virtually all of their trips in cars. This disparity can only be overcome by new and better processes .*

Below: The shoulderless roadway edge dropoff below resulted in a fatal crash to a 13 year old in Tallahassee.

River fronts offer one of the few occasions where sidewalks can transport bicyclists with minimal conflict with motorized traffic. Sufficient width must be provided to reduce conflict with pedestrians.



Whether planning for the future when this rail line will be abandoned (above), or providing a bicycle rental and storage facility along a new rail line (below), bicyclists and transit users benefit from planning.

If there is effective interaction during the planning process between user types and groups, the bicyclist criteria should closely match the criteria of the motorist and the community/ transportation vision and goals. Likewise, design criteria may be modified to permit flexibility for a community to achieve its goals and objectives. It is important to recognize that this is a dynamic process that can be achieved only with full involvement of the community in each phase of planning. If this process has not been effective, major planning revisions are usually necessary at every stage of the project.

Selection of location will normally involve a cost analysis of alternatives. Funding availability can limit the alternatives. However, it is important that a lack of funds not result in a poorly designed or constructed facility. It is usually more desirable not to construct a bicycle facility than to construct a poorly planned or designed facility. The decision to implement a bikeway plan should be made with a conscious, long-term commitment to a proper level of maintenance. If only a small amount of funding is available, emphasis should usually be given to low-cost improvements (i.e., bicycle parking, removal of barriers and obstructions to bicycle travel, roadway improvements and non-construction projects such as mapping).

2.14 Development of Implementation Strategy

There are three steps in developing a strategy for implementation:

- Identify required actions and the departments or agencies to carry them out;
- Develop a budget. This may flow from the benefit/cost analysis done for each option in the previous step; and
- Develop of a work program schedule.

2.15 Assessment

The success of any program or planning exercise can only be determined by assessment at regular intervals. Feedback can be obtained from surveys, usage rates, comments and complaints and from comparison of observed behavior and crash statistics before and after implementation. This monitoring can lead to reassessment of the goals and objectives and/or the selected option.

Skinny Houses and Skinny Streets. *Above: These Dutch skinny streets (note the width of the road as compared to the truck) slow neighborhood traffic at special choke points. New urbanism works best with moderate densities (5-7 units per acre). Such densities are considered minimum to allow walking, transit and bicycling to succeed. This contrasts with 1-3 units per acre for suburban style development. Seattle developers are encouraged to build more houses to the block by using 25 foot wide lots. Ranch style house lots can often provide space for 2 or 3 homes.*

Below: Bulbouts help bicyclists and pedestrians by reducing turning speeds and narrowing crossings, but may be disliked by some bicyclists in some locations since it forces them to merge.

Section 3 Safety

3.1 Who are we designing for?

Basic human performance is detailed in this section. Reading this section before the design sections to follow allows better understanding of the needs of bicyclists and the motoring public.

The first part of this chapter discusses crash causation, bicycle crash classes and identifies root causes of crashes. Next, human performance is detailed. This includes abilities and limits of bicyclists according to age. Also addressed are the unique properties of a bicycle. The unique problems of vision and visual detection of bicyclists are explained. Bicycle physical/spatial needs and bicycle physics are also explored in this section. Other principles of physics as they relate to bicyclists are discussed.

Bicyclists are involved in highly characteristic crashes, often associated with age, experience and ability. While only 15% of bicycle crashes involve a motor vehicle, these crashes tend to be the most serious, and hence have been studied more. The two types of crashes (motor vehicle related and non-motor vehicle related) are detailed below. By studying the morphology, mechanism and forensics of injuries and bicycle or path related crashes, it is possible to see how a particular design influences or fails to change essential human performance.

3.2 Bicycle Falls and Crashes

Non-motor vehicle bicycle crashes are quite common. Only one in ten bike crashes are reported to police. Yet bike crashes make up as much as 15% of emergency room care. We lack a complete understanding of their nature. We do know that bicycle helmets can greatly reduce the likelihood and severity of a head injury. It is important to understand that a simple fall can produce "g" forces to the brain three times the force required to produce death. Bike helmets save lives.

In many non-motor vehicle bicycle crashes the bicyclist loses control of the bicycle, going off the road or path. Causes of crashes include hitting an obstruction, skidding on sand, ice, water, wet leaves; or hitting a seam, flange, pothole or other surface irregularity that affects the wheels and hence the stability of the bicycle.

Another common form of non-motor vehicle crash is a bicyclist colliding with another bicyclist, a pedestrian, in-line

> The safety of the public is the highest law.
>
> - Roman Law

Children are highly over-represented in bicycle injuries. *Walking and bicycling related crashes are children's' single greatest risk of injury and death. These injuries are not accidents, and they are not random events. Bicyclist injuries are highly predictable, preventable events that result from known circumstances. There is much we can and should do to prevent them.*

Above: Bicycle/car crashes can often be prevented by either party. If a bicyclist makes a mistake, the motorist can and often does correct for that mistake, and visa versa. For childhood injuries, usually the child makes the primary error and the driver can correct. With adult bicycle crashes, the motorist most often makes the error, and the bicyclist has a chance to correct for the driver's error.

Precipitating Events. *Below: In the photo to the bottom left the truck driver pulled too far forward. The front end of his cab will hide the children. A poorly marked stop bar is considered a contributing environmental cause to this crash. Other predisposing operator attributes include the inexperience of the children who don't predict that they will be undetected.*

skater, dog, or other moving object. Such crashes can be serious. Thus, attention to proper maneuvering widths and sight distances to help bicyclists maintain control are essential on pathways and other locations where mixed use can be anticipated.

Non-motor vehicle crashes comprise over 85% of all crashes. Yet they are studied less, since only 10-15% of fatal or severe trauma crashes occur in this way. We need more knowledge about their causes.

3.2.1 TransAmerica Bicycle Trail Crashes

One problem we have determining causes and frequency of crashes is the lack of reporting. The most comprehensive and best documented cause of crashes to a large number of bicyclists, riding a well defined number of miles, using rural type roadways, was documented in 1976. During that summer, researchers Dan Burden and Bruce Burgess analyzed the results of 10.4 million miles of exposure to 4,065 novice and skilled bicyclists using the 3,600 mile long *TransAmerica Bicycle Trail*. Most of these bicyclists rode in small groups or alone. The *TransAmerica Trail* uses low-volume-traffic, paved roadways, 20-24 feet (6.1 - 7.3 m) wide.

Even with light to moderate traffic, and thousands of junctions with motor vehicles, most crashes occurred between bicyclists. Two fatalities occurred. Both involved motor vehicles. In both cases the motorist was found to be at fault. From this exposure analysis, it was determined that a mix of beginning to experienced riders on a rural road riding in a group have an injury-producing crash every 12,500 miles, a crash resulting in permanent injury every 250,000 miles, and risk a fatality every 5.2 million miles. Skilled bicyclists had a much better rate. Fatigue and higher traffic volumes play a big factor, with 75% of crashes occurring late in the day, usually after riding 70 miles (107 km).

Principal non-fatal causes are listed as follows:

Bicyclist hit bicyclist	20.1%
Pothole or broken pavement	10.7%
Car hit bike	7.8%
Loss of control	6.5%
Bike crashed trying to avoid car	5.8%
Loose gravel on roadway	5.2%
Rider fell off bike	4.9%
Slipped on gravel road	2.6%

It should be noted that surface conditions and other maintenance issues are significant factors in bicyclists stability and safety.

3.2.2 Potholes and Longitudinal Seams.

Bicyclists are most likely to hit potholes when traveling at higher speeds, such as on a downhill descent, or when light conditions are poor. Another significant maintenance problem for all bicyclists are longitudinal seams, such as those created by a dropoff from the road or path edge, bridge expansion joint or skewed railroad crossings and drainage inlets.

3.3 Common Bicycle - Motor Vehicle Crashes

Research (Cross & Fisher) has identified 36 mutually exclusive types of motor-vehicle/bicycle related crashes. Most of these can be generalized into 7 classes (A-G). These classes are explained below. As a general rule, children are involved heavily in classes A, B and E, where they most often make the primary errors. In contrast, adults are more typically involved in classes C, D, F and G, where the motorist most often makes the primary errors. Numerous local and Florida state studies reveal striking similarity between this data base and current crash statistics.

Wrong-way riding, although a major factor in many of the crash classes, was not isolated as a separate class during the original research. It is known that wrong way riding contributes heavily to many crashes, and especially class B, C and F categories.

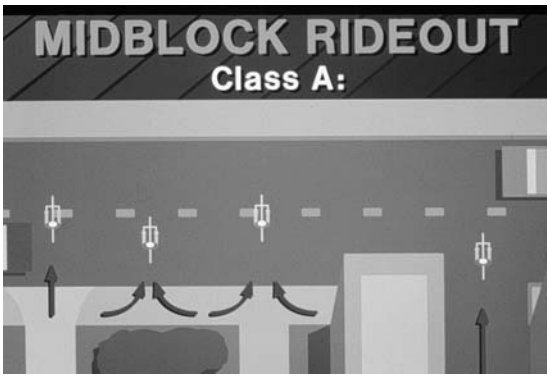
3.3.1 Bicyclist Rideout: Driveway/Alley And Other Mid-block

Class A: 15.1% of fatalities, 13.9% of Non-fatalities

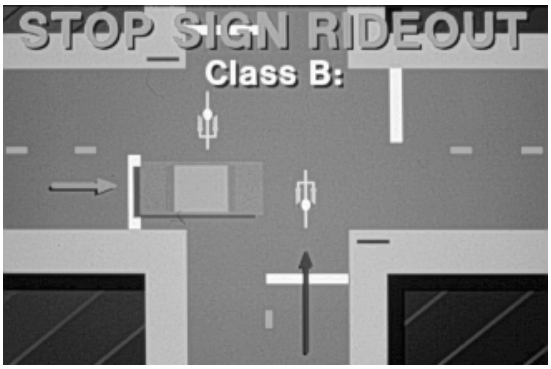
This crash type involves bicyclists who enter roadways without adequate searches. Skilled bicyclists had a much lower rate. In nearly 70% of the occurrences it is near-side motorists that are involved in crashes. The majority of these crashes are restricted to children under 12 years of age. Complicating factors include restricted sight distances, blocked sidewalks forcing the bike rider into the street, and lack of parental guidance.

These crashes occur (79% of the time) on two-lane urban roadways with light traffic and a posted speed of 25 mph or less. Only 2% occur on multi-lane highways, while the other 19% occur on 2-lane rural roadways. One of the subtypes, where the bicyclist is riding along a sidewalk then goes out a driveway, occurs on multi-lane highways 16% of the time. Class A crashes comprise over half of fatalities to young children, and up to 1/3 of fatalities to older children.

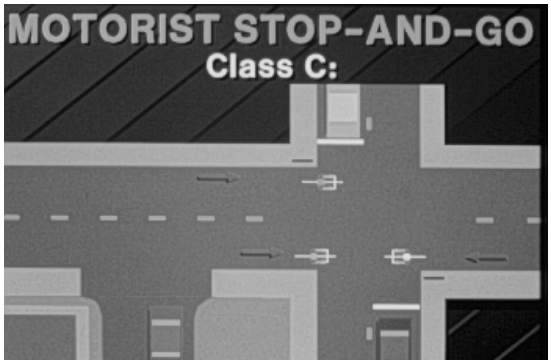
Wrong way riding. *Many bicyclists believe riding facing traffic is safer than riding with the flow of motor vehicles. However riding on the wrong side of the roadway places the bicyclist in a hazardous position. An oncomming motor vehicle cannot readily decide when to pass a wrong way cyclist and may have to pass at the same time as a vehicle coming from the other direction. Motorists making right turns are not looking for traffic coming from their right and may turn right into a wrong way bicyclist.*



Above: ***Bicyclist Ridout****: Driveway/Alley and Other Mid-block.(Class A)*



Above: ***Bicyclist Intersection Rideout*** *(Class B)*
Below: ***Motorist Turn-Merge/Drive Through/ Driveout*** *(Class C)*



3.3.2 Bicyclist Intersection Rideout

Class B: 12% of fatalities, 17% of non-fatalities

This class is very similar to the driveway rideout. Bicyclists fail to yield the right of way, usually at non-signalized intersections. The majority of these crashes involve children, who may have competing interests/needs (e.g., riding with friends, being chased by dogs, or hurrying to school). Most often the intersections involved are familiar to the bicyclists. These bicyclists rarely encounter any traffic and thus fail to make adequate searches. One sub-class of this crash involves bicyclists who enter intersections with latent green phase signals. Due to inadequate clearance intervals, they become trapped in the intersections. Children under age 15 are highly over represented in this crash class (up to one-third of the fatalities).

3.3.3 Motorist Turn-Merge/Drive Through/Driveout

Class C: 2.4% of fatalities, 18.7% of non-fatalities

Motorists in this crash type typically fail to yield the right of way to bicyclists at a controlled intersection, a driveway or other road entry. Although motorists stop or slow significantly, they fail to detect or respond to the presence of bicyclists. Low speed conditions often result in minor injuries, although both bicyclists and motorists often feel victimized by the conditions that created the crash scenario. In many cases bicyclists complicate the situations by coming from unanticipated directions, such as from the motorists' right side on a sidewalk or wrong way street approach (62.5%). In some cases motorists are making right on red turns and fail to detect or respond to bicyclists. Recent Florida data reveal that these crashes often occur on multi-lane highways, comprising 14-16% of all bicycle crashes. In 75% of these cases bicyclists are on sidewalks coming from unanticipated directions. Increased bicycle friendly roadway operating conditions on multi-lane highways can substantially reduce these surprised-condition crashes.

Class C is one of the most common crashes in Florida. The lack of other routes through neighborhoods which forces bicyclists to principle roadways which lack bike lanes, place many bicyclists in this common crash pattern. These Class C crashes rarely result in fatal injuries. The crash is so common, however, that it is the subject of many motorist law suits. Both parties feel victimized by these conditions.

3.3.4 Motorist Overtaking/Overtaking Threat

Class D: 37.8% of fatalities, 10.5% of non-fatalities

Motorists in this crash group typically drive right into cyclists from the rear. This is the most serious crash class, comprising nearly 60% of fatal bicycle crashes in Florida (37.8% nationwide). These crashes often occur on suburban or rural 2-

lane or multi-lane highways with design speeds above 40 mph, under low light conditions (71% of the time). They occur where provisions (shoulders/bike lanes) are lacking to separate bicyclists from motorists. In over one third of these cases, an intoxicated driver is involved. In another third the bicyclist is impaired. In many cases the bicycle and rider are poorly lit, and roadway lighting may be inadequate. This class of crash largely involves adults or older teens. Factors which complicate night riding include alcohol and higher speed.

Class D crashes are Florida's most frequent and deadly, accounting for nearly 60% of Florida's fatal bicycle crashes. Bike lanes, by providing a separate space for motorists and bicyclists, will reduce this conflict.

3.3.5 Bicyclist Unexpected Turn/Swerve

Class E: 16.2% of fatalities, 14.2% of non-fatalities

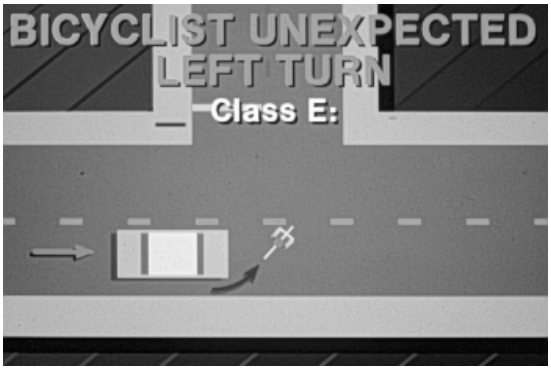
In this crash group, bicyclists suddenly turn left without warning. About half of the bicyclists initiated unexpected turns at intersections or driveways. The other half made turns mid-block toward unidentified points. Nearly 50% of the crashes occur on 2-lane, urban roads, while 30% occur on rural 2-lane roads. The other 20% occur on multi-lane roadways in both urban and rural settings. In 94% of the cases bicyclists failed to search or conduct an adequate search. Researchers suspect that bicyclists in such cases are relying on auditory cues to detect the presence of overtaking cars. Too often, however, the sounds of cars may be masked by other traffic, wind, or other noise. It is also suspected that many, especially younger bicyclists, feel uncomfortable scanning to the rear. This task often causes them to steer toward the traffic lane. Children 14 years and under make up 75% of this crash class.

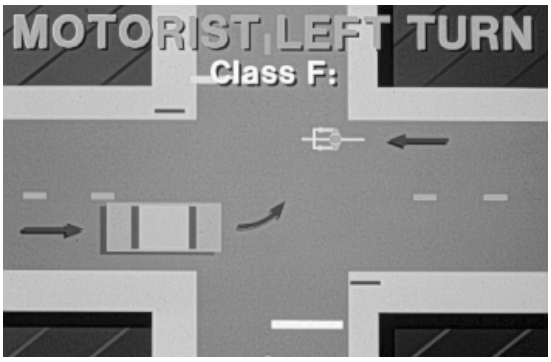
3.3.6 Motorist Unexpected Turn.

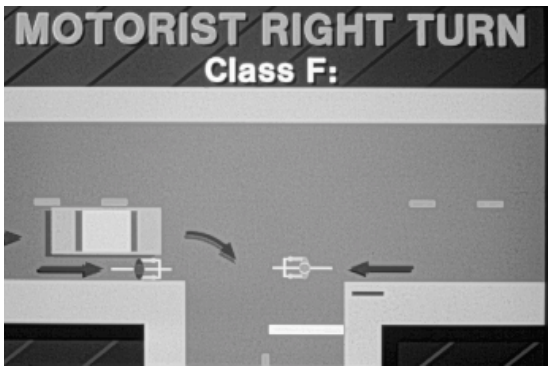
Class F: 2.4% of fatalities, and 14.5% of non-fatalities

In nearly all cases motorists turn directly into paths of bicyclists (left and right turns). Usually bicyclists are coming from unexpected directions (on sidewalks or wrongway lane positions). The most serious of these crashes occur when motorists turn left into the path of bicyclists (either on roadways or sidewalks). These crashes tend to be higher speed, resulting in more severe injuries. These unexpected left turns are the most serious bicycle crashes in many college communities. Glare, inattentiveness and information overload to motorists are suspected to be major contributing factors to this crash class. Driveway access management (right in, right out) should be considered as an engineering countermeasure in some locations. Motorists' right turn crashes are often caused by serious misjudgments of the speed of bicyclists just passed by these motorists. Most (64%) are at roadway junctions,

Avove: ***Motorist Overtaking/Overtaking Threat*** *(Class D)*
Below: ***Bicyclist Unexpected Turn/Swerve*** *(Class E)*







Above: ***Motorist Unexpected Turn*** *(Class F)*

while 29% are at driveways. Bicyclists travelling undetected on sidewalks contribute significantly to this crash class.

3.3.7 Other

Class G: 13.8% of fatalities, and 11.2% of non-fatalities

This category involves numerous other crash conditions, such as uncontrolled intersections, short clearance intervals, parking lots, other crossing conflict situations, head-on collisions with wrong way bicyclists or motorists, and objects falling from vehicles.

3.4 Types of Bicyclists

A high percentage of Florida's citizen's neither own nor operate automobiles. These people make up at least 37% of our state population. Unfortunately, harsh roadway conditions where they live and must travel make their movement challenging. Many of these people must use bicycles during all times of day, and many times in low light (on the way to school), exposing them to higher risk. Their crash involvement can be 3-8 times that of the general population. Extra efforts must be made to provide safe roadway environments in low socioeconomic environments. Affordable housing and quality, low-speed roadways need to be synonymous.

From a planning and design perspective, bicyclists can be divided into six overlapping categories that cover a range of physical, psychological, physiological and emotional abilities,

Table 1

CRASH TYPE SUMMARY		
CRASH TYPE	**% OF FATALITIES**	**% OF NON-FATALITIES**
Bicyclist Rideout: Driveway/Alley and other Mid-block, Class A	15.1%	13.9%
Bicyclist Intersection Rideout, Class B	12%	17%
Motorist Turn-Merge: Drive Through/Driveout, Class c	2.4%	18.7%
Motorist Overtaking/Overtaking threat, Class D	37.8%	10.5%
Bicyclist Unexpected Turn/Swerve, Class E	16.2%	14.2%
Motorist Unexected Turn, Class F	2.4%	14.5%
Other, Class G	13.8%	11.2%

experience and skill. In general, these abilities are broken down by age and experience. The ages and abilities of bicyclists are far more varied than those of motorists. Indeed, before, during and after motorists gain or lose their ability to drive, they bicycle for mobility.

3.4.1 Young Children - Ages 5-11

At a young age children lack traffic experience. They are often impulsive. They have limited peripheral vision and cannot easily detect the source of sounds. They feel compelled to complete an action they have started and they think grown-ups will look out for them. Young children have not fully developed depth perception, gap assessment, peripheral vision and sound directionality. Since children do not drive cars, they have difficulty understanding why adults cannot see and respond to them. They are primarily involved in class A, B and E crashes, and numerous non-motorized crashes.

3.4.2 Youth - Ages 12-15

Children at this age take increased risks, travel farther from home, ride at night, and use main roads to access shopping malls, schools, parks and other places they wish to go. Children of this age often overestimate their abilities. They are primarily involved in class A, B, C and E crashes.

3.4.3 Young Adult - Ages 16-22

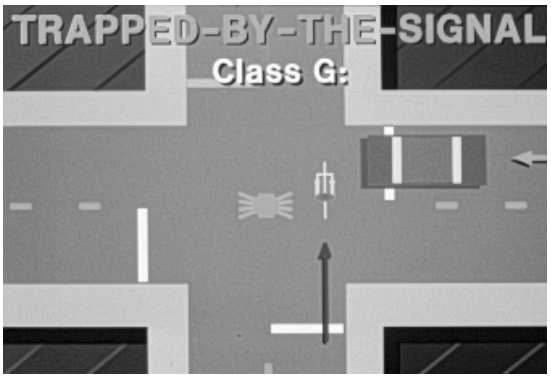
People of these ages now travel at higher bicycling speeds. Many have developed a keen sense of invincibility and have increased experimentation with drugs and alcohol. For some, bicycles may be their only means of transportation to school or work. Many of this age work night jobs and rely on bicycles for transportation. They know the basic rules of the road. They are primarily involved in class C, D and F crashes.

3.4.4 Novice Adult - Ages 23-64

The majority of adults (95%) are novice bicyclists. This category of bicycle riders uses bicycles too infrequently to develop many cycling skills. Some ride at night, greatly increasing their risk. They are primarily involved in class C, D, and F crashes.

3.4.5 Senior Adult - Ages 65+

Senior adults increasingly experience some physiological decline, especially in vision. There are pronounced loss of physical abilities starting around age 75 which can include: loss of balance, vision, hearing, and strength. Reduced bicycling speed is common to this age group. Their needs to be independent, to get exercise and to move about the community do not diminish. They are primarily involved in class A, B, C and F crashes.



Above: Trapped-by-the-signal. If a signalized intersection has an inadequate clearance interval, a cyclists may enter the intersection on a green light and have the light turn amber, then red while the cyclist is still within the intersection. Motorists who are not alert may leave the cross street as soon as the light turns green for their movement and hit the cyclist.

Motorist Unexpected Turn *These crashes are common among adults and highly preventable. Bike lanes place bicyclists in the motorist's visual field. It is anticipated these lanes can be effective in reducing the frequency of these crashes.*

In many crashes involving adult cyclists the motorist makes the primary error. Frequently the motorist turns directly in front of the cylclists.

3.4.6 Proficient Adult - All Ages

These cyclists comprise only 1-4% of the bicycling population. But their frequency of bicycling on major roadways is high. These cyclists tend to ride in all seasons and weather. Some ride mostly for recreation, others mostly for primary transportation. They most often have highly predictable road behavior. Most are excellent role models. A few are scofflaws. Speeds of 18-24 mph (28-38 km/h) are common for this category of cyclist. They are primarily involved in class D and F crashes.

3.5 Intersection and Path Junction Crashes

In a nationwide sample (by Wachtel and Lewiston) it was found that 57 percent of pedestrian and 73 percent of bicyclist crashes occurred at junctions. Another study examining police-reported bicycle motor vehicle collisions covering a four-year period in Palo Alto, California found that 74% occurred at a junction.

Sensitive design of path and roadway junctions is vital to safe path development.

3.6 Bicycle Helmets

Bicycle helmets save lives. A full 75% of bicycle fatalities and permanent injuries are head injuries. At least 60% of all fatalities include only a brain injury. Thus, bicycle helmets can eliminate up to 60% of all fatalities. Florida State Law requires anyone younger than 16 years of age to wear a bicycle helmet.

A bicycle helmet works by reducing the "g" forces to the brain. A fall while a person is sitting stationary on a bike onto a concrete surface can produce forces of nearly 2000 g's. It only takes 150 g's to produce minor injury, 300 g's to produce permanent injury. At 600 g's, no one survives. A bicycle helmet reduces the nearly 2,000 g's from a hard fall or crash to often below 150 g's.

3.7 Traffic Safety Education

Even if an ideal network of facilities for bicyclists was in place we would still have bicycle/motor vehicle crashes. This is because most crashes are the result of an error on the part of the bicyclist or motorist. The Department of Transportation is dedicated to reducing the number of roadway crashes, not just through engineering, but also through education.

The FDOT oversees the Florida Traffic Safety Education Program. This program teaches children in grades 3 - 5 bicycle traffic safety skills (grades K - 2 are taught pedestrian traffic safety skills). The program involves 10 hours of in

class and outside on-bike training. State trainers teach local teachers and regional trainers to implement program in their school districts. These same state trainers also teach a bicycle rodeo course to interested individuals.

Community Traffic Safety Teams deal with all traffic safety and play an important role in bicycle safety education. Community Traffic Safety Teams are groups of agencies and corporations within a community who work to reduce the number of traffic crashes. They work with the 4E's of traffic safety - Engineering, Enforcement, Education, and Emergency Medical Services - to make people aware of traffic safety concerns. They are active in safety fairs, bike rodeos, safety towns and other awareness events. Also Community Traffic Safety Teams are an excellent way for bicyclists to voice concerns about particular facilities.

Motorists need to be educated as to the rights and responsibilities of bicyclist as roadway users. Motorists need to look out for bicyclists on the roadway.

Police officers need to be trained in bicycle law enforcement. They need to know why it is important to ensure bicyclists obey the law. Some communities have instituted a Bicycle Offender Program which gives bicyclist sited for braking a law an chance to attend a bicycle driving class.

*Above and bottom (facing): **Bicyclists can be any age.** There are no restrictions to bicycling ability, just as there are no restrictions to walking. However, parents should be cautioned most children are not ready to bicycle out of sight until ages 9-11. Once children are 12-13, they often explore many places on their own. The developmental abilities of children are well explained in the "Children in Traffic" video available at most AAA Clubs.*

***Helmets save lives**. Florida law requires all cyclist under the age of 16 to wear a helmet.*

Section 4 DESIGN On-Road

Special Note: *Prior to reading this section, designers are asked to read the contents of Section 3 (Crash Causation and Human Factors)*

4.1 Design Issues

The ultimate test of any design is the response to this question: ***"Does this design improve the safety and performance of the motoring, walking and bicycling public?"*** It is important to observe how the design provides desirable operations and controls or improves conditions or eliminates conflicts between users. Generally, bicycling improvements will improve conditions for motorists, both when bicyclists are present and when they are not present.

We recognize the recommendations and criteria do not cover all types of design details encountered in development of bicycle facilities. Where details are not covered, appropriate engineering principles and judgment must be applied in providing for the safety and convenience of bicyclists, pedestrians and motorists.

4.2 The Design Bicyclist

The bicycle is a single track human propelled vehicle having highly similar properties to other single track vehicles (i.e. motorcycle). Bicycles have been tinkered with for more than a century. There are many variations, but all operate according to basic principles outlined in the following pages. Keep these variations in mind when you design.

4.2.1 Dimensions, Speed, Psychological Needs

To design effectively for bicycle riders, physical details of typical riders must be understood. Although riders vary in their dimensions and needs, these guidelines will cover virtually all cyclists:

User Characteristics:

Design Viewing Ht	54" (1.4 m)
Rail Height	54" (1.4 m)
Center of Gravity (adult, child varies)	33-40" (0.84-1.02 m)
Speed for Crossing Intersections	10 mph (15 km/h)
Speed, (level terrain)	20 mph (30 km/h)

1

Principle: -- Improve the safety of everyone. *Protector of errant autos, guard rails also impact bicyclists. The designer must be alert so guardrails and all design treatments benefit all users. (1) Sections of guardrail are a hazard to those they were placed to protect. (2) A falling bicyclist can be seriously hurt. (3) Solution: FDOT standards now require guardrails to have protective pipes to minimize the threat of puncture wounds. (Standard Index 400, 9 of 20)*

2

3

What Do Bicycles Look Like?

Downhill Speed 30 mph (50 km/h)
(roads and bridges)
Uphill Speed 5-12 mph (8-19 km/h)
(roads and bridges)
Note: Try not to exceed 5-6% grade, 3% preferred for long sections

Likely Speeds by Age

Child 6-9 mph (10-14 km/h)
Youth 7-11 mph (11-17 km/h)
Young adult 8-15 mph (13-24 km/h)
Adult 8-15 mph (13-24 km/h)
Proficient Adult 12-24 mph (19-38 km/h)
Senior Adult 8-15 mph (13-24 km/h)
Cycling club pace lines may ride at 15 -30 mph (24 to 50 km/h)

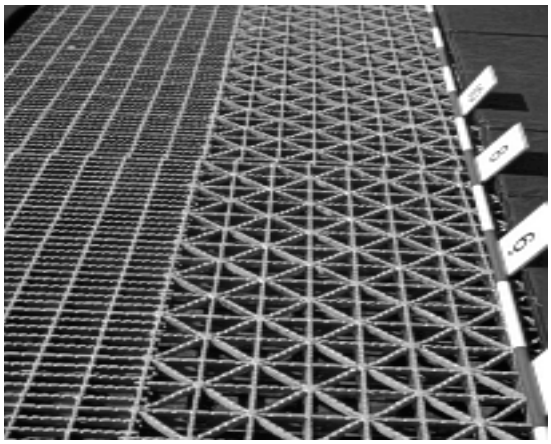
Width and Distances:

Riding width, including trailers 4 ft. (1.2 m)
Lateral clearance to seams, smooth walls, curbs 2 ft. (0.6 m)
Lateral clearance to trees, posts 4 ft.(1.2 m)
Lateral clearance to steep grade 6 ft. (1.8 m)
Vertical clearance 8.0 ft. (2.4 m)
Psychological clearance (tunnels) 10 ft. (3.0 m)

4.2.2 Wheels and Tires

Wheels and tires on bicycles are much narrower than other roadway vehicles. Like motorcycles, bicycles are a single track vehicle, and are far more sensitive to surfaces. Unlike motorists, bicyclists must maneuver to avoid even tiny obstacles or defects. In contrast, autos have complex suspension systems to overcome surface defects. Pedestrians travel slowly enough to step around most defects. Bicyclists, when surprised by potholes, seams or fissures, may suddenly swerve in order to avoid the irregularity. Thus surface irregularities are a serious problem for all bicyclists. Roadside maintenance should be accomplished with this in mind. Considerations when designing for bicyclists are:

- Bicycle tires contact the earth with the equivalent of 2 dimes of surface area
- Bicycles rarely have shock absorbers or suspensions



Above: Very little of a bicycle is actually in contact with the road. It is very important the roadway surface be well maintained. Steel deck bridges present additional hazards to bicyclists. They are both slick when wet and tend to steer the bike.
Below: The side pull brakes used on many bikes can be hard to maintain and may require long stopping distances.

- Sand, mud, leaves, oil and skewed railroad tracks and moisture cause slippage
- Longitudinal seams greater than 1/4 inch wide impact control (gobble ability of tire)
- Steel (rails, bridge decks) and rubber tires do not mix well
- Bicyclist stability calls for a nearly zero vertical object design height for roadway objects. A very small object or even a longitudinal crack can cause a bicyclist to fall. Therefore a sight distance must be calculated base upon an obstruction flush with the surface of the road.

4.2.3 Brakes and Braking

Bicycles vary in their ability to stop quickly. Some brake designs (cantilever) approach the efficiency of autos, and others (cheap side pull) require much longer stopping distances at high speed. Coaster brakes are the least efficient design. Due to overheating they can lose further effectiveness on long downhills. Caliper (hand) brakes are inefficient when the rims are moist. Since many people bicycle infrequently, their reaction and braking response times may increase. Surfaces affect braking. Loose materials such as sand, ice and moisture can increase braking distance by a factor of 1.5-10.0. The following are additional concerns:

- Allow 2.5 seconds reaction time.
- Allow an added 3.0 seconds for surprised condition reaction time.
- It takes about 1.5 seconds to fully set up braking (reach, mechanical delay).
- Maximum deceleration for a bicycle is 11 mph (17 km) per second.
- When rims are wet or coaster brakes are used, braking performance is 50-80% less efficient.

4.2.4 Steering

Emergency maneuvers on bicycles cannot be accomplished quickly, because it takes time to set up for a quick turn. Most people do not understand how bicycles steer. Mechanically, emergency turns take much longer on bicycles than in autos:

- To turn right bicyclists must first steer left a bit to set up a counter lean.
- It takes about 1.5 seconds to set up for a turn.
- Bicycles steer more slowly when fully loaded.
- To stay upright, riders must constantly steer bicycles to keep them in balance and under the body's center of

gravity (wobble).

4.2.5 Profile and Visibility

As many as 80% of motorists involved in car/bicycle or pedestrian/car crashes report they did not see the bicyclist or pedestrian. While this lack of cognition may be true in many cases, the motoring public must learn to regularly search for non-motorized traffic. Ultimately, increased bicycle use will increase motorist awareness. In Holland and in U.S. cities where bicycles are common, car/bicycle crashes are decreasing as use increases. The design community can help by recognizing the following:

- Bicyclists are pencil thin in the complex visual traffic soup.
- Their curbside location often hides them from other traffic.
- Motorists tend to see what they expect to see (Many are not looking for bicycles or pedestrians.)
- Motorists tend to overlook objects they see infrequently.
- Bicyclists are especially hard to detect under low light and nighttime conditions.
- More bicycles and pedestrians are needed to increase detection. When bicyclists and pedestrians are common on the roadways, motorists will expect to see them. As a result the motorist will detect them more readily.

4.2.6 Vehicle Dimensions

Although many existing bicycles are 10 to 21 speed touring/racing "road" bikes, most bicycles sold today are "mountain" bicycle designs. Mountain bicycles tend to have greater handlebar widths and be wider and lower than other bikes. Dimensions for the design bicycle include the full range of existing common commercial bicycles. Use these dimensions to determine median storage and other facilities design details:

Uphill Speed (roads and bridges)	5-12 mph (8-19 km/h)
Bicycle Width (at handlebars)	28" (0.71m)
Width of Bicycle (with trailer)	34"-36"(0.8-1.0m)
Width of Adult Tricycle	34"-36" (0.8-1.0m)
Length of Average Bicycle for an Adult	68" (1.7m)
Length of Kid's Bike	36-46" (1-1.2m)
Length of Tandem Bicycle	95" (2.4m)

Above: (1) Many bicyclists have learned the tendency to turn in the search direction. By knowing this tendency, skilled bicyclists learn to counter the steering. (2) Mountain bicyclists learn quick turning judgement, reading their downstream conditions seconds before they arrive. (3) A quick thinking urban cyclist, faced with a left turning motorist, has learned to do an emergency turn by first steering towards the auto to go into a counter-lean.

Below :*Early roadway designers asked "Where do we put the bicyclist?" The answer often came up wrong, largely because the wrong question was being asked. Instead, as we now know, the question is "How do we help the bicyclist?"*
....Michael Ronkin
Oregon DOT
Asking the wrong question led to early Florida bike facilities failing to meet the public need. Pedestrians, bicyclists and motorists were adversely affected. These signs have been removed.

Length of Tandem Towing a Trailer	140" (3.6m)
Height of Average Bicycle	44" (1.1m)
Weight of Average Bicycle	20-30 lbs. (10-20 kg)
Weight of Tandem Bicycle	35-50 lbs. (15-25 kg)

Due to steering wobble, bicyclists typically track over a 1.2 m (4.0 foot) width. This width should be increased to 6-10 feet (2.3 - 3 m) for steep hill climbs and descents. With variable gearing, bicyclists can comfortably climb up to a 10% grade for short stretches. Grades of 6% are the more common limit. Increases in grade generate more wheel wobble by bicyclists and thus require a wider design width.

4.3 Guidelines, Criteria and Standards

Guidelines, criteria and standards are presented in this chapter to help design and construct both roadway improvements and separate lanes that accommodate the operating characteristics of “bicycles” as defined in this handbook. Modifications to facilities (e.g., widths, curve radii, superelevations, etc.) necessary to accommodate adult tricycles, bicycle trailers, and other special purpose human-powered vehicles and accessories should be made using sound engineering judgment and be based on anticipated use of the facility.

It is best to estimate high levels of use. Presently there are so many disincentives for bicycling that judging the need for a bicycle facility based on existing bicycle counts or projections can be highly deceiving.

A design, such as paved shoulders, that ultimately benefits a bicyclist can usually be justified for other reasons, such as maintenance, general safety, and other joint uses. As a result, a given facility can often be justified with little or no projection of increased short term bicycling activity.

This handbook contains both FDOT standards and examples of more progressive treatments. FDOT standards will be noted in the text.

4.3.1 History of Bicycle Facilities Design

Most urban roadways were designed and built during a period of little bicycle use. Hence, early design decisions to provide for bicyclists were often based on the assumption it was best to separate bicycling from roadways. This assumption quickly proved unpopular with bicyclists. It led to a proliferation of conflicts due to lack of facilities, bicyclists

being on sidewalks and thereby hidden from motorists, poorly built bicycle paths, and bicyclists and motorists attempting to mix on roadways with inadequate mixed use design.

4.3.2 Current Practice

New construction, as well as RRR projects, must give full consideration to the needs of bicyclists. Measures should also be taken to retrofit the backlog of roadways not currently scheduled for improvement. This can and should include attention to safety needs identified through the statewide Safety Management System, and Community/ Corridor Traffic Safety Programs.

Key attractions are found along main thoroughfares; and they attract bicyclists just as they attract motorists. This concept requires full consideration of bicycling for new transportation projects.

There is a wide range of facility improvements which can enhance bicycle transportation. Improvements can involve a detailed design (e.g., providing a bicycle path), or they can be simple and involve minimal design consideration (e.g., changing drainage grate inlets).

The Department's current policy is to consider the needs of bicyclists on all projects, including in some case limited access facilities. This policy will generally provide for the construction of bike lanes or paved shoulders in conjunction with other planned roadway improvements. (See FDOT's Plans Preparation Manual.) Since bicyclists may ride on all non-limited access roadways, bicycle facilities should be included on all projects unless there is compelling reason not to include them. If there is a question as to whether or not some special effort, such as purchasing additional right-of-way or narrowing medians, is justified the following should be considered:

- The section is identified for bicycle improvements in the Transportation Improvement Program, the State Transportation Plan, or the Community Comprehensive Plan. *(Plans Preparation Manual)*
- Bicycle facilities have been requested by the local government.
- Project is within 1 mile of an urban area. (F.S. 335.065)
- There are other considerations suggesting bicycle facilities would be required. These include but should not be limited to the following:
  - Schools, parks or greenways near the project corridor
  - Access or connectivity
  - High bicycling volumes
  - High bicycle crash rates

Florida's First Bike Lane. *The 13th Street bike lane in Gainesville is well accepted by both motorists and bicyclists. It is shown above with standard FDOT symbols.*

Bike Lanes Help Motorists and Pedestrians. *Even if this Siesta Key bike lane were never used by bicyclists, its value to the roadway is significant. Pedestrians now have a buffer from moving traffic. Traffic moves slower due to the reduced lane width. Motorists turning into this space now have added turning radii.*

Bicycle facilities should be included on all appropriate projects. The amount of accommodation which can be provided will vary from project to project. Bike lanes were added to this intersection improvement, beginning and ending several hundred feet from the intersection. Because of this improvement, even if the intersection is excepted from a later resurfacing project, the facility along the section will be continuous.

Lower speed trucks have no wind blast (*Trucks passing at 45 mph/60 kmh). During the 1980's the Gainesville area benefited from the installation of nearly 100 miles of paved shoulders and bike lanes. The installation of these facilities has been largely credited with an 80% reduction in fatal bicycle crashes.*

4.3.3 The Florida Intrastate Highway System

The Department procedure, Development of the Florida Intrastate Highway System (FIHS) (Topic No. 525-030-250), gives the following guidance relating to the provision of bicycle and pedestrian facilities on the FIHS:

"Legislation authorizes the Department to develop the FIHS to provide for high-speed and high-volume traffic movement as its primary function. In this context, accommodation of bicycles and pedestrians requires a careful balancing of the FIHS with the safety of bicycles, pedestrians, and vehicular traffic."

"Bicycle and pedestrian facilities shall not be provided on FIHS limited access roadways. For FIHS controlled access facilities, the safe movement of bicycles must be carefully considered and accommodated in such a way as to have no adverse impact to safety, capacity or speed. Separate, off-site, and/or parallel facilities shall be used where practical and feasible. Bicycle facilities shall be consistent with the requirements of the Florida Bicycle Planning and Design Manual, Topic No. 625-010-055, and the Department's Plans Preparation Manual, Topic No. 625-000-101."

Special care is needed in the planning and design of bicycle facilities on the FIHS. Negative impacts to bicycling should be minimized. If the decision is made to provide off-site and/or parallel bicycle facilities, they should be developed, and possibly improved, concurrently with the FIHS. When developing these facilities consider the following:

- Bicyclist safety should be a primary concern. If an alternate facility is dangerous or uncomfortable for bicyclists it is not appropriate as an alternate route. Alternate facilities with numerous access points, continuous turn lanes, high speeds and volumes are unsafe for bicyclists.
- Travel time for bicyclists should be kept to a minimum. If the use of off-site facilities requires bicyclists to use less direct routes, consider placing a facility on-site. If this would not compromise safety, an on-site facility may be appropriate.
- Traffic control on the parallel off-site facility should not impede bicyclists. If bicyclists encounter a stop sign at every intersection along the parallel facility it is probably not appropriate.
- Access should be maintained. Bicyclists should be able to access the same destinations as motor vehicle drivers.
- If an off-site parallel facility is a combination of roadways and/or trails, bike route signage should be considered.

When provisions for bicycles must be made along a controlled access FIHS facility, first consideration should be to provide a separate facility. This facility would probably be a multi-use trail. The following concerns should be addressed:

- Conflict points should be minimized.
- Access for bicyclists should be at the same level as that for motorists. If developments are present on both sides of the FIHS controlled access roadway and may be accessed from both sides of the roadway, a separate facility would have to provide access for bicyclists.

If a parallel facility is not available and a separate facility is not appropriate, bicycle facilities may be provided on the FIHS controlled access roadway. This is the least preferred option and should be considered only if the off-site or separate facilities are not appropriate.

High Speed Truck Wind Blast *effect extends 6 feet (2 m). The combination of travel lane and paved shoulder should allow a 6-foot (2 m) physical separation between truck and rider. Truck wind blasts are considered minor at or below speeds of 40 mph (65 km/h). Special consideration is needed when designing bicycle facilities for high speed, high truck volume roadways such as the Florida Intrastate Highway System.*

4.4 Bicycle Lane Widths

Bicycle lanes are to be used on future urban roadway sections, whenever right of way and existing curb/drainage sections permit. Occasionally it is possible to convert wide curb lanes on multi-lane highways to bike lanes by reducing the travel lane widths to 11 ft. (3.3 m), and turn lanes to 10 ft. (3.0 m). The width of the bike lane is included within the motorist clear zone and horizontal clear distance. Additional clearance is not required.

Bicycle lanes have proven their value to all highway users. Among their benefits in creating a smooth, efficient and safe sharing of the highway are the following:

- Establishing the correct riding position for bicyclists.
- Sending a message to motorists that bicyclists have a right to the roadway.
- Establishing the correct riding direction for bicyclists.
- Reducing motorist and bicyclist sudden swerves (lane changing).
- Reducing serious bicycle crashes by up to 80% within some corridors (Gainesville, Florida).
- Guiding bicyclists through intersections on the safest, most predictable course.
- Permitting bicyclists to pass stopped motorists and queue properly at traffic signals.
- Permitting motorists to pass bicyclists on 2-lane roadways.

There are many secondary benefits of bike lanes as well:

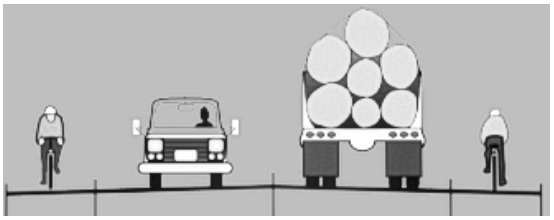
- Providing added border width.
- Enhancing highway drainage and reduce vehicle hydroplaning.
- Creating an essential buffer between the pedestrian and motorist.
- Improving opportunity for landscaping (border width).
- Reducing pedestrian/bicyclist conflicts (no longer on sidewalks).
- Increasing turn radii at driveways and intersections.
- Improving sight distances.

Figure (a) - *page 4-11 - and the top photo depict a standard width bike lane.*

Figure (b) - *page 4-11 - and the center photo , depict on-street parking in combination with a bike lane. This roadway section lane provides a separate space for motorists, bicyclists and pedestrians.*

Figure (c) - *page 4-11 - and the bottom photo depict a standard paved shoulder. This shoulder is 4 feet (1.2 m) wide. These facilities have helped reduce serious bicycle crashes by up to 80%.*

Bike lanes provide space for motorists to pass bicyclist without encroaching into the oncoming lane of traffic.



1.5 m *3.6 m* *3.6 m* *1.5 m*

The Department's standard bicycle lane widths are:

- Urban (curb & gutter) 4 ft. (1.2 m)
- Urban with Parking 5 ft. (1.5 m)
- Rural Section 5 ft. (1.5 m)

The minimum width of an urban bike lane from left side stripe to face of curb is . The 13 inch (450 mm) gutter included on most curb an gutter sections provides for this additional requirement. Certain edge conditions may dictate additional desirable bicycle lane width.

4.4.1 Bicycle Lanes on Curb and Gutter Sections

Bicyclists do not generally ride near a gutter because of the possibility of debris, of hitting a pedal on the curb, of an uneven longitudinal joint, or of a steeper cross slope. However, many novice bike riders will ride in a gutter if the roadway is too narrow, and thus bike lanes help reduce this problem. Bicycle lanes in this location should have a minimum width of 4 ft. (1.2 m) from the edge of pavement to the motor vehicle travel lane. Since Florida measures most dimensions from the edge of pavement, it can be assumed an additional 1.5 ft. (0.5 m) lateral separation exists from the curb face. See graphic on next page.

4.4.2 Bicycle/Parking Lanes

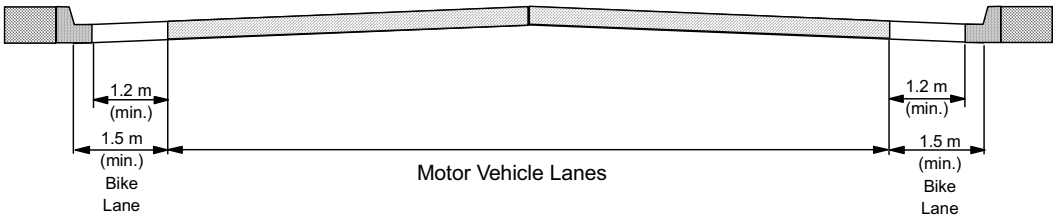
As shown in graphic (b) on the next page, a bicycle lane may be put on an urban curbed street where a parking lane is provided. The required bicycle lane width for this location is 5 ft. (1.5 m). The minimum combined bike lane/parking lane width is 13 ft. (3.9 m). This space is to provide adequate width for bicyclist to avoid car doors without encroaching upon the motor vehicle lane.

Bicycle lanes should always be placed between the parking lane and the motor vehicle traffic lane. Bicycle lanes between the curb and the parking lane can create obstacles for bicyclists from opening car doors and poor visibility at intersections and driveways. They also prohibit bicyclists from making left turns; therefore, this placement should not be considered.

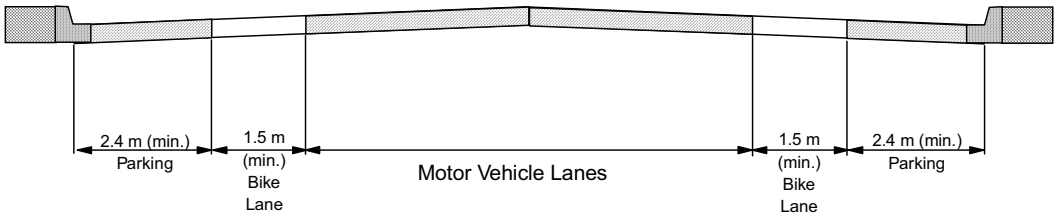
This treatment may not be appropriate on sections with narrow motorist lanes.

Transition taper lengths around parking lanes are based on speed, sight distances, type of vehicles, and related factors. Make sure that both the bicyclist and motorist are given adequate information and decision making time. Taper

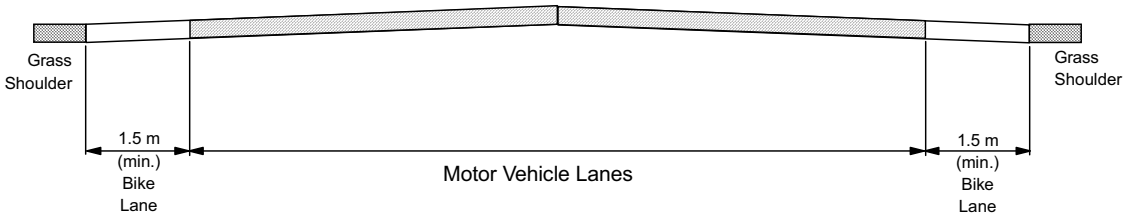
a) Curbed Street without Parking



b) Curbed Street with Parking

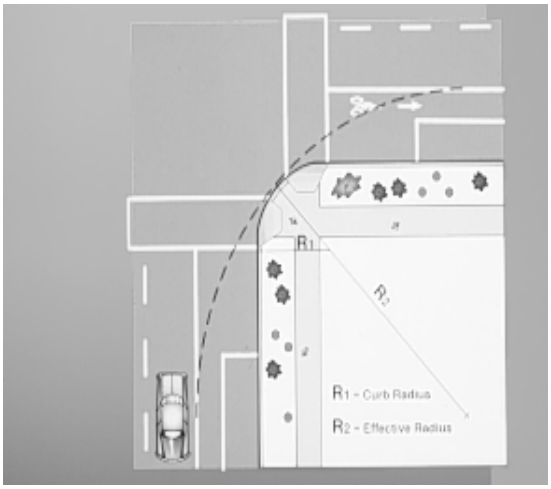


c) Roadway without Curb or Gutter



FDOT Bicycle Lane Width Requirements

Parking Lane Transitions. *Above: Appropriate tapers should be used when transitioning to and from parking. Below: These treatments can provide additional turning radii at intersections.*



Source: Oregon DOT

rates for various speeds are specified in the Department's *Roadway and Traffic Design Standards*.

When parking and bike lanes are used in a pattern as shown in the graphic at right, the motorist ends up with added turning radii; sometimes a needed bonus for trucks and buses. To reduce maintenance, and improve the life of markings, make sure bike lane markings may be kept out of the turning radius. To reduce wrong way bike riding, always use directional arrows in bike lanes.

4.4.3 Paved Shoulders and Rural Bike Lanes

Adding or improving shoulders often can be the best way to accommodate bicyclists in rural areas. Paved shoulders are also a significant safety benefit to motor vehicle traffic. Where funding is limited, adding or improving shoulders on uphill sections first will give slow moving bicyclists needed maneuvering space and decrease conflicts with faster moving motor vehicle traffic.

Current FDOT standards call for a 5 ft. (1.5 m) wide paved shoulder on the outside edge of all rural roadway sections (*Plans Preparation Manual*, Vol. 1, Ch. 2 for details). Additional width can be considered when heavy truck volumes or other conditions warrant. Since bicyclists often ride on shoulders, smooth paved shoulder surfaces should be provided and maintained. Pavement edge lines 6 inch (150 mm) wide supplement surface texture in delineating the shoulder from the motor vehicle lanes.

4.4.3.1 Shoulder Width

The minimum paved shoulder width is 5 ft. (1.5 m) when designated as a bike lane or intended to accommodate bicycle travel. The combined width of the paved shoulder or bike lane and the width of the adjacent motor vehicle travel lane determine whether or not bicyclists and motorists can safely pass each other. The FDOT standard of a 12 ft. (3.6 m) lane with a 5 ft. (1.5 m) shoulder provides for adequate separation of bicyclists and motor vehicles when speeds exceed 60 km/h (45 mph), the percentage of trucks, buses, and recreational vehicles is high, or static obstructions exist at the right side.

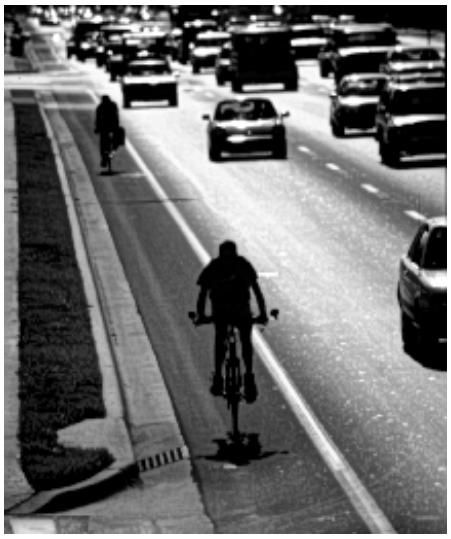
At speeds above 45 mph (60 km/h), bicyclists need a 6 ft. (1.8 m) minimum lateral separation from trucks. The full 12 ft. (3.6 m) width travel lanes in combination with 5 ft. (1.5 m) paved shoulders accommodates this lateral separation need.

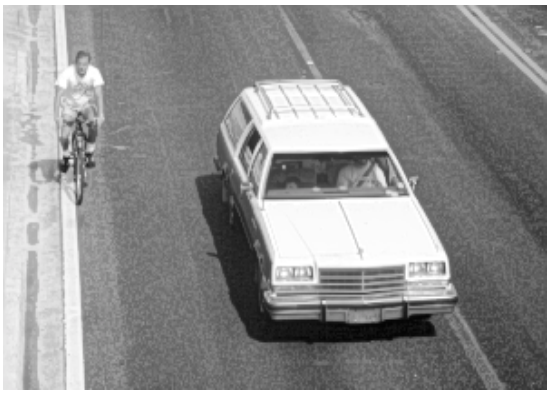
Due to the buildup of debris, and the trapped condition a bicyclist faces, shoulders on bridges are especially important. Bridge shoulder width, as a minimum, should match the

Examples of rural paved shoulders and the lack of shoulders. Recent research (1996) from the University of North Carolina Highway Safety Research Center reveals motorists and bicyclists both feel greater comfort when the edge line and paved shoulder are provided. This improves the perception of safety by both user groups. Bike lanes and paved shoulders reduce motorist encroachment into left side lanes from occurring in 27% of passes (without special lanes) to 3% of passes (with bike lanes or paved shoulders).

Rural section facilities. *Left: One of the best bicycling trails in North America takes bicyclists through Canada's Banff National Park. The ample 10' wide paved shoulders are not marked as bike lanes. Yet they perform equally well, doing double service to motorists and bicyclists, and help one another pass. Below: In contrast, U.S. Alternate 19, in Pinellas County Florida awaits a RRR improvement that will allow the addition of 5.0 foot (1.5 m) shoulders. Once the shoulders are in place bicyclists and motorists will be able to share the space and move in greater safety and efficiency.*

Below. *Lower left: The lane on this section is undesignated. The rural character of the roadway, with minimal intersections and infrequent bicycling does not warrant marked bike lanes. Lower right: Sarasota motorists are able to move more freely with bicyclists separated from the travel lane. Motorists can get into and out of the road more safely. The 4 foot (1.2 m) paved shoulder area is attractive to many adult bicyclists.*





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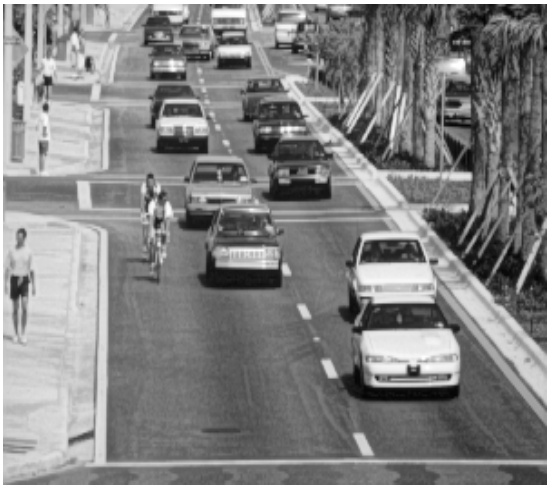


2

3

Wide Curb Lanes. *A*
As pictured above, (1) novice bicyclists tend to ride in unsafe gutter areas, (2) while some competent bicyclists take their fair share of this lane and more. (3) Recent FDOT research reveals that bike lanes create more appropriate placement and more predictable movements for bicyclists and motorists.

approach roadway shoulder width.

Bridges exceeding a 3% grade benefit from wider shoulder widths. The added width compensates for climbing wobble conditions and higher descent speeds.

4.4.4 Wide Curb Lanes

Wide curb lanes no longer meet FDOT requirements and are not used on new construction on state roadways. Local jurisdictions may still use them. They are a "least preferred" option in Florida. Although wide curb lanes benefit motorists and bicyclists by providing additional operating space compared to a 12 ft. (3.6 m) lane, only 5% of bicyclists feel comfortable using these facilities. In some conditions, a wide curb lane may still be the only practicable option. The following principles and details are provided.

On highway sections without bicycle lanes, a right lane wider than 12 ft. (3.6 m) can better accommodate both bicycles and motor vehicles in the same lane and thus is beneficial to both bicyclists and motorists. In many cases where there is a wide curb lane, motorists will not need to change lanes to pass a bicyclist. Also, more maneuvering room is provided when drivers are exiting from driveways or in areas with limited sight distance.

In general, a lane width of 14 ft. (4.2 m) of usable width is desired. Usable width would normally be from edge of pavement (gutterpan seam), but adjustments need to be made for drainage grates, parking and longitudinal ridges between pavement and gutter sections. If 14 ft. (4.2 m) of usable width is available, and speeds and traffic volumes are low, a 3 ft. (0.9 m) shoulder may be striped next to a 11 ft. (3.3 m) lane. When 16 ft. (4.8 m) is available, it should be striped as a 4 foot (1.2 m) bike lane and a 12 foot (3.6 m) lane.

Restriping to provide wide curb lanes may also be considered on some existing multi-lane facilities by making the remaining travel lanes and left turn lanes narrower. This should only be performed after careful review of traffic characteristics along the corridor.

4.5 General Signing and Marking of Bike Lanes

In Florida, designated bike lanes are to be marked with signs and pavement markings. Standard FDOT striping is shown in its *Roadway Traffic and Design Standards*. The bike lane is separated from the regular travel lane by a 6 to 8 inch (150 - 200mm) solid lane line. Pavement markings are used within the lane to designate the bike lane. The diamond

shape Preferential Lane Symbol is used as required by the *MUTCD*. Additionally, Florida uses the bicycle symbol to clarify the purpose of the bike lane and an arrow to provide guidance on legal direction of travel. (*Roadway and Traffic Design Standards*) Bicycle Lane signs, R3-17, are used to supplement the pavement markings.

4.5.1 Directionality

Bicycle lanes should always be one-way facilities, be marked as such, and carry traffic in the same direction as adjacent motor vehicle traffic. Two-way bicycle lanes on one side of the roadway are unacceptable because they promote riding against the flow of motor vehicle traffic. Wrong-way riding is a major cause of bicycle crashes and violates the Rules of the Road stated in the Uniform Vehicle Code.

4.5.1.1 Wrong Way Signs

A sign may be placed on the back side of the Bike Lane sign (R3-17) to notify bicyclists when they are riding the wrong direction in a bike lane. The proposed sign for this purpose is a "Wrong Way" with a "Bikes" supplemental plate. This sign, in addition to the lane directional arrow, is intended to reduce wrong way riding. This sign also makes it easier for police to cite bicyclists and defend a violation before a judge.

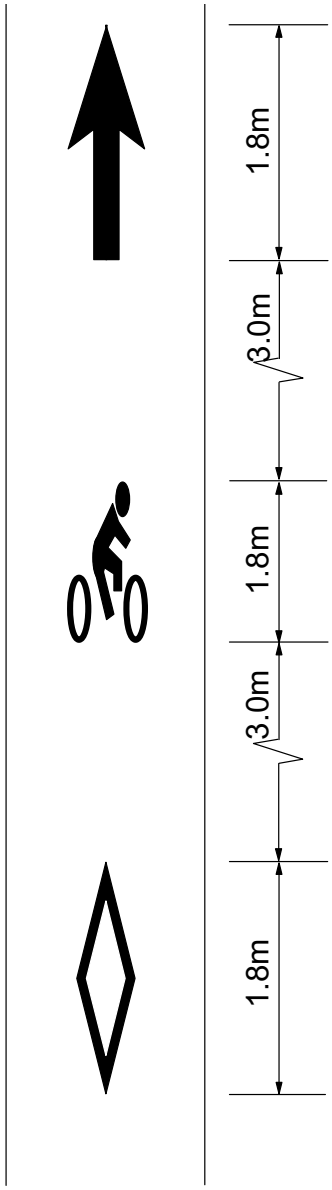
4.5.1.2 Bicycle Lanes on One Way Streets

On one-way streets, bicycle lanes should be on the right side of the street, except in areas where a bicycle lane on the left will decrease the number of conflicts (e.g. those caused by heavy bus traffic).

Although not recommended, contra-flow bike lanes (those in an opposing direction from the normal traffic flow) on one-way streets may be allowed to provide connectivity for bicycles within a roadway system. They can be used to fill gaps in the system or provide a more convenient route for bicyclists. Bicyclists using these lanes will be coming from a direction motorists do not expect. Also, traffic control, signs and signals, must be provided for the contra-flow bicyclists. Ideally, instead of using a contra-flow bike lane, the lane could be put on a parallel facility.

4.5.2 Additional Emphasis Markings

In especially hazardous rural and higher speed suburban locations, such as bridges, curves and areas where motorists frequently run off the roadway, added emphasis may be given to the markings. In these locations, additional glass beads, special bicycle-safe markers, and other treatments should be considered.



Standard FDOT Markings. *Standard bike lane markings for FDOT projects include the preferential lane use symbol, the bicycle symbol, and the directional arrow. The recommended spacing for these symbols is immediately after intersections and major driveways and at a maximum spacing of 600 feet (182 meters) on urban sections and 1/4 mile (400 meters) on rural sections. For more details, consult the FDOT's Roadway and Traffic Design Standards.*

Standard size Raised Pavement Markings (RPM's) and raised barriers present a hazard to bicyclists and shall not be used to delineate bicycle lanes. Experimental low level RPMs, inset into the pavement, are being tried in test sections with effective results. RPM's may be considered for special areas where additional guidance and control are warranted. Also, thermoplastic pavement markings pose a hazard to bicyclists because they are slick, especially when wet. The Florida Department of Transportation has developed a special thermoplastic mix using additional grit to combat this problem.

A thermoplastic that makes a sound when a car drives over it is being tested south of Gainesville. This edgeline alerts motorists and bicyclists that a motorist is driving on the edgeline.

4.5.3 Designated versus Undesignated Bike Lanes

In some cases, the designer may not wish to designate a bike lane with pavement markings and signs. Undesignated bike lanes differ from shoulders in being striped to the left of right turn lanes. This allows for the eventual designation of the bike lane.

Preliminary research and observations reveal a wider separation of motorists and bicyclists when wide curb lanes are converted to lanes of even as little as 3 - 3.5 ft. (0.9-1.1 m). However, the Department prefers, in many instances, to leave this substandard width undesignated.

There are some cases where even a full width 4 foot (1.2 m) space may be left undesignated. Decisions on when to designate and leave undesignated should be made by a joint partnership of the Department and the local Bicycle Advisory Committee (BAC). The following are some reasons a designer may wish to leave a bike lane unmarked:

- Short or discontinuous
- Rural with a low probability of use
- First segment, to be joined later by other pieces.

There are, however, advantages to marking a bike lane. Some of the advantages of designating a bike lane are as follows:

- Reminds motorists to stay alert for bicyclists
- Creates a true system of support
- Provides system continuity
- Further reduces likelihood of wrong way sidewalk riding
- Allows signing warning against wrong way riding.

Bike Lanes on One-Way Streets. *This bike lane is on the left side of a one-way street and fully separated from the curbside parking lane.*

Additionally, marking a bike lane changes the way the facility is treated in law. Motorists are not allowed to park, except momentarily, in a bike lane. Also, motorists entering the roadway from a side street are required to yield to bicyclists within a bike lane.

4.5.4 Pigmented Bike Lanes

On some minor and major collector roadways, there is a need to keep the visual width of the roadway narrow. Under such conditions, bike lanes can be pigmented a brownish orange, giving the effect that the overall roadway width has been decreased. Such treatments are often desirable where speed studies indicate that motorists routinely exceed reasonable and prudent speeds.

4.6 Bicycle Lane Treatments at Intersections

Bicycle lanes and their position is an inportant consideration in intersection design. A bicycle is a vehicle. As such, the bicyclist is required (with the left turn as an exception) to ride through an intersection just as a motorist would drive through the intersection. The bicyclist should travel through the intersection on the right side of the right most lane for the direction of travel.

4.6.1 Bicyclists' Movements

At intersections without right turn lanes, bike lanes encourage bicyclists to keep to the right and motorists to keep to the left, both operators are somewhat discouraged from merging in advance of turns. Thus, some bicyclists will begin left turns from the right-side bicycle lane and some motorists will begin right turns from the lane to the left of the bicycle lane. Both maneuvers are contrary to established *Rules of the Road* and result in conflicts.

To promote proper behavior, the bike lane striping should be discontinued 50 ft. (15 m) prior to an intersection without a right turn lane. This encourages motorists and bicyclists to merge in advance of the intersection. In this way most bicyclists behave as follows:

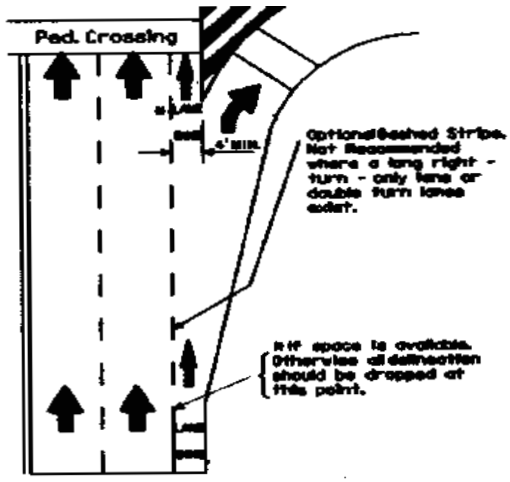
4.6.1.1 Straight Through Bicyclists

Straight through bicyclists move to the left, merging into the travel lane, staying alert to right turning motorists. Competent bicyclists often do this early in the taper. Novice bicyclists more typically complete the maneuver closer to the intersection, where speeds are lower. Either works well in practice.

Undesignated Bike Lane. *Above: The lane to the right is left undesignated. The rural character of this roadway, with minimal intersections and infrequent bicycling does not warrant marked bike lanes. In addition to providing for the bicyclist, paved shoulders provide additional motorist safety, enhance drainage, improve maintenance and improve appearance.*

Pigmented Bike Lanes. *Below: The bike lane below is treated with a deep ocher pigment. A section of roadway in Lake County, Florida has used the type of paint used on tennis courts to achieve the same affect. FDOT is evaluating the Lake County section.*

Turns. *Top: The top photo shows a cyclist preparing to make a right turn. The left turner in the above photo is required to search and weave across two lanes of traffic.*



With a right-turn lane or slip lane.

4.6.1.2 Right Turning Bicyclists

Right turning bicyclists simply turn right by staying to the right. It is best if they center themselves in the turn lane. Staying too far to the right encourages motorists to pass them while turning.

4.6.1.3 Left Turning Bicyclists

Left turning bicyclists search, signal and move left if traffic gaps occur. Others may choose to go straight through the intersection to the far side, pivot their bikes, and when the light changes, complete their movement. Both procedures are permitted under Florida traffic law. The second method is referred to as a "box left hand turn". Note the bicyclist in the bottom photo (100 yards back from the intersection) is in a position to search, find a gap and move to his left. This is a simple procedure when traffic is slowing.

4.6.2 Bike Lane Position at Intersections

The Department's bike lane striping guidelines assume and support the idea bicyclists will function as vehicles. Bicycles are required to ride as nearly as practicable to the right side of the right lane serving the movement they are making. This requires bicyclists riding through intersections with right turn lanes, and possibly those turning left at intersections with left turn lanes, to ride between parallel flows or queues of traffic. The inclusion of bike lanes provides space for the bicyclists to do this with more safety and comfort than if the bike lanes were not present. The guidelines are refinements of the AASHTO drawings shown on the next page left. These striping guidelines shown as typical intersections are included in Appendix C.

4.6.2.1 Intersections with Driveways

Bike lane striping at driveways is dependent upon edgeline striping, as shown in the guidelines. At low volume residential type driveways where the edge line is continuous, the bike lane striping is also continuous. At high volume commercial driveways where the edgeline is discontinued (but regular vehicle lane striping is continuous), the striping separating the bike lane from the regular travel lane becomes a 2 ft. - 4 ft. (600 mm - 1.2 m), or dotted, skip line. These treatments are shown in most of the guideline cases.

4.6.2.2 Roadway Intersections

On roadways without right turn lanes, the line separating the bike lane from the regular travel lane should become a dotted line, 2 ft. - 4 ft. (600 mm - 1.2 m), not less than 50 ft. (15 m) prior to the intersection. By using this skip line we allow right turning motorists to merge into the bicycle lane so the turn can be made from the right side of the roadway. The

skip line also serves to inform motorists they are encroaching on the bike lane. Examples of this treatment are shown in guideline cases 2, 2A and 2B (Appendix C).

When a right turn lane is present, a lane is provided for the through bicyclists between the regular through lane and the right turn lane. Through the turn lane taper the right edge line of the bike lane is discontinued and the line separating the bike lane and regular travel lane becomes dotted line. Examples of this treatment are shown in guideline cases 1, 4 and 6 (Appendix C).

On the approach to a right lane drop, the bike lane is shifted from the right side of the roadway to between the dropped lane and the through lane. Dotted lines are used to provide a transition area where the bicyclist can move to the left. A similar technique is used at tee intersections. Pavement markings warning the bicyclist to yield may be used prior to the transition area. Examples of this treatment are shown in guideline cases 7 and 8 (Appendix C).

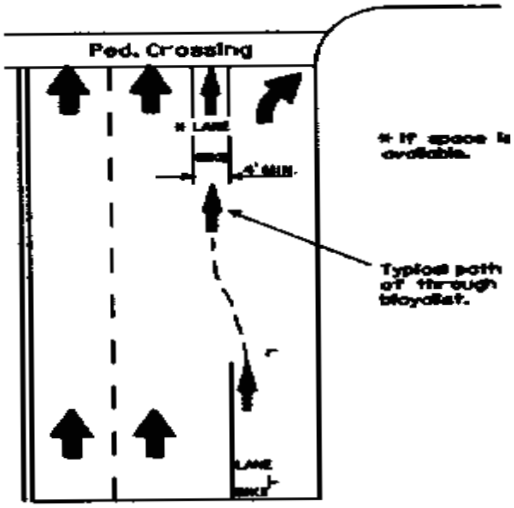
On a road with on street parking the bike lane is continued with solid edge lines beyond the parking to not less than 50 ft. (15 m) prior to the intersection where the edge lines become dotted lines. Examples of this treatment are shown in guideline case 3 (Appendix C).

In cases where there is a right turn lane and a shared through/right turn lane, the bike lane must be terminated prior to the intersection. Designers should weigh the confusion created for bicyclists and motorists before applying this treatment.

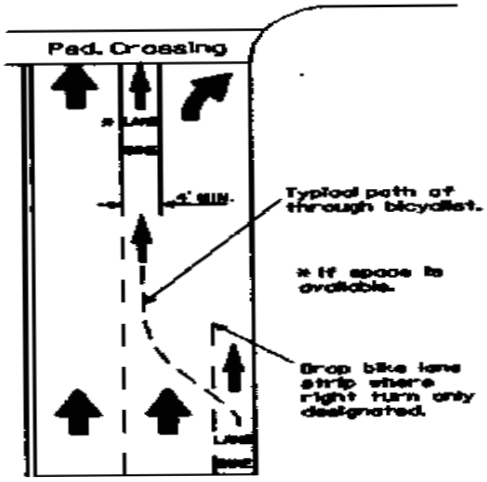
The MUTCD allows for the inclusion of a left-turn lane for exclusive use by bicyclists. This treatment would be useful to keep large numbers of left turning bicyclists stored out of the left turn lanes. This treatment also could be used when there is a problem with bicyclists turning from the inside (left side) of the left turn lane, particularly if there is a double left turn lane. Providing this lane tells the bicyclists where to ride and lets one avoid weaving across one or two lanes of left turning traffic.

4.6.2.3 Storage Lane Optional Markings

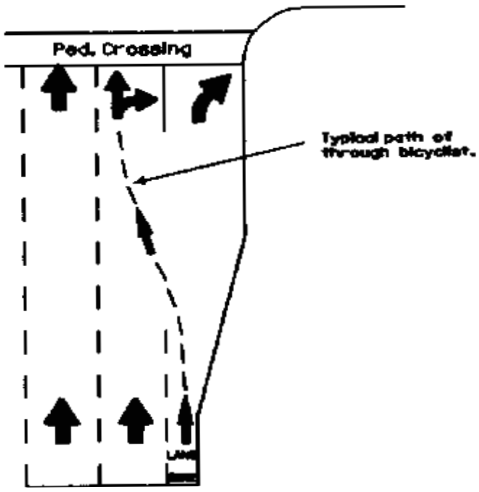
There may be times when a designer believes additional striping, guidance or a modification of a standard treatment is warranted. If an alternative treatment is used it should be supported by an engineering study before implementation and an evaluation after it is in place.



Parking lane becomes right-turn-only lane



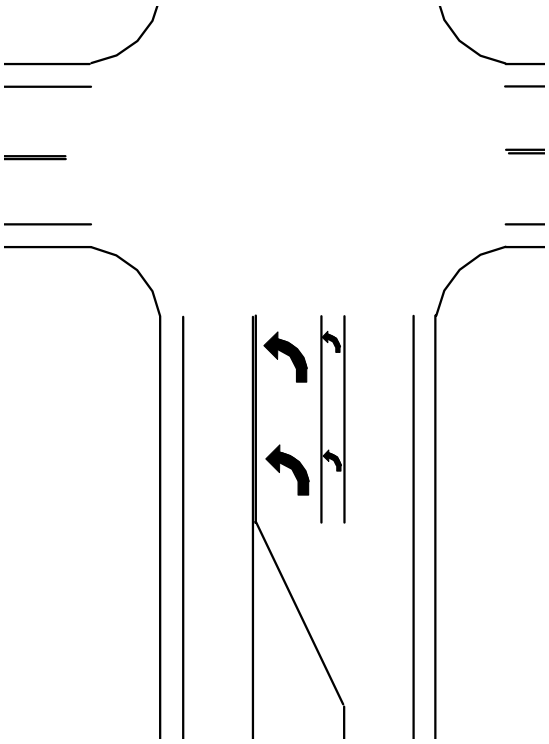
Right lane becomes right-turn-only lane.



Optional right-turn and through-right lanes.

Above: *Glenn Grigg, traffic engineer for Cupertino, California created the special detector for bicycles (center) and then used the baby arrow system to communicate to bicyclists which lane to use to queue and turn left.*

Dedicated left-turn lane for bicycles*. The MUTCD allows for a left-turn for bicyclists. This treatment is useful in areas where there are large numbers of left turning bicyclists.*



4.6.2.4 Alternative Marking

Cupertino and Davis, California are two towns using a different approach. Where speeds and right turning volumes are moderate, they have found it desirable to widen out the bike lane to 10 feet (3.0 m) on final approach to an intersection, rather than to create a continuous right turn lane. This has the effect of inviting the motorist into the bicyclist's space, as opposed to forcing the bicyclist out of the right portion of the roadway. This can be a safe practice due to the lower speed of turning traffic. The treatment should be 75-100 feet (25 -30 m), in order to control the entering speed. In such a case, bicyclists intending to go straight may end up centered in the lane and thus will tend to momentarily block a right turning vehicle, although in actual practice this has minimal negative effect.

4.6.3 Traffic Signals

There may be a case when a signal is required to cross bicyclists across a roadway (possibly a trail intersection). The MUTCD's Part IV should be consulted for warrants and other requirements relating to signal installation. Since bicycles are vehicles, warrants used for motor vehicles are considered appropriate for bicyclists. Warrant Four for school crossings is also considered appropriate for bicyclists.

4.6.3.1 Traffic Signal Timing

At intersections where bicycle traffic exists or is anticipated, bicycles should be considered in the timing of traffic signal cycles, as well as the traffic detection devices. Normally, a bicyclist can cross an intersection under the same signal phasing arrangement as motor vehicles. On multi-lane street crossings, special consideration should be given to ensure short clearance intervals are not used. An all-red clearance interval is often used in intersections today and benefits bicyclists who need the extra time. With wider and wider intersection designs, the traffic engineer must pay close attention to crossing times. The desire to keep lanes full width and to add more turn lanes must be balanced by alternatives that provide protective channeling, reduced crossing width or other designs. For the above reasons, geometric designers and operations staff must work closely to create supportive bicycle crossings.

To check the clearance interval, a bicyclist's speed of 10 mph (16 km/h) and a perception/reaction/braking time of 2.5 seconds should be used. Detectors for traffic-actuated signals should be sensitive to bicycles and should be located in the bicyclist's expected path, including left turn lanes. In some situations, the use of pedestrian actuated buttons may be a preferred alternative to the use of detectors, provided

they are placed so they do not require bicyclists to dismount or make unsafe leaning movements. Push buttons intended for use by bicyclists must always be on the right side of the travelway. Where programmed visibility signal heads are used, they should be checked to ensure they are visible to bicyclists who are properly positioned on the road. Signal systems should be designed to permit the bicyclist to detect any change in traffic signals.

4.6.3.2 Signal Loop Markings

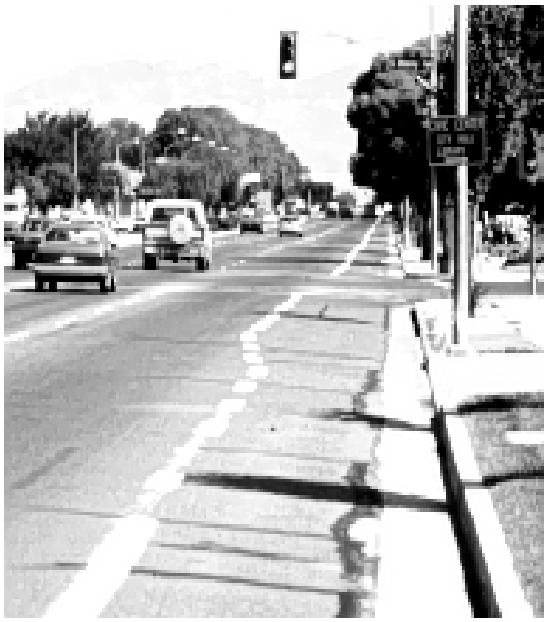
One of the most frequent motorist complaints against bicyclists is they run red lights. However, when bicyclists approach red traffic signals they have no way of determining where they need to place their bikes to be detected by the signal. Even conscientious bicyclists may get discouraged waiting for a green signal and run the red light. Eventually, this can lead to a disregard for traffic signals and hazardous riding practices for bicyclists.

Many traffic signals in urban areas are activated by detector loops embedded in the roadway. These traffic detector loops respond to the electrical field variations induced by the metal in a vehicle over the detector loop.

The sensitivity of these loops should be adjusted to detect a bicycle without sensing passing vehicles in adjacent lanes. This can be facilitated by using a short length (under 15 m or 50') quadrapole loop. This minimizes sensitivity outside the loop while increasing it within.

Detector loops are not usually installed across the entire lane and it is quite possible a bicycle on the far right side of the road will not be detected. Some children's bicycles have plastic rims, and thus greatly reduces the chance of being detected. By marking the part of a signal loop where the bicycle will be detected, preferably on the right side of the lane, we would be helping bicyclists obey the law. The symbol shown on the previous page, in conjunction with a sign telling bicyclists to "STOP ON [SYMBOL] FOR SIGNAL" has been approved for testing in Florida. (Both the symbol and the sign are shown in the Appendix D.) This symbol would probably be used primarily on side streets crossing major arterials. These roadways frequently do not get a green light unless there is a detected vehicle. This is frequently a problem on weekend mornings when there is very little side street traffic and the signal is resting on the arterial. Protected-only left turn lanes are another location where this symbol would be useful.

This symbol has been used in Gainesville to mark a loop that had been installed within a bike lane.



Widened bike lane. *Experimental treatments in California. Instead of creating a dedicated right turn lane, motorists are invited into a widened bike lane for low speed cautious entry.*

Freeway and other on-off ramp crossings pose special problems for bicyclists and designers. The principles include: (1) convert from lanes to paths on wide roadways and cross where motorist is steering, not searching. Bicyclists should yield. (2) Avoid acceleration lanes like these in urban areas. They are rarely needed. (3) For low volume (bicyclist and motorist) merge such as here in rural British Columbia, no special treatment is needed. (4) use this design on high volume crossings, (5) Never cross the pedestrian and bicyclist here where the motorist is searching over his shoulder for autos. The crossing should be upstream where the motorist is steering.

Examples of Crossings - Limited Access, etc.

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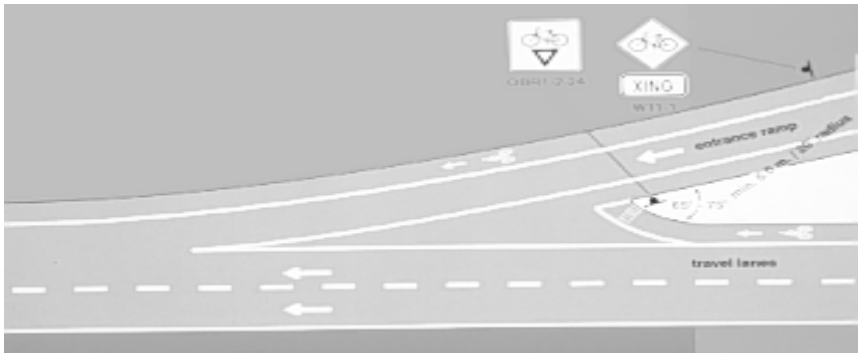


3

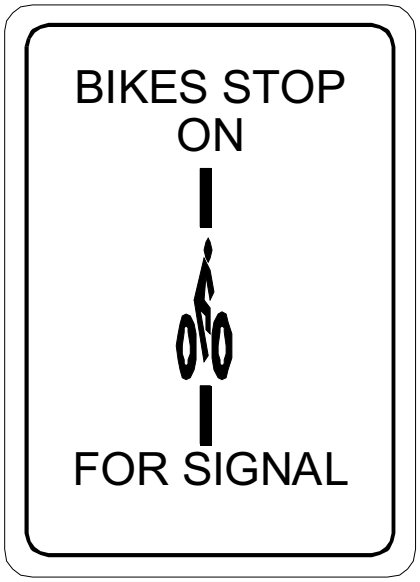
TRANSITIONS, MERGES AND OTHER CROSSINGS

Steel and Rubber Don't Mix Well. *Railroad tracks are serious conflict points for bicyclists. Designers should not only treat the geometrics of skewed railroad crossings, but in the interim, provide guidance and warning of any special risk. Some areas do not lend themselves to a bulbout, and so, as a minimum, special warning signs and pavement markings should be provided.*

Big Box Retailers. *The bicyclist along this high speed roadway has little choice. Mix with high speed traffic, or stay on the parallel facility and risk high speed and right exiting turns. A full median, highly channelized islands with low turning speeds will help. However, the lack of paved shoulders will lead to constant narrow misses from the right turning motorists.*

Cattle Guard Treatment. *The warning comes first. Located at the bottom of a steep hill, this cattle crossing leaves little warning. Note that the deck treatment and sign have been used in combination.*

Loop Marking for Bicyclists. *Above: Signals should be engineered to gain the maximum compliance from bicyclists. This loop marking from Boulder, Colorado has been proposed for use in Florida. The symbol is placed to show bicyclist where to stop for maximum detection.*
Below: Proposed sign for use with symbol.



4.6.3.3 Bicycle Actuated Signals

In some instances it may be desirable to place a traffic signal loop within the bicycle lane. If a loop is installed, bicyclists should be informed of the loop's presence by a pavement symbol and sign.

Advance loops have also been used in bike lanes. By placing the signal loops in advance of the intersection the signal can change prior to the cyclists' arrival. Trails may be another appropriate place for advance loops.

4.6.3.4 Special Signals for Bicyclists

Special signals and signal phases have been used for bicyclists. Where bicycle lane volumes are heavy, and on a case-by-case basis, the designer could consider a special phase signal for bicycle use only. This allows cyclists to cross the street and make turns without having to contend with motor-vehicle traffic. This approach solves the problem of intersection conflicts inherent in the mixing of users on a roadway.

4.6.4 Limited Access Intersections

Crossing the intersection terminal on freeway ramps poses special hazards to bicyclists due to speed of entry and exit, long tapers, and expansive roadway crossing widths. Bicyclists can be aided through several principles of design:

- Slow the speed of the bicyclist on final approach, and create a yield for the bicyclist.
- Create a right angle crossing and a reasonable viewing distance by separating the bicyclist with a jughandle pathway, and crossing the bicyclist at a point in the ramp where the motorist is attending to steering control as opposed to an over-the-shoulder gap assessment.

4.7 Roadway Treatments

Bicycle-safe design practices, as described in this handbook, should be followed to avoid the necessity for costly subsequent improvements. Because most highways have not been designed with bicycle travel in mind, there are often many things which can be done to improve the roadway for bicyclists. In addition, the desirability of adding facilities such as bicycle lanes, shoulder improvements, and wide curb lanes (the least preferred option) should be considered.

Roadway conditions should be examined and hazardous conditions removed. Information on several roadway improvements is contained in this section. The controlling feature of the design of every bicycle facility is its location (i.e., whether it is on the roadway or on an independent alignment).

4.7.1 Cross slopes

Paved shoulders are frequently designed with cross slopes of 6%. While this cross slope does not create difficulties for bicyclists, it is the maximum which should be used on bicycle facilities.

4.7.2 Lighting

On road bicycle facilities should be lit to the same levels as the roadways. The *Plans Preparation Manual* gives the following standards:

For major arterials:
Illumination level (Average initial lux) = 16
Uniformity ratio:
avg./min. 4:1 or less

max./min. 10:1 or less

For all other roadways:
Illumination level (Average initial lux) = 11
Uniformity ratio:
avg./min. 4:1 or less

max./min. 10:1 or less

4.7.3 Drainage Grates

Drainage grate inlets and utility covers are potential problems to bicyclists. Typical drainage grates can be:

- slippery
- not flush with the road surface
- a prime location for debris and water, and
- capable of trapping bicycle wheels.

When a new roadway is designed, all such grates and covers should be kept out of bicyclists' expected path, or they should be designed to accommodate bicycle traffic, as described below.

On roadways where bicyclists will be permitted, curb inlets should be used, wherever possible, to eliminate exposure of bicyclists to grate inlets. It is important that grates and utility covers be adjusted flush with the surface, including after a roadway is resurfaced.

Parallel bar drainage grate inlets can trap the front wheel of a bicycle, resulting in loss of steering control and often serious damage to the bicycle wheel and frame and/or injury to the bicyclist. Grates with parallel slat designs that trap bicycle wheels are still used frequently in some roadway and many non-roadway environments, such as in parking lots, across driveways, and other hazardous locations. These grates should be replaced with bicycle-safe and hydraulically efficient ones. Designers must be vigilant always to specify bicycle safe inlet grate designs.

As a last and temporary resort, identifying a grate with a pavement marking would be acceptable in some situations. As indicated in the MUTCD, parallel bar grate inlets deserve special attention. Because of the serious consequences of a bicyclist missing the pavement marking in the dark or being

The advance loop shown below is in Corvalis, Oregon.

This specially marked lane in Copenhagen, Denmark illustrates a method used when bicycle and motor vehicle volumes are high. The bicyclists and motorists each have their own signal for right turns and through movements.

"Bicycle Parking Rack". *Keep these out of the roadway. The above inlet is hazardous. Use inlet grates following FDOT Standard Index 229. If roadway placement is necessary use "bike safe" grates as shown below. The grates shown for in-street use in the FDOT Standard Index sheets are also bicycle friendly.*

When older drainage facilities extend into the paved area, mark the hazard to steer bicyclists around them.

forced over such a grate inlet by other traffic, these grates should be physically corrected, as described above, as soon as practicable, after they are identified.

4.7.4 Railroad Crossings

At highway grade crossings of railroads, the rails should ideally be at a right angle to the road. The greater the crossing deviates from this ideal angle, the greater is the potential for a bicyclist's front wheel to be trapped in the flangeway causing loss of steering control. It is also important that the roadway approach be at the same elevation as the rails.

Consideration should be given to the materials of the crossing surface and to the flangeway depth and width. If the crossing angle is less than approximately 45 degrees (crossing angles of 30 degrees or less are considered exceptionally hazardous), consideration should be given to widening the outside lane, paving the shoulder or providing a bulbed out bicycle lane to allow bicyclists adequate room to cross the tracks at a right angle. The approach and departure shoulder should be paved, and should provide sufficient length to allow the bicyclist to merge into a gap in traffic. This treatment is shown in the graphic on the left. Where this is not possible, commercially available compressible flangeway fillers can enhance bicyclist safety. In some cases, abandoned tracks can be removed. Warning signs and pavement markings should be installed in accordance with the MUTCD. Additional pavement markings directing the bicyclist toward the best crossing angle should be considered.

Ensure any crossing designs are approved by the state rail office and the appropriate railroad.

4.7.5 Pavements

Often the right-most portion of a highway deteriorates first in a highway cross section. Since this is the area of a roadway where bicyclists generally ride to stay out of traffic, it is imperative pavements be selected and constructed to provide long life. Pavement surface irregularities can do more than cause an unpleasant ride. Gaps between pavement slabs or drop-offs at overlays parallel to the direction of travel can trap a bicycle wheel and cause loss of control. Holes and bumps can cause bicyclists to swerve into the path of motor vehicle traffic. Thus, to the extent practicable, pavement surfaces should be free of irregularities and the edge of the pavement should be uniform in width. On older pavements it may be necessary to fill joints, adjust utility covers or, in extreme cases, overlay the pavement to make it suitable for bicycling.

4.7.6 Rumble Strips

Rumble strips can be a deterrent to bicycling on shoulders and their benefits should be weighed against the probability bicyclists will ride in the motor vehicle lanes to avoid them. As a general rule, rumble strips should only be used on curves, approaches to narrow bridges and other locations where there is a high potential for benefit.

4.7.6.1 FDOT Rumble Strips

The FDOT Roadway and Traffic Design Standards (Standard Index) gives locations for rumble strips. The use of raised rumble strips restricted to the approaches to narrow bridges. The Department only permits the use of continuous rumble strips on limited access facilities.

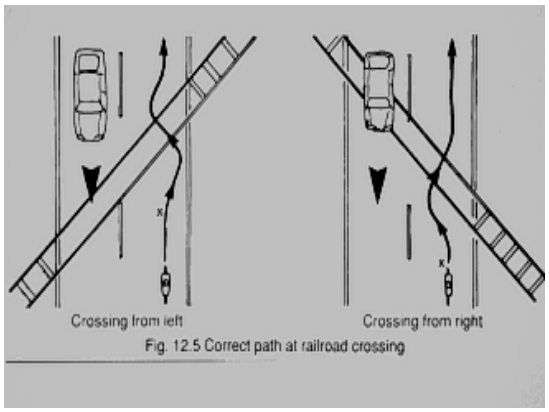
4.7.6.2 Other Applications of Rumble Strips

In other restricted applications, the shoulder should be widened to provide at least a 1.2 m (4 foot) riding surface. Rumble strips should be of a design that does not create instability to the bicyclist who inadvertently drifts onto one, especially under low light conditions. Designs other than those shown in the Standard Index sheets should be evaluated for their impact on bicyclists.

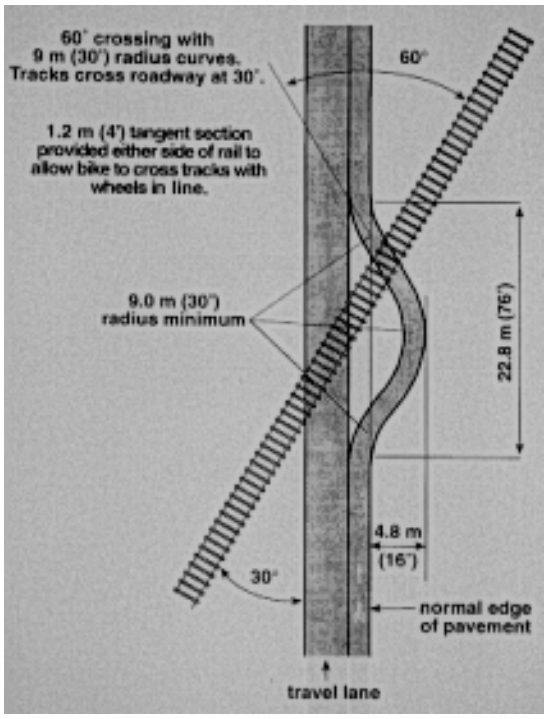
One treatment which has been suggested for use on busy two lane roads is the use of continuous ground in rumble strips. A test section in FDOT District 5 used 7" x 12" by 3/8" (175mm x 300mm x 10 mm) ground-in rumble strips adjacent to the edge line on existing 1.2 m (4-foot) paved shoulders. Since the 1-foot width uses up only the room needed for the handle bars overhang, there is no real infringement of the bicyclist space. The recent research report from the University of Maine by Professor Per Garder substantiates this, along with the benefits for ground-in rumble strips for bicyclists. A 6 mile (10 km) test section has been installed on a two-lane highway, SR 44, that has bicycle traffic. There have been no complaints to date. The 3/8"(10mm) depth was used because the asphalt on the shoulders is only 1" (25mm) thick per the plans, but is less in places. The audio response of vehicles on these 10mm rumble strips approximates that of the 1/2" (13mm) strips. Initial evaluations suggest these strips are safe for bicyclists. A detail of the rumble strips is included in Appendix E.

4.7.7 Bicycle Sharing Roadway Signing

Special guidelines have been issued (FDOT Traffic Engineering Manual) for the use of "Bicycle Sharing Roadway" signs. These signs are to inform motorists that bicy-



Bicycles at railroad crossings.
Above: Proper path for a cyclist across a railroad track. Below: Recommended treatment for less than 45 degrees angle crossing.



clists and motor vehicles are legally required to use/share travel lanes. These signs are generally used where safety problems or inappropriate motorist behavior indicate a need to remind users they are sharing the roadway with others. These signs may be appropriate for long narrow bridges in both urban and rural locations. Also, these signs can be used when a bike lane ends and the bicyclist is required to move into the roadway.

Designated bicycle facilities are not eligible for this sign. As a general rule, unless there is a special safety or road courtesy problem, corridors with paved shoulders or bike lanes will not be considered for this sign. As with any sign, overuse tends to breed disrespect for those cases where they are needed most.

Before issuing the signs, the district or community bicycle coordinator is asked to review the signing request.

4.7.8 Bicycle Routes

It may be advantageous to sign some urban and rural roadways as bicycle routes. When providing continuity to other bicycle facilities, a bicycle route can be relatively short. However, a bicycle route can be quite long. For longer bicycle routes, a standard bicycle route marker with a numerical designation in accordance with the MUTCD can be used in place of a bicycle route sign. The number may correspond to a parallel highway, indicating the route is a preferred alternate route for bicyclists.

It is often desirable to use supplemental plaques with bicycle route signs or markers to furnish additional information such as direction changes in the route and intermediate range distance and destination information. Bicycle route signing should not end at a barrier. Information directing the bicyclist around the barrier should be provided.

Overall, the decision whether to provide a bicycle route should be based on the advisability of encouraging bicycle use on a particular road instead of on parallel and adjacent highways. The roadway width, along with factors such as the volume, speed and types of traffic, parking conditions, grade and sight distance should be considered when determining the feasibility of bicycle routes. Recommended grades and sight distances are discussed in the Section 5.

Generally, bicycle traffic cannot be diverted to a less direct alternate route unless the favorable factors outweigh the inconvenience to the bicyclist. Roadway improvements, such as adequate pavement width, drainage grates, railroad crossings, pavement smoothness, maintenance schedules and

signals responsive to bicycles, should always be considered before a roadway is identified as a bicycle route. Further guidance on signing bicycle routes is provided in the MUTCD.

4.7.9 Bicycle Boulevards

In contrast to bicycle routes, bicycle boulevards offer more support to bicyclists by enhanced signing, traffic controls and connections. Bicycle boulevards serve as a primary route for bicyclists through a collection of lower speed side roads where traffic controls favor the through movement of bicyclists. Motorists attempting to use the same route for distance travel are thwarted through an occasional traffic diverter, a series of roundabouts, and other devices used to slow or rechannel motor vehicles. Boulevards may also have special trails, bridges or connections, offering the rider the most direct and quiet routing to primary destinations such as a downtown.

4.7.10 Special Neighborhood Bike Lane

Special bike lanes can be created on highly select local streets by restricting auto movement to one way, placing a low median divider of at least 70 inch (1.7 m) width, and with a 6 inch (150 mm) curb face on the motor vehicle traffic side. The bicycle side can have a zero curb height to allow additional maneuvering width. The created space can thus be dedicated for bidirectional bicycle travel. Such treatments call for special side entry signing to alert motorists of the bidirectional bike travel. These local bicycle streets should only be considered through full involvement of the neighborhood, and where at least 60% of the adjacent residents approve of the design. Other criteria include the number of conflict points and the volumes of traffic and potential bicycle traffic.

4.8 Existing Hazardous Conditions

There are some conditions which deserve special attention because of the danger they pose to bicyclists. Special efforts should be made to eliminate these hazardous conditions.

4.8.1 Continuous Right Turns

In some cases, designers have permitted right turn only lanes for extended distances. Drivers using these lanes do not always turn at the first available location, making these de facto through lanes. These right turn lanes should be discontinued with a raised island breaking up the through movement.

Bikes Sharing Roadway Signing. Above: This sign has been used in other states. Florida's sign uses the same symbol with the text "BICYCLE SHARING ROADWAY." Florida's procedure would not permit the use of the "BICYCLE SHARING ROADWAY" sign as shown above. In Florida the sign can only be used when cyclists are sharing the actual roadway. In this case the cyclists have a paved shoulder.

Below: *This Canadian bike route sign serves as an important navigational aid, provides system continuity and reduces the potential for bicyclists to use roadways where they feel uncomfortable. Bike route signs are less effective when used without the navigational placard.*

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Continuous right turn lanes present a problem for the designer. To be consistent, the bike lane must be between the through and right turn lanes. This puts bicyclists in a continuous high conflict zone. They must negotiate high speed, accelerating, or decelerating traffic which is passing on the right and left or weaving across the bike lane. The difficulty in predicting motorists movements within these lanes can also make continuous turn lanes hazardous to pedestrians and motorists.

4.8.2 Continuous Through Lanes

In a few isolated cases, at tee intersections, designers have permitted a continuous green through lane on the long leg, allowing motorists to continue higher speed through movement, while traffic is entering from their left. This creates an impossible merge condition for bicyclists and pedestrians. Both bicyclists and pedestrians become trapped in an interior lane. For this reason such operations are discouraged in most urban applications.

4.8.3 Intersection Improvements

Since facilities are commonly installed on a project-by-project basis, bicycle lanes should be provided even for such short sections as an intersection improvement. If desired, the lane markings and signing can be left out until a longer facility can be connected. Designers should extend the bike lane portion of such intersection improvements into a logical merge location, allowing the bicyclist to accept a comfortable gap. This lane extension may require extending the normal length of the project several hundred additional feet.

4.8.4 Climbs , Descents

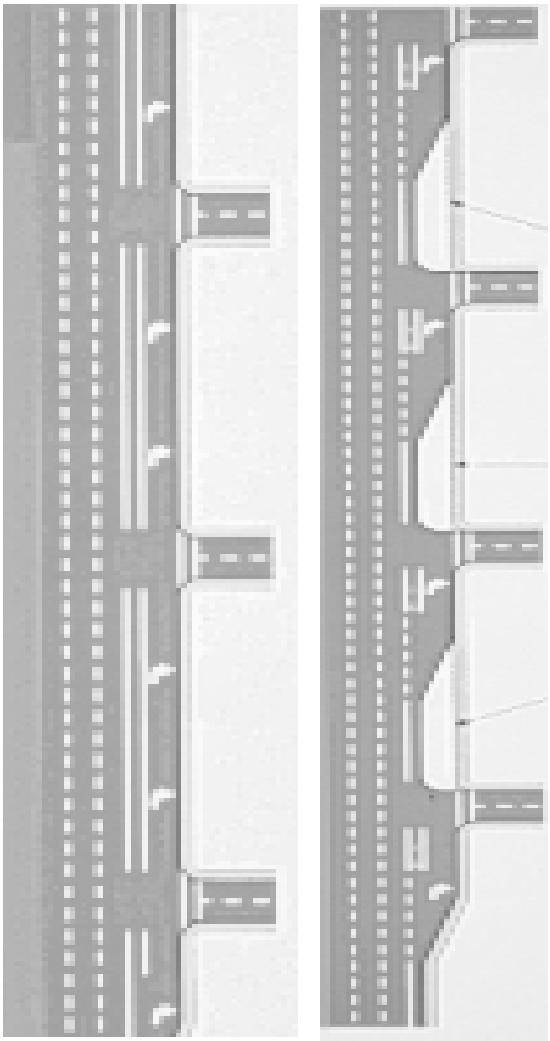
Bicyclists require additional room to climb and descend. Six to eight feet is recommended for the ascent side, and ten to twelve feet is recommended for the descent. Typically the descent requires bicyclists to take the full lane. Speeds of 30 mph or greater are common. Special signs to create the best actions of motorists and bicyclists have been developed. These signs are applied in Boulder, Colorado.

4.8.5 Bike Lane Conditions and Maintenance

If a drainage grate exists within a bike lane or shoulder area it should be marked to steer bicyclists around it.

Utility covers are also a hazard for bicyclists. The surface is slippery when wet. They also tend to be higher than the normal roadway surface. The asphalt around utility covers must be maintained to provide a smooth ride. Where possible they should be relocated to outside the bicyclists expected

Continuous right turn lanes. *Continuous right turn lanes create an extremely hazardous situation for bicyclists and should be interrupted to provide separate right turn lanes.*



path.

Adequate pavement surface, bicycle-safe grate inlets, safe railroad crossings and traffic signals responsive to bicycles should also be provided on all urban roadways. These treatments should be provided especially where bicycle lanes are designated. Raised pavement markings and raised barriers can cause steering difficulties for bicyclists and should not be used to delineate bicycle lanes. Specific maintenance criteria can be found in FDOT's Maintenance Rating Program Manual.

4.9 Travel Lane Reductions

There are a few places where roadway sections were either overbuilt (beyond capacity demands) or where a new emphasis is being given to balanced transportation. Communities can shift lanes to other roadways. In these areas, there may be potential to reduce the number of motor vehicle lanes. To assist the designer with lane reductions, this section illustrates some of these conversions.

4.9.1 Four Lane Reductions

Where traffic speed and volumes and other conditions warrant, 4-lane highways can be reduced to two lane designs with raised medians and turn medians. The left over space can be used for bike lanes.

An engineering study and citizen support are required before a lane reduction is permitted.

This continuous flow through movement creates a trap condition for left turning bicyclists. They are sandwiched between two through lanes.

4.9.2 Three Lane Reductions

Some local and minor collector roadways were constructed with three lanes and yet carry very light traffic. Where traffic volumes and speeds are sufficiently low and other conditions warrant, bike lanes can be placed in the curb-to-curb width. In this treatment, the center scramble lane is converted to a raised traffic separators. When completed this cross section could look like the pigmented bike lane section shown on page 4-12. Such treatments may require speed controls every or every other intersection.

4.10 Limited Access Corridors

Although a new concept for Florida, most western states have been providing for bicycles within many freeway rights of way. Florida's Turnpike Office will be building a **3.6 m** trail along its new Suncoast Parkway. Cross section information on the trail is included in Appendix F. Attention to design detail, especially at bridges and on-off ramps, will be important.

Two good examples of using limited access corridors for bicyclists can be found in Washington State. In Olympia, bicyclists are provided an independent right-of-way in the I-5 corridor. A crossing is provided at grade, and bicyclists continue on the other side. Bidirectional bicycle traffic is accommodated across the I-90 Mercer Island floating bridge in Seattle.

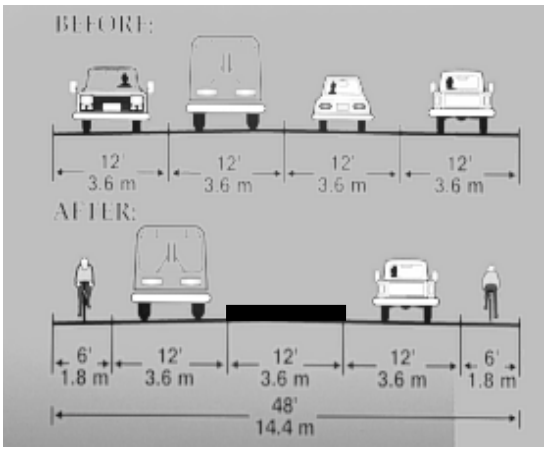
4.11 Bridges, Tunnels, and Overpasses

Bicycle use is largely dependent upon convenience. Any barrier causing bicyclists to travel long distances to avoid it is a serious disincentive to bicycling. Common barriers include water, canyon or gully, rails, freeway or major arterial. Occasionally, bridges, overpasses and tunnels are the only way to overcome the barrier and provide needed linkages within the bicycle transportation system. Indeed, without linkages there can be no system. Every manner of barrier, whether man made or natural, must be bridged. No new barriers should be created.

Most bridges used by bicyclists will be roadway bridges. A 8 foot (2.4 m) shoulder on bridges is usually adequate to serve bicyclists. Where frequent use by inexperienced riders or children is expected it may be appropriate to include a wide sidewalk physically separated from the roadway. Appropriate railings for separating sidewalks from the roadway and from the edge of the bridge are shown in the *FDOT Structures Design Office Standard Drawings*.

This sign, used in Boulder, Colorado, alerts motorists to the bicyclists' need for the entire lane width for decent.

Riding Surface. *Right edge portion lane stability and maintenance are essential to a safe roadway. Pay special attention to utility caps, gutter seams, pavement quality and pavement life.*



Above: Four-lane to two-lane reduction with median and bike lanes.

Mercer Island Bridge. *Above: Unique features of this bridge include a see-through railing, permitting motorists to view water activities, and low angle lighting imbedded in the barrier wall to light the trail without creating glare for motorists.*

Below: The I-5 Corridor in Olympia, Washington includes a multi-use path.

Roadway tunnels must also accommodate bicyclists. A 2.4 meter shoulder should be provided through all tunnels.

Bridges built exclusively for bicyclists' use in Florida are usually associated with trails. Therefore, the design considerations of bridges will be covered in Chapter 5.

4.12 Bicyclists at Roundabouts

A number of studies have shown crashes involving bicyclists increase at roundabout controlled intersections. However, the countries doing the studies have varying design standards. Florida has developed a Roundabout Design Guide. Under these standards, bicyclists should fare well at roundabouts for two reasons: First, there is no possibility of a left hand or cross-motorist turning crash. Second, the right turning conflict can be fully controlled by the bicyclist. By claiming the lane upon entering the roundabout, a bicyclist can enter and exit the roundabout without conflict from an overtaking motorist. The only remaining threat is for the bicyclist to watch for the entering motorist.

Seattle, Washington now has 500 neighborhood mini-traffic circles in place. Records show an 80% reduction in all types of crashes. This includes a 30% reduction in bicycle crashes as well. Universally, bicyclists need not stop, since they can see the vehicle in their conflict path, and simply increase or lower their entry speed.

For one lane roundabouts, bicycle lanes shall end and permit a merge during the last 75 - 100 ft. (22 - 30 m) of approach. When bike lanes are used, it is a general rule to drop the bike lane about 75 - 100 ft. (20 - 30 m) feet before the intersection, and allow a low speed merge. No special markings are needed in the roundabout. Roundabout speeds should be controlled through design at no more than 25 mph (40 km/h).

For high capacity roundabouts of 2 lanes or more, special crossing areas set back 20 ft. (6 m) from the intersection can be considered. Separate paths may be appropriate for high volume roundabouts (3000 VPH or higher)

For rural roundabout locations where higher entry and exit speeds are permitted, multi-use trails and crossings set back 20 ft. (6 m) from the intersection should be considered.

4.13 Traffic Calming

Florida is one of the leading states in traffic calming, neo-traditional design and new urbanism (see Planning section). The designer must pay close attention to the elements of designing collector and local roads, making sure speeds are

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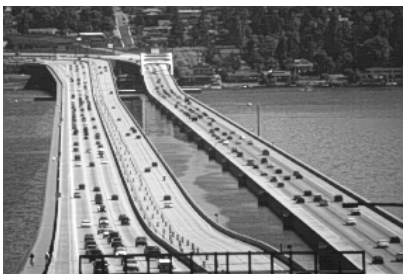

Structures That Work For Everyone

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Top: (1) Washington and (2) Oregon spared no expense to provide access for bicyclists across their major water barriers. Added to the initial design of these structures, the costs were affordable. The structure was the only way to provide continuity to their systems. (3-4) Below, Vancouver, Washington addressed the barrier wall with style, while (5-6) (center photos) Seattle connected two neighborhoods using a canyon bridge no longer safe for motorized loads.

Bottom right (7) Davis, California and (8)Boulder, Colorado each tunneled major roadways to provide bright, attractive tunnels. The Boulder tunnel has fossil embedded walls with glazing, to prevent vandalism. The center shaft of light is essential on wide and long tunnels. Another secret to tunneling is to raise the roadway half-way, so that people entering the tunnel can see the land on the far side of the tunnel. Top right: (9) Construction from overhead requires safety for pedestrians and bicyclists. Rather than cross bicyclists to the far side of the street this structure was provided.

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Overcoming Barriers with Bridges, Overpasses, Tunnels

"Bridges are the big issue in bicycle transportation. Unless this issue is addressed, there are no other issues."

Peter Lagerwey, Seattle Pedestrian/ Bicycle Coordinator

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(7) Even a simple (Dutch) one person crossing is better than balancing on the levee wall. Although not supported by anyone's design standards, there is a need to come up with realistic solutions to people's problems. This little bridge is better than a do it yourself "walking the plank" approach. Top (8) For fifty years bicyclists were denied access to Captiva Island, a popular bicycling destination. Finally, in 1991 the commission listened to Alex Sorton, a top bicycle engineering consultant who advised that this bridge was safer than most in the area. The barrier finally came down, and with it died many myths of children being attracted to the bridge, or the island being overrun with transients.

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Man-made barriers. *(1) Whether rail, (2-3) Freeway, or bridge, bicyclists seek understanding and support for crossings that work. (4) Boulder's well designed below water path under a bridge. (5-6) A homeowners association was sued, and lost, when two bicyclists collided entering and exiting of this under-the-bridge tunnel. Sight distance is poor. The insulting sign was brought up in court. "Motorists crossing on the bridge deck had full design support, and were not being asked to get out of their vehicles to push their cars across, and so it was argued "Why must bicyclists have a lesser standard of care?"*

kept low.

As a general rule, well designed neighborhoods need little traffic calming. Many of these principles apply to developments already in place where motorists exceed prudent neighborhood speeds (20 mph). New developments, such as Truman Annex in Key West, and Seaside, as well as older developments such as Coral Gables and Winter Park, need only limited refining.

Some traffic calming treatments may not be appropriate on the State Highway System. The Florida Department of Transportation is investigating how traffic calming techniques may be used on its system.

If traffic calming is used, there are several key techniques to be used:

- Keep blocks short
- Provide tight turning radii
- Provide tree canopies
- Permit narrow lanes, or medians
- Slow speeds at intersections
- Create constant movement to maintain flow (avoid stop signs in favor of roundabouts).

Bicyclists are concerned with things they don't see (speed bumps), but they don't mind speed humps or tables. Use tapers and full openings for bicycle movement. Some of the graphics showing speed humps show treatments which allow bicyclists to ride around the treatments. The approach to a speed table, a raised intersection, or other raised object should be 1:6. A more sudden rise creates problems, and a shallower rise has reduced effect. Always mark changes in elevations with roadway markings and signs. This increases their effectiveness. Because bicycles lack adequate lighting, street lighting should be used with traffic calming features.

Traffic calming features should only be installed after a complete engineering study and extensive neighborhood involvement process. After installation, a follow-up study is needed to determine if the treatment had the desired effect.

4.13 A Final On-Road Thought

Bicyclists are not seeking special favors. Like everyone else, they are taxpayers. Most bicyclists drive their cars much of the time. When they are driving they want to be treated with respect. And when they are bicycling they are owed the same respect. Bicyclists simply want to be part of the system.

Good Design Helps Everyone. *A very costly cantilevered retrofit of Pensacola's "Three Mile Bridge" benefited motorists by creating a much needed vehicle emergency lane. A side benefit was the creation of narrow but essential shoulders for bicycling. Fatal bicycle crashes dropped from an average of one a year in the early 80's to zero since the treatment in 1986.*

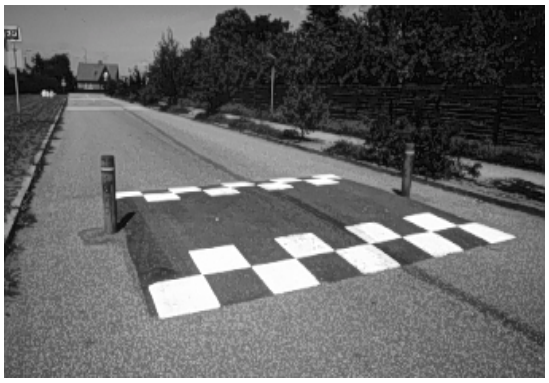
Below: At this intersection in Gainesville, Florida, the bike lanes are dropped prior to the intersections and bicyclists are to travel through just as motorists do. If curb and gutter had been included on this intersection, it would meet the FDOT requirements to be considered a roundabout. With curbed approaches, this "roundabout" would have a design speed of 20 mph.

Traffic Circles. *Above: A mini-traffic circle in Seattle, Washington.*

Bicycle friendly traffic calming. *Below: The raised area in the upper photo allows cyclists to pass uninhibited. In the lower photo, a speed table is created at a trail crossing . Cyclists and pedestrians are provided an at grade crossing. Motorists are forced to slow down.*

It was acceptable to build roadways in the 1950's that accommodated the through movement of motorized vehicles, and little else. With rare exception, only children rode bicycles then, and their riding spaces were confined to their neighborhoods. It is no longer acceptable to build roadways without fully considering the pedestrian and bicyclist.

Designers must seek new and innovative solutions to the multi-modal transportation challenge. Florida leads the nation in new and innovative ideas. We are building more, faster, and in more places, than any other state. Our areas are diverse: from sleepy towns to bustling metropolises. We have a greater diversity of drivers than most places. What you learn should be shared with others. We look forward to hearing from you in our courses, and at any time you have an experience, a question, or possible solution.



These speed humps features have been designed to minimize their impact on bicyclists.

Design for everyone, and you will be praised. Design for one, and you design for no one.

Section 5 DESIGN Shared Use Paths

5.1 Introductory Essay by Dan Burden

You may well ask, "What's an essay doing here in the middle of this book?" Good question. In response, there is a vast difference in what we, as designers, seek to achieve with a trail, as compared to a roadway. It is necessary to look at trails as features of the land, adding value to the experience of place.

Trails require far greater sensitivity than has been given them in the past. We fail in our mission, when we look at the design of a trail in a purely physical sense. Our AASHTO design criteria, wonderful for highways, limit our understanding of how to work with shared use paths. Paths must fit into nature, not the other way around.

Penciled in the margins of a book I recently read, *The Experience of Place,* by Tony Hiss, I jotted this note: "Too many cities in America have become places to survive. We need more places to thrive." What was I thinking? I had just re-read Jane Jacobs' book, *The Death and Life of Great American Cities.* Both her book and Tony's emphasized how we have become lost in our need to create real places where individuals can enrich their lives.

Urban settings can and should be designed as places to live. Shared use paths, greenways and other open spaces are just as vital

People need immediate places to refresh, reinvent themselves. Our surroundings, built and natural alike, have an immediate and a continuing effect on the way we feel and act, and on our health and intelligence. These places have an impact on our sense of self, our sense of safety, the kind of work we get done, the ways we interact with other people, even our ability to function as citizens in a democracy. In short, the places where we spend our time affect the people we are and can become. .....Tony Hiss, The Experience of Place

"Too many cities in America have become places to survive. We need more places to thrive".

... Dan Burden

an ingredient of successful towns or cities as efficient highways. If shared use paths and highways are going to be designed or at least funded by the same professionals, then we need to make sure that these designers understand the distinction between highways and shared use paths. To detail these differences, I take you back a step to a very different place. The time is 1972.

When I took the above photo, I was absorbed in nature. My wife, companions and myself were into our seventh month of a one and a half years bicycling journey from Alaska to Argentina for *National Geographic*. We were following the mountainous backbone of the Western Hemisphere. We spent our time equally on roads and on trails. We preferred the trails for more reasons than those that are obvious.

The Sonora Desert in Baja, Mexico is a natural space. The road here, sinewy and rugged, was built from a former animal trail. The designers were people attempting to move themselves and goods by foot, burro, or wagon. They had no spare labor, so they carved this road by pick, shovel and wheel barrow. But mostly they just let the wagon wheels etch the land. The builders never attempted to undo a kink, change a grade or tunnel into a hillside. The land kept its natural form. Indeed, the road is a trail. This trail has endured largely because it focuses movement in a natural way. It is far less efficient in moving goods than a road. If people want to go thirty, forty or fifty miles an hour, it won't work.

Today, when I go back to nature to reinvigorate myself, I may find an adventuring friend or two and head for California's Anza Borrego Trail. Like the Baja, it is another place in the Sonora, forgotten by time. Although Jeeps and Bronchos share the space, the jeep road will never be widened. Nothing will ever go fast here. The Anza Borrego is an historic trail. By law it's features are preserved for all of time. And that is why the Anza Borrego Trail is worth returning to, again and again.

A trail offers its users awareness of surroundings. Trails preserve vistas. Trails preserve ecosystems which allow natural sounds to drown out urban sounds. Trails invite touch and discovery. Trails protect and preserve fragrance. The trail experiences offer users feelings of bigness and connection with the earth. Trails unfold mystery, offer surprise, preserve the detail. In fact, well designed trails offer the hikers, bicyclists, skaters or other adventurers new sensations each time they are used.

I have walked trails in Northern European towns where I lost all sense of self, where the only sounds were comforting ones, where each turn brought a new reward. And as I encountered

A trail offers users awareness of surroundings.

others on these trails it became obvious that they too were off in private worlds of thought and contemplation. "These trails are working", I said to myself, as I attempted to capture first in my own mind, and later with camera, this special link from urban surroundings to natural world.

Of course, roadways cannot do this. They are not supposed to, and they don't. The mission of a roadway is to preserve free movement, to offer choice in transportation and to move people and goods safely and efficiently.

The mission of trails is vastly different. Trails allow visits with the natural world; they do not disturb it. At the same time, trails share places that people find cheering, attractive, sparkling, comfortable, reassuring, and welcoming.

We all have our favorite walking and riding places. As designers it is our task to learn why these places are so special. Once we understand these principles, then we can begin to apply them to our own trail designs.

For me a ride along Boulder Creek in Boulder, Colorado is a yearly must; as is a stroll through Stanley Park in British Columbia. The vistas there are like none other. Where I enjoy "people watching" as I ride or stroll the shared use paths of Santa Barbara, South Beach or Venice, these places fail to give me trail "experiences" like the former ones.

Finally, where I caution the reader to pay close attention to the standards and guidance found in this section, I urge that equal attention be devoted to how and why a trail must first serve the land through which it passes. Take down no unnecessary trees, work within the natural terrain, narrow when you must for short distances. Never speed up bicyclists or skaters when your quest is to preserve the land.

We have overbuilt many roadways in America. We can afford to do that. We cannot afford to overbuild our shared use paths. For in making them "better," we make the experience worse.

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5.2 Definition

Shared use paths are facilities on exclusive rights-of-way and with minimal cross flow by motor vehicles. Since bicycle paths are almost always used by pedestrians, joggers, in-line skaters, equestrians and bicyclists, they will subsequently be referred to as shared use paths.

Shared use paths can serve a variety of purposes. They can provide a school age child or a commuting bicyclist with a shortcut through a residential neighborhood (e.g., a connection between two cul-de-sac streets). Located in a park, they can provide an enjoyable recreational opportunity. Shared use paths can be located along abandoned railroad rights-of -way, the banks of rivers and other similar areas. Shared use paths can provide bicycle access to areas that are otherwise served only by limited access highways and closed to bicycles. Appropriate locations can be identified during the planning process.

Shared use paths should be thought of as extensions of the highway system that are intended for the exclusive or preferential use of bicycles and pedestrians in much the same way as freeways are intended for the exclusive or preferential use of motor vehicles.

There are many similarities between the design requirements for shared use paths and those for highways (e.g., in determining horizontal alignment, sight distance requirements, signing and markings). On the other hand, some criteria (e.g., horizontal and vertical clearance requirements, grades and pavement structure) are dictated by operating characteristics of bicycles that are substantially different from those of motor vehicles. The designer should always be conscious of

Trails may serve variety of purpose such as,
(1) offering children a link between cul-de-sac streets so they can go places,
(2) offering college students a way to study nature without getting into cars,
(3) offering children a safe place to move,
(4) offering a peaceful view of waterways
(5) offering a clear route through urban spaces.

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similarities and differences between bicycles and motor vehicles and how these similarities and differences influence the design of shared use paths. The following section provides guidance for designing a safe and functional shared use path.

5.3 Shared use paths Adjacent to Roadways and Sidewalk Bike Paths

When two-way, shared use paths are located immediately adjacent to roadways, some operational problems may occur:

- Unless shared use paths are paired, they require one direction of bicycle traffic to ride against motor vehicle traffic, contrary to normal rules of the road. This movement greatly increases Class C and F bicycle crashes (See Section 3). The designer is often left with complex placement issues. Should the facility be placed close to the highway creating turning/merge conflicts at the intersection? Should it be placed at the back of the right-of-way, increasing detection problems at each driveway and intersection? Shrubs, other vegetation and fencing can hide the bicyclist from the motorist.
- When the path ends, bicyclists going against traffic will tend to continue to travel on the wrong side of the street. Likewise, bicyclists approaching a path often travel on the wrong side of the street to get to the path. Wrong-way travel by bicyclists is a major cause of bicycle/automobile crashes and should be discouraged at every opportunity. The Department is doing research to determine how to best distribute trail users back into the normal roadway network.
- At intersections, motorists entering or crossing the roadway often will not notice bicyclists coming from the right, as they are not expecting or looking for contra-flow vehicles. Even bicyclists coming from the left (the expected direction) often go unnoticed, especially when sight distances are poor.
- Bicyclists using the roadway are often subjected to harassment by motorists who feel that, in all cases, bicyclists should be on the trail instead. Many bicyclists will use the roadway instead of the shared use path because they have found the roadway to be safer, less congested, more convenient, or better maintained.
- Bicyclists using shared use paths generally are required to stop or yield at all cross streets and driveways. Whereas, bicyclists using the roadway usually have priority over cross traffic, because they have the same right of way as motorists. This treatment is unfair to trail users and may be contrary to the *Manual on Uniform Traffic Control Devices.* In some cases, shared use paths may have such

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Sidewalk Bike Paths Often Fail.
(1) Each driveway can be a conflict to bicyclists. Half of all riders come against traffic. (2) Where does the designer place the facility laterally? Too close to the road and there are serious operational problems. The motorist blocks the path, and some bicyclists are inclined to go to the front. Too far back the turning motorist picks up speed and fails to notice the crossing. This motorist lost in court when the bicyclist was injured while going in front.

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Every driveway is a conflict. *An adult bicyclist, moving at 15 mph here, crashed into the side of a car exiting the drive. A settlement of over $500,000 was assessed against the motorist.*

Parallel paths often face barriers and challenges.

Sidewalk Bike Paths. *Below: This community has chosen to place a bidirectional bike path parallel to this roadway. Exotic signing and measures do not eliminate motorist/bike crashes. The frequency of driveways and intersections alone is ample reason not to build parallel bike paths in most locations. Bike lanes work better for everyone.*

heavy volumes the cross street should be required to yield. The Department has available *Trail Intersection Design Handbook* which will help address this issue.

- Stopped cross street motor vehicle traffic or vehicles exiting side streets or driveways may block the path crossing.
- Because of the proximity of motor vehicle traffic to opposing bicycle traffic, barriers are often necessary. They keep motor vehicles separated from shared use paths and bicyclists from traffic lanes. These barriers can represent obstructions to bicyclists and motorists. They can complicate maintenance of facilities and cause other problems as well.
- Many bicyclists' destinations may be on the opposite side of the street from where the bicycle path is located. This is a common situation when shared use paths are built along railway corridors or canals. In this case, the bicyclists' desire to access these destinations must be addressed.

Using sidewalks as pathways further increases the hazards. Providing a sidewalk shared use path is unsatisfactory for a variety of reasons:

- Sidewalks are typically designed for pedestrian speeds and maneuverabilities.
- They are not safe for higher speed bicycle use.
- Conflicts are common between pedestrians and bicyclists. Pedestrians exiting stores or parked cars may surprise bicyclists.
- Conflicts with fixed objects (e.g., parking meters, utility poles, sign posts, bus benches, trees, fire hydrants, mail boxes, etc.) are also common.
- Walkers, joggers, skateboarders, in-line skaters and roller skaters can, and often do, change their speed and direction almost instantaneously, leaving bicyclists insufficient time to react to avoid collisions.
- Pedestrians often have difficulty predicting the direction an oncoming bicyclist will take.
- At intersections, motorists are not often looking for bicyclists (who are traveling at higher speeds than pedestrians) entering the crosswalk area, particularly when motorists are making a turn. Sight distance is often impaired by buildings, walls, property fences and shrubs along sidewalks, especially at driveways.

For the above reasons, bicycle lanes may be the best way to accommodate bicycle traffic along a highway corridor. If the intent is also to accommodate pedestrians, sidewalks must be provided.

Bicyclists riding on sidewalks can be expected in residential areas with young children. With lower bicycle speeds and lower motor vehicle speeds, potential conflicts are somewhat lessened, but they still exist. Although this type of bicycle sidewalk use is generally accepted, it is inappropriate to sign a sidewalk as a shared use path or bicycle route, if doing so would prohibit or discourage bicyclists from using an alternate facility that might better serve their needs.

Use of commercial district sidewalks pose extreme risk to the bicyclist, pedestrian and motorist. Many communities do not permit such riding

Top: Another problem is the bike/ped conflict -- who belongs where? Above: Santa Barbara has had its bidirectional bike path parallel to this major road for many years. The risk still persists. Note, the motorists entering or exiting this roadway are surprised by bicyclists, especially from their right (entering motorist) or coming up behind (left turning motorist).

5.4 Mixing Users

Is it best to mix bicyclists, pedestrians and equestrians or to keep them separate? The question is best answered in terms of volume and user type. Horses prefer a softer surface and space away from bicycles, tricycles and skaters. At low volumes of each group a fully mixed path is observed to work. Once volumes increase, there is a need to provide separate spaces. Increased volume also requires lower operating speeds. The most universal answer is to provide a simple "wheels 'n heels" design which separates the bicyclists from the pedestrians by marking designated areas. ADA accessible paths must be designed as such. Circular pathways should normally restrict wheeled vehicles (and in-line skaters) to one direction.

Using the same path for bicycles and horses creates an unsatisfactory and possibly dangerous mix. Horses startle easily and may kick out suddenly, if they perceive bicyclists as a danger. A shared use path and bridle path are also incompatible in their surface design requirements. Bicycles function best on hard surfaces; horses function best on soft surfaces. A compromise to accommodate both would result in a less than adequate surface for both. Separate portions of the right-of-way should be used for equestrian needs.

Mixing of high speed bicyclists with pedestrians, tricyclists or people using wheelchairs is another concern. In addition to

Mixed Uses. *Left: Horses prefer softer surfaces away from bikes. Right: This path offers a paved surface and an earth surface.*

Above: Sometimes safety needs can be met by careful placement of users. Stanley Park recommends all wheeled users stay to the left, away from the water. If adhered to, this low wall, important for vistas, is safe for pedestrians. Below: A similar separation of users on another trail.

separate areas for different users, some paths may require a speed limit, This might be the case on a commuter path for children going to school.

5.5 Width

The paved width and the operating width required for shared use paths are primarily design considerations. According to FDOT's PPM, the minimum paved width for a two-directional shared use path is 12 feet (3.6 m). This width is required because most paths are heavily used, are shared use by bicyclists, joggers and in-line skaters, must accommodate occasional maintenance vehicles, have sections with steep grades, and are used by recreational bicyclists who like to ride two abreast.

The minimum width of a one-directional, bike path is 5 feet (0.5 m). Eight feet may be considered on sections where maintenance vehicles where have no other access. It should be recognized, however, that one-way bike paths almost certainly will be used as two-way facilities unless effective measures are taken to assure one-way operation. Without such design and enforcement, it should be assumed that shared use paths will be used as two-way facilities. They should be designed accordingly.

5.5.1 Reducing Width

The Florida Greenbook's minimum width requirement for paved paths is 10 feet. However, only under extreme constraints should building a path less than 12 feet wide be considered. A thorough analysis should be performed to ensure all the following criteria are met.

- Bicycle traffic will be low, even on peak days or during peak hours (most paths actual usage rates far exceed pre-construction estimates).
- Pedestrian or in-line skater use of the facility will be only occasional.
- There will be good horizontal and vertical alignment providing safe and frequent passing opportunities.
- The path will not be subjected to maintenance vehicle loading conditions that would cause pavement edge damage.

5.5.2 Increasing Width

Under certain conditions it may be necessary or desirable to increase the width of a shared use path to up to 22 feet (6.6 m). Examples include:

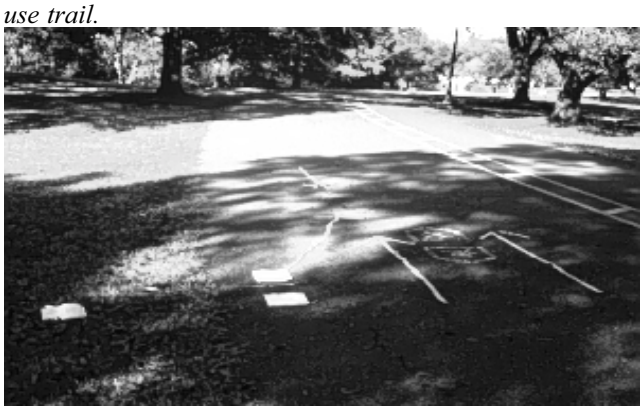
- substantial bicycle volume

Left: The Venice Beach Bike Path, well used and the most photographed trail in the nation. The pathway is a 15.0 foot (4.5 m) wide facility in most locations. Right: The newer Long Beach Bike Path boasts a 17 foot(5.2 m) width.

Pinellas Trail. *Above: 12 feet + 6 foot pedestrian trail. Pedestrians use separate trail when wheeled use is heavy. Other times they mix by choice.*

Insufficient width. *Above: Signs prohibitting pedestrians from using the trail do not work. Adequate width should be provided for all users.*

Adequate width. *Below: A roller skater (single arrow) approaching two bicyclists swerved to pass between the bicyclists and four pedestrians (white papers), clipped the left bicyclist and fell at the heels of the pedestrian, shattering her ankle. The skater skated on, so the pedestrian sued the park. The park won the case on having provided adequate width and design for a mixed use trail.*



***Horizontal clearance**. Above: Santa Barbara's coastal bike path has trash cans within the recovery area. Why? A park manager explained, "The maintenance crews prefer it this way." Both trail users and the trash collection staff can walk the extra distance. The cans should be moved away from the trail to ensure they are not obstacles.*
Below: If there is an embankment within 1.8 m of the trail it is vital to place a positive barrier to eliminate loss of control. The barrier wall or top rail should be at least 3.5 feet high to prevent toppling, and can be designed to allow viewing.

Below: Sanibel Island residents duck under a tree nearly a foot below standards.

- probable shared use with joggers, in-line skaters and other pedestrians
- use by large maintenance vehicles
- steep grades
- sharp curves
- places where bicyclists will be likely to ride two abreast.

Wide paths may benefit by designating separate sections for use by "wheels and heels."

5.6 Horizontal Clearances

A minimum, 4 feet (1.2 m) of clearance is desirable to provide distance from trees, poles, walls, fences, guardrails, or other lateral obstructions. A 2 feet (0.6 m) width graded area should be maintained adjacent to both sides of the pavement. A wider graded area on either side of the shared use path can serve as a separate jogging path. Any edge dropoff should be eliminated.

Embankments are especially hazardous to bicyclists. A 6 foot (2.0 m) lateral separation is desirable from any embankment that would create difficulties for bicyclists (greater than or equal to a 3:1 slope). Otherwise and appropriate safety railing should be installed.

A wide separation between a bicycle path and canals, ditches or other significant depressions is essential for safety. A minimum 6 foot separation from the edge of the bike path to top of slop is desirable. If this is not possible, a positive barrier such as dense shrubbery or chain link fence shall be provided.

A wide separation between a shared use path and adjacent highway is desirable to confirm to both bicyclists and motorists that the shared use path functions as an independent way for bicycles. When this is not possible and the distance between the edge of the shoulder and the shared use path is less than 3.5 feet (1.1 m), a suitable physical divider may be considered. Such dividers serve both to prevent bicyclists from making unwanted movements between path and highway shoulder and to reinforce the concept that the shared use path is an independent facility. Where used, dividers should be a minimum of 3.5 feet (1.1 m) high, to prevent bicyclists from toppling over them. They should be designed so they do not become an obstruction or visually shield small cyclists from motor vehicle traffic. The FDOT *Standard Index Sheets* Index 520, 2 of 2, shows bicycle and pedestrian railings.

5.7 Vertical Clearances

The vertical clearance to obstructions should be a minimum of 8 feet (2.4 m). However, vertical clearance may need to be greater to permit passage of maintenance vehicles and, in undercrossings and tunnels, a clearance of 10 feet (3 m) is desirable for adequate physical and psychological vertical shy distance. Equestrian trails should be designed with a 10 foot (3 m) vertical clearance.

5.8 Design Speed

The speed a bicyclist travels is dependent on several factors, including the type and condition of the bicycle, the purpose of the trip, the surface condition and location of the shared use path, the speed and direction of the wind, and the physical condition of the bicyclist. Shared use paths should be designed for speeds at least as high as the preferred speed of the faster bicyclists. *However, paths should not be designed to encourage speed.*

5.8.1 AASHTO Design Speed

According to AASHTO's *Guide for the Development of Bicycle Facilities* (1991), a minimum design speed of 20 mph (30 km/h should be used; however, when the downgrade exceeds 4 percent, or where strong prevailing tailwinds exist, a design speed of 30 mph (50 km/h) is advisable.

On unpaved paths, where bicyclists tend to ride slower, a lower design speed of 15 mph (25 km/h) can be used. Similarly, where the grades or the prevailing winds dictate, a higher design speed of 25 mph (40 km/h) can be used. Since bicycles have a higher tendency to skid on unpaved surfaces, horizontal curvature design should take into account lower coefficients of friction for unpaved conditions.

5.8.2 Reduced Design Speeds

There is growing concern that the 20 mph (30 km/h) design speed prescribed by AASHTO may create too great of an operating speed differential between families riding and high speed bicyclists. It may be different types of paths require different design speeds. Urban paths used by school children may have a lower requirement than rural paths with a large percentage of high speed cyclists. The Department is doing research to determine appropriate design speeds.

Intersection approaches may be another location which would benefit from a low design speed. Reducing the speed of path users approaching intersections could allow for the replacement of some STOP signs with YIELD signs. Unless the speed reduction is obvious, posting of the recommended speed and changed condition is essential (See MUTCD). Since most bicycles don't have speedometers, signing, how-

Trail Design Speeds. *Trails which will be predominantly used for commuting to school probably do not need to be designed for 20 mph (30 km/h). Mixing the school children above with the high speed bicyclist below would create a hazardous situation.*

Fails to meet AASHTO, but is it safe? *A multi-use trail, to meet AASHTO, and therefore current FHWA funding guidelines, must handle 20 mph turns. This 20 mph speed calls for a 95 foot turning radius, which would consume far more land than available to this Scottsdale, Arizona trail. The designer must answer the question whether a particular design is safe. Balancing natural aspects and function of a trail and existing standards requires more knowledge.*

Different trail users are forcing designers to reconsider the AASHTO 20 mph design speed. The characteristics of in-line skaters also need to be documented.

ever is limited in its effectiveness. Any designs using low +design speeds should be evaluated for safety and effectiveness.

5.9 Horizontal Alignment and Superelevation

The minimum radius of curvature negotiable by a bicycle is a function of the superelevation rate of the path, the coefficient of friction between the bicycle's tires and the path and the speed of the bicycle.

According to AASHTO, the minimum design radius of curvature can be derived from the following formula:

$$R = V^2 / 15(e/100+f)$$

Where:

R = Minimum Radius of Curvature (ft.)
V = Design Speed (mph)
e = superelevation rate as a %
f = coefficient of friction

For most shared use path applications the superelevation rate should not exceed 2% (the maximum allowed by ADA for pedestrian paths and the minimum necessary to encourage adequate drainage). A higher cross slope cannot be handled by wheelchairs or 3-wheelers. The minimum superelevation rate of 2% will be adequate for most conditions and will simplify construction. If a path is only to be used by bicyclists, a maximum superelevation rate of 6% may be used. At lower speeds this superelevation acts as a cross slope. This is the maximum cross slope for bicycle facilities as small children on bicycles may have trouble negotiating steeper cross slopes.

The coefficient of friction depends upon speed; surface type, roughness and condition of asphalt; tire type and condition; and whether the surface is wet or dry. 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. Extrapolating from values used in highway design, design friction factors for paved shared use paths can be assumed to vary from 0.30 at 15 mph (25 km/h) to 0.22 at 30 mph (48 km/h).

Although there is no data available for unpaved surfaces, it is suggested that friction factors be reduced by 50% to allow a sufficient margin of safety. Based upon a superelevation rate (e) of 2%, minimum radii of curvature can be selected from

Table 1. Radii based upon other superelevation rates to 6% are given in Appendix G.

When substandard radius curves must be used on shared use paths because of right-of-way, topographical or other considerations, standard curve warning signs and supplemental pavement markings should be installed in accordance with the MUTCD. The negative effects of substandard curves can also be partially offset by widening the pavement through the curves.

5.10 Grades

Grades on shared use paths should be kept to a minimum, especially on long inclines. Grades greater than 5% are undesirable, because ascents are difficult for many bicyclists to climb and descents cause some bicyclists to exceed the speeds at which they are competent. Where terrain dictates, grades greater than 5% and less than 500 feet (150 m) long are acceptable, when a higher design speed is used and additional width is provided. Grades steeper than 3% may not be practical for shared use paths with crushed stone surfaces.

Grades can be increased to 6% for bridges where wide paved shoulders [10 feet (3.0 m)] or paths are provided and a leveling off at the base permits adequate recovery before an intersection or other conflict point. ADA/ADAAG rules apply (a level area is needed for 10 feet each 30 feet).

Descending this grade (11%) for 900 feet, *an average bicyclist would not discover this turn in time to slow to a safe cornering speed.*

TABLE 1. Minimum Radii for Paved Bicycle Paths

Design Speed V- km/hr	Friction Factor f	Superelevation - e %	Minimum Radius R-m
20	0.31	2	10
25	0.30	2	16
30	0.28	2	24
35	0.26	2	34
40	0.25	2	48
45	0.23	2	65
50	0.21	2	87
55	0.19	2	115
60	0.17	2	150

The AASHTO *Guidelines for the Development of Bicycle Facilities* acknowledges that on recreational routes, designers may need to exceed a 5% grade recommended for bicycles in some short sections. As a general guide, AASHTO states the following grade restrictions should be followed:

The following grade lengths are suggested:

5-6%	for up to 240 m (800 ft.)
7%	for up to 120 m (400 ft.)
8%	for up to 90 m (300 ft.)
9%	for up to 60 m (200 ft.)
10 %	for up to 30 m (100 ft.)
11%	for up to 15 m (50 ft.)

AASHTO also provides for options to mitigate excessive grades:

- When using an longer grade add and additional 4 - 6 foot (1.2 - 1.8 m)or width to permit slower speed bicyclists to dismount and walk may be considered.
- Provide signing alerting bicyclists of the maximum percent of grade (reference MUTCD).
- Provide recommended descent speed.
- Provide adequate stopping sight distances.
- Provide adequate horizontal clearances, recovery areas and/or protective bike rail.
- When possible, use a wider path, 4 - 6 foot (1.2 - 1.8 m) additional recommended, and a series of short switchbacks to contain the speed of descending bicyclists.

***Stopping sight distance**. Adequate sight distance needs to be provided for a cyclists to see an object lying on the trail surface and come to a complete stop before hitting the object.*

5.11 Sight Distance

To provide bicyclists with an opportunity to see and react to the unexpected, a shared use path should be designed with adequate stopping sight distances. The distance required to bring a bicycle to a full controlled stop is a function of the bicyclist's perception and brake reaction time, the initial speed of the bicycle, the coefficient of friction between the tires and the pavement, and the braking ability of the bicyclist.

Figure 1 indicates the minimum stopping sight distance for various design speeds and grades based on a total perception and brake reaction time of 2.5 seconds and a coefficient of friction of 0.25 to account for the poor wet weather braking characteristics of many bicycles. For two-way shared use paths, the sight distance in descending direction, that is, where "G" is negative, will control the design.

Table 2 is used to select the minimum length of vertical curve necessary to provide minimum stopping sight distance at various speeds on crest vertical curves. The eye height of the

bicyclist is assumed to be 4.5 ft (1.4 m) and the object height is assumed to be zero to recognize that impediments to bicycle travel exist at pavement level.

Table 3 indicates the minimum clearance that should be used to line-of-sight obstructions for horizontal curves.

Bicyclists frequently ride two abreast on shared use paths; and, on narrow shared use paths, bicyclists have a tendency to ride near the middle of the path. For these reasons, and because of the serious consequences of a head-on bicycle crash, lateral clearances on horizontal curves should be calculated based on the sum of the stopping sight distances for bicyclists traveling in opposite directions around the curve.

Where this is not possible or feasible, consideration should be given to widening the path through the curve, installing a yellow center stripe, installing a "CURVE AHEAD" warning sign in accordance with the MUTCD, or proper combination of these alternatives.

***Waiting**. Significant trail crossings should be designed with pleasant waiting areas with benches, water and other features back from the trail. Children sometimes arrive before their parents. An out of the way place to rest and wait benefits users of both the trail and the roadway.*

5.12 Path/Roadway Intersections

Path intersections with roadways are important considerations in shared use path design. The Department has developed a *Trail Intersection Design Handbook* document which is undergoing its final edit concurrently with this handbook. These guidelines will provide a more comprehensive treatment of path intersection design than this handbook. Future revisions of this handbook will incorporate more of the guidelines material. In the meantime, the following principles apply. If alternate locations for a shared use path are available, the one with the most favorable intersection conditions should be selected.

5.12.1 Crossing Limited Access Roadways and Other High-Speed, High-Volume Roadways

For crossing freeways and other high-speed, high-volume arterials, a grade separation structure may be the only possible or practical treatment. Unless bicycles are prohibited from the intersecting highway, providing for turning movements must be considered. In many cases, however, the cost of a grade separation will be prohibitive.

***Limited Access Crossing.** The Orlando, Florida area West Orange Trail takes advantage of an existing railroad crossing, adding the cage and other refinements. It provides a critical separated grade crossing of the Florida Turnpike (below).*

5.12.2 Assigning Right-of-Way

When intersections occur at grade, a major consideration is the establishment of right of way. According to the *Traffic Control Devices Handbook*, the following conditions should normally be assigned right of way:

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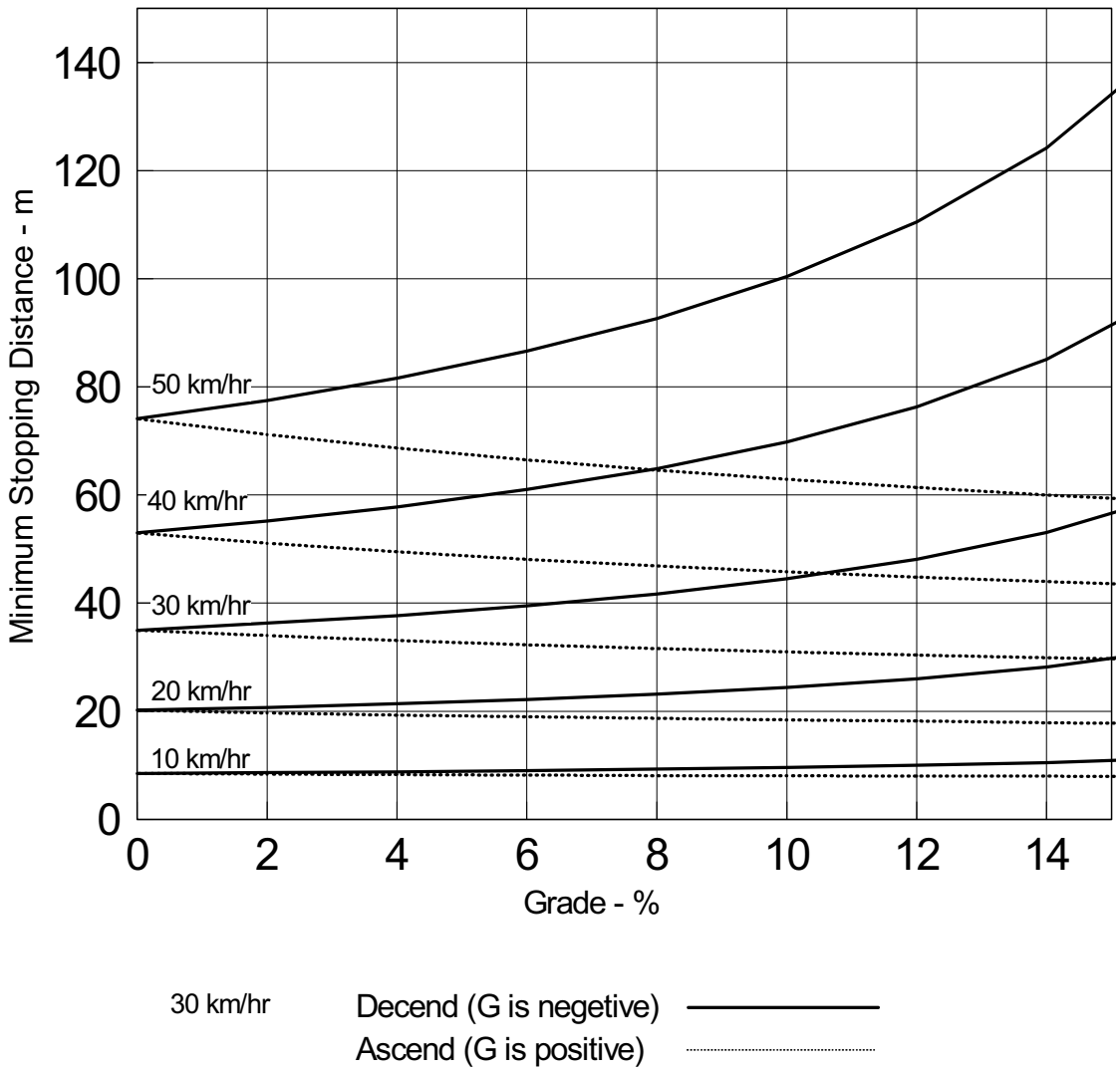
MINIMUM STOPPING SIGHT DISTANCES



$$S = \frac{V^2}{254(f+G)} + 0.695V$$

Where: S = Minimum Sight Distance, m
V = Velocity, km/hr
f = Coefficient of Friction (use 0.25)
G = Grade m/m (rise/run, may be positive or negetive)

Table 2

GIVEN "A" AND "S"; FIND "L"

A %	Stopping sight distance, "S", in meters 10	15	20	25	30	35	40	45	50
5					4.0	14.0	24.0	34.0	44.0
6				3.3	13.3	23.3	33.3	43.3	53.6
7			0.0	10.0	20.0	30.0	40.0	50.6	62.5
8			5.0	15.0	25.0	35.0	45.7	57.9	71.4
9			8.9	18.9	28.9	39.4	51.4	65.1	80.4
10		2.0	12.0	22.0	32.1	43.8	57.1	72.3	89.3
11		4.5	14.5	24.5	35.4	48.1	62.9	79.6	98.2
12		6.7	16.7	26.8	38.6	52.5	68.6	86.8	107.1
13		8.5	18.5	29.0	41.8	56.9	74.3	94.0	116.1
14	0.0	10.0	20.0	31.3	45.0	61.3	80.0	101.3	125.0
15	1.3	11.3	21.4	33.5	48.2	65.6	85.7	108.5	133.9
16	2.5	12.5	22.9	35.7	51.4	70.0	91.4	115.7	142.9
17	3.5	13.5	24.3	37.9	54.6	74.4	97.1	122.9	151.8
18	4.4	14.4	25.7	40.2	57.9	78.8	102.9	130.2	160.7
19	5.3	15.3	27.1	42.4	61.1	83.1	108.6	137.4	169.6
20	6.0	16.1	28.6	44.6	64.3	87.5	114.3	144.6	178.6
21	6.7	16.9	30.0	46.9	67.5	91.9	120.0	151.9	187.5
22	7.3	17.7	31.4	49.1	70.7	96.3	125.7	159.1	196.4
23	7.8	18.5	32.9	51.3	73.9	100.6	131.4	166.3	205.4
24	8.3	19.3	34.3	53.6	77.1	105.0	137.1	173.6	214.3
25	8.8	20.1	35.7	55.8	80.4	109.4	142.9	180.8	223.2
26	9.2	20.9	37.1	58.0	83.6	113.8	148.6	188.0	232.1
27	9.6	21.7	38.6	60.3	86.8	118.1	154.3	195.3	241.1
28	10.0	22.5	40.0	62.5	90.0	122.5	160.0	202.5	250.0
29	10.4	23.3	41.4	64.7	93.2	126.9	165.7	209.7	258.9
30	10.7	24.1	42.9	67.0	96.4	131.3	171.4	217.0	267.9

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

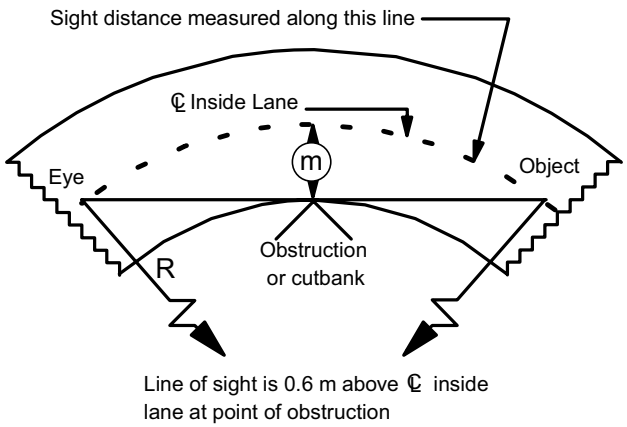
$L = \frac{AS^2}{280}$ When $S < L$

Double line represents S = L
L = min. length of vertical curve in meters
A = Algebraic diverence ingrades in %
S = Stopping sigh distance in meters
V = Design speed in km/hr

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

Table 3

Table 3 - Minimum Clearance for Horizontal
Given "R" and "S" : Find "m"



S = Sight distance in meters
R = Radus of ℄ inside lane in meters
m = Distance from ℄ inside lane in meters
S = Stopping sight distance in meters
V = Design speed for S in meters

$$m = R\left[1 - \cos\left(\frac{28.65\,S}{R}\right)\right]$$

$$S = \frac{R}{28.65}\left[\cos\left(\frac{R-m}{R}\right)\right]$$

Angle is in degrees
Formula applies only when S is equal to or less than the length of the curve.

Sight Distance

Radius of Centerline	10ft	20ft	30ft	40ft	50ft	60ft	70ft	80ft	90ft	100ft	110ft
25ft	0.50	1.97	4.37	7.58	11.49	15.94	20.75	25.73	30.68	35.41	39.72
50ft	0.25	1.00	2.23	3.95	6.12	8.73	11.76	15.17	18.92	22.99	27.32
75ft	0.17	0.67	1.50	2.65	4.13	5.92	8.02	10.42	13.10	16.06	19.28
100ft	0.12	0.50	1.12	1.99	3.11	4.47	6.06	7.90	9.96	12.24	14.75
125ft	0.10	0.40	0.90	1.60	2.49	3.58	4.87	6.35	8.01	9.87	11.91
150ft	0.08	0.33	0.75	1.33	2.08	2.99	4.07	5.30	6.70	8.26	9.97
175ft	0.07	0.29	0.64	1.14	1.78	2.57	3.49	4.55	5.75	7.10	8.57
200ft	0.06	0.25	0.56	1.00	1.56	2.25	3.06	3.99	5.04	6.22	7.52
225ft	0.06	0.22	0.50	0.89	1.39	2.00	2.72	3.55	4.49	5.53	6.69
250ft	0.05	0.20	0.45	0.80	1.25	1.80	2.45	3.19	4.04	4.98	6.03
275ft	0.05	0.18	0.41	0.73	1.14	1.63	2.22	2.90	3.67	4.53	5.48
300ft	0.04	0.17	0.37	0.67	1.04	1.50	2.04	2.66	3.37	4.16	5.03

Priority Backwards. *Two minor dirt roads serving about 30 houses cross here. The homes generate no more than 100 auto trips a day.. Meanwhile, there are over 2000 trail users. The designer assigned the through movement to the minor traffic. Bicyclists quickly learn that the signs are "crying wolf". This leads to disregard for this and other stop signs by trail users. It also creates confusion among motorists, most of whom stop for trail users.*

Crossing angles. *Above: Trail/roadway intersections should be designed at 90 degree angles. This minimizes crossing distance and exposure time for the trail users.*
Advance Warning Signs. *Advance warning signs should be installed in advance of the crossing location.*

- heavier volume of traffic;
- higher speed traffic; and
- superior classification of highway.

Because some paths have daily traffic exceeding 1000 users, the roadway could be required to yield right of way to the path. Bicycles are considered vehicles and should be counted as such when determining traffic control. (Pedestrians are not considered vehicles.)

A common mistake at an intersection is to assign the through priority to the wrong traffic. Some designers assume that because the bicyclist has more to lose if hit by an auto, the bicyclist should stop at virtually all intersections, including driveways and even sidewalks. This assumption is incorrect. It can lead to unsafe practices, confusion, and increase the potential for a bad crash.

Another common operations error is to stop traffic in both directions "just to be safe" when there is a clear majority of movement on one alignment. This also leads to confusion. Four-way stops should be avoided. They are even more tricky with paths than they are with roadways. There is a general tendency for motorists at 4-way stops to over-yield to bicyclists, again creating unsafe expectations and practices. At times a motorist motions one bicyclist on in one direction, starts up, only to be confronted by a bicyclist coming the other direction.

The type of traffic control to be used (signal, stop sign, yield sign, etc.), and location, should be provided in accordance with the MUTCD. Traffic volumes for paths being developed will have to be estimated. An evaluation after the path is in use should be done to confirm the proper treatment is being used.

5.12.3 Traffic Control at Intersections

Sign type, size and location should also be in accordance with the MUTCD. Care should be taken to ensure the shared use path signs are located so motorists are not confused by them and that roadway signs are placed so bicyclists are not confused by them.

Bicyclists need to be warned in advance of intersections. Stopping sight distances at intersections should be checked and adequate warning should be given to permit bicyclists to stop before reaching the intersection, especially on downgrades. Yellow centerline striping and advance pavement markings (the word STOP or YIELD) may be appropriate. STOP and YIELD messages should be in standard lettering so they are distinguishable from other markings which may

be on the path.

Changes in surfaces can alert the bicyclist to upcoming intersections. Brick or stone inserts across the path are one method. Changing the asphalt mix to a coarser grade would give a rougher surface suggesting a slower speed be used. A speed bump or a change to a loose surface is not recommended. A pullout near the intersection with benches, water fountains or navigational information, can act as a resting and gathering point for riders.

Advance warning signs of all crossings should be on the roadway in advance of the intersection as prescribed in the *MUTCD.* Signs should be erected about 750 feet (230 m) in advance of the crossing location in rural areas or areas where speeds are greater than 35 mph (60 km/h) and 250 feet (75 m) in urban residential or business districts where speeds are low.

Often shared use paths intersect busy roads and thus need signals. Instead of traffic lights, a flashing bicycle crossing signal can be used. This signal can be a pedestrian crossing signal that has been modified for cyclist use. The signal actuation mechanism should be mounted on the right side of the path approximately 4 feet (1.2 m) above the ground. This allows the cyclist to activate the signal without dismounting. Another method of activating the signal would be a detector loop in the path. At some crossing locations, where optimum progression is not a factor, the designer may consider giving the shared use path user a "hot response" or immediate call, to encourage bicyclists with the shortest possible wait. This feature increases the number of path users that wait for the signal.

5.12.4 Designing Crossings

There are times when it is preferable that the at-grade crossing of a shared use path and a highway be at a location away from the influence of intersections with other highways. Controlling vehicle movements at such intersections is more easily and safely accomplished through the application of standard traffic control devices and normal Rules of the Road. Right of way should be assigned and sight distance should be provided so as to minimize the potential for conflict resulting from unconventional turning movements.

Junctions should cross at right angles wherever possible. If the pathway parallels a roadway, or intersects the roadway at an acute angle, jughandle final approaches to the crossing point should be considered.

Dutch trail crossing *(above) employs double set of medians, one for bicyclists, the other for motorists. The medians and tight geometrics force low speed approaches by both groups, creating near ideal crossings of lower volume roadways.*

Bollards *(below) used to keep motorized vehicles off the trail are dangerous to children and other living things. They can be hit easily and they focus attention away from the real danger (traffic). So don't put them in. Most motorists don't want to drive on the path, and there are better ways to deal with those who do, such as the tight curbing shown above. (Note fresh nick on bollard and child being assisted)*

1

2

3

Median refuges. *Above: (1 &2) Wide median aids bicyclists in Orlando; and, (3) the Ringling Art Museum rotates new art into the median twice a year.*

Intersections must be designed with proper sight distances. The traffic control devices used (stop or yield signs) will in part depend upon the available sight distances. Shared use path intersections and approaches should be on relatively flat grades so required sight distances will be minimized.

Intersection design should limit turning speeds so motorists do not exceed 10 mph (15 km/h) for right turns and 20 mph (30 km/h) for left turns. At crossings of high volume multi-lane arterial highways where signals are not warranted, consideration should be given to providing a median refuge area for bicyclists and pedestrians.

Bicyclists, elderly adults, and mobility disabled, all need median cuts as well as cuts through channelized islands.

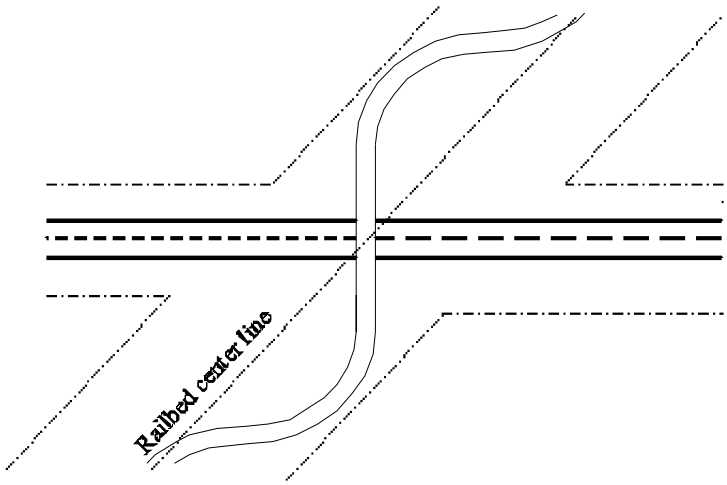
5.12.5 Median Refuge

A refuge is a place in the middle of a road where bicyclists and pedestrians can wait safely before crossing the next lane of traffic. A refuge allows a path user to cross one direction of traffic at a time without waiting until both directions are clear. A refuge separates conflicts and simplifies the crossing procedure. The refuge can be simply a cut in the existing median or a structure can be built specifically as a refuge. Although they can be used on 2-lane roadways, they are especially helpful on multi-lane roadways.

The minimum median width to meet the needs of bicyclists should be at least 10 feet (3 m). If large numbers of bicyclists can be anticipated, a storage space of 12 - 14 feet (3.6-4.2) meters is preferred.

The median cut should be as wide as the path. The cut may be angled 45 degrees toward the approach traffic. This forces bicyclists to stop for the second search, and orients them to look directly into the source of danger.

Jughandle crossings*. Left: Junctions should cross at right angles wherever possible. The jughandle should occur as far as possible from the roadway so the trail and roadway are separated when parallel.*



Lighting should be used for median crossings. W11-1 advanced warning and warning signs should be used for the motorist approach, and approach speeds should be regulated and further constricted by design, when practicable.

5.13 Signing and Marking Path Sections

Adequate signing and marking are essential on shared use paths. They alert bicyclists to potential conflicts and convey regulatory messages to both bicyclists and motorists at highway intersections. In addition, guide signs, such as those indicating directions, destinations, distances, route numbers and names of crossing streets should be used in the same manner as they are used on highways. In general, uniform application of traffic control devices, as described in the MUTCD, will tend to encourage proper bicyclist behavior.

Where conditions make it desirable to separate two directions of travel, a solid yellow line should be used to indicate no passing or no traveling to the left of the line. This is particularly beneficial in the following circumstances:

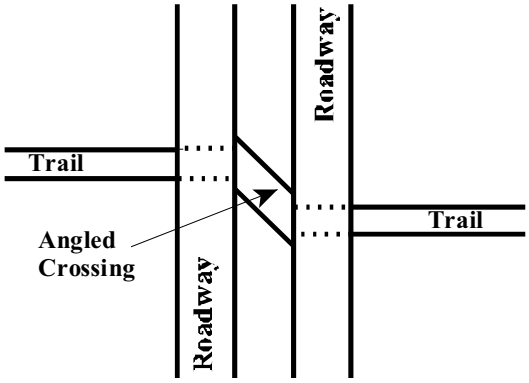
- For heavy volumes of bicycles
- On the approach to intersections
- On vertical and horizontal curves with restricted sight distance
- On unlighted paths where night time riding is expected.

Edge lines can also be very beneficial where nighttime bicycle traffic is expected. The desire to omit lines for aesthetic reasons is common, but is sometimes contrary to operations and safety needs.

General guidance on signing and marking is provided in the MUTCD. Care should be exercised in the choice of pavement marking materials. Some marking materials are slippery when wet and should be avoided in favor of more skid resistant materials. Adding glass beads to thermoplastic increases skid resistance.

5.14 Path Termination

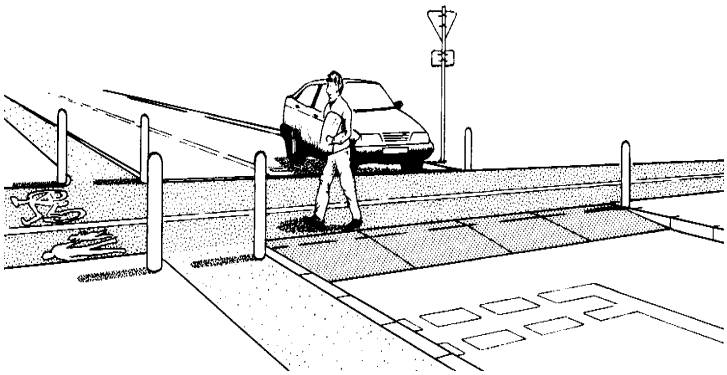
When shared use paths terminate at existing roads, it is important to integrate the path into the existing system of roadways. Care should be taken to properly design the terminals to transition the traffic into safe merging or diverging situations. Appropriate signing is necessary to warn and direct both bicyclists and motorists regarding these transition areas. Care must be taken so wrong way riding is discouraged. The Department has developed a *Designing Trail Termini* handbook.



Above: An example of an angled median cut through.

Middle: Pedestrians on the Santa Monica Bike Path behave as expected, walking on the pavement instead of the sand. Bottom: Arrows provide directional through a roundabout.

Speed table crossing. *Right: This British design solves many operational (stop sign) problems. In many cases the bicyclist and pedestrian deserve and require precedence over motor traffic. Assigning the through movement to the motorist regardless of the respective volumes, not only sets the wrong tone, it creates unsafe movements of autos, pedestrians and bikes. Note that the use of this speed table forces a low speed motorist crossing. This design is appropriate when motorized crossings are under 1000 ADT, and when speeds are at or below 30 mph (45 km/h) on approach. (Although shown in this graphic, the use of bollards is discouraged.)*



5.15 Median Ramps/Cuts and Raised Crossings

Ramps for curb cuts at intersections should be the same width as the shared use paths. Curb cuts and ramps should provide a smooth transition between the shared use paths and the roadway.

An alternative treatment is to install a speed table at the crossing. At locations where the path is given priority over the intersecting roadway, the crossing may be raised to the level of the path.

5.16 Staircases

Staircases. *Below: This Japanese staircase has a ramp alongside providing a helpful solution to top deck parking. A similar treatment is used for an underpass crossing Tennessee Street at Florida State University in Tallahassee.*

Although ADA requires ramps, stair cases may be used in addition to ramps or be present on existing routes. Staircases can pose a problem for cyclists if the bicycle has to be carried up or down the staircases. A simple solution is to build concave or trough type ramps on either side of the staircase. These ramps allow bicyclists to roll their bicycles up or down the staircase without having to carry them. Each ramp should be at least 6 inches (150 mm) wide. Preferably there should be two ramps; one for ascending and the other for descending. A concave ramp is preferred as it will help keep the bicycle wheels centered on the ramp.

5.17 Pavements

Designing and selecting pavement sections for shared use paths is in many ways similar to designing and selecting highway pavement sections. A soils investigation should be conducted to determine the load-carrying capabilities of the native soil and the need for any special provisions. The investigation need not be elaborate, but should be done by or under the supervision of a qualified engineer.

5.17.1 Materials

Hard, all-weather pavement surfaces are usually preferred over those of crushed aggregate, sand, clay or stabilized earth,

since these materials provide a much lower level of service. In some low-use areas, limestone screens, or other porous materials have proven economical.

Good quality pavement structures can be constructed of asphaltic or portland cement concrete. Because of wide variations in soils, loads, materials and construction practices, it is not practical to present specific or recommended typical structural sections that will be applicable statewide. Decisions should be based on the principles outlined above and attention to local governing conditions. Experience in highway pavement, together with sound engineering judgment, can assist in the selection and design of a proper shared use path pavement structure. Experience also may identify energy conserving practices, such as the use of sulfur extended asphalt, asphalt emulsions and fused waste materials.

Top: pavement 20 years later, Middle: new concrete will last over 50 years with low maintenance, Below: hardened soil promotes lower speed movement.

5.17.2 Pavement Loads

Several basic principles should be followed to recognize some basic differences between the operating characteristics of bicycles and those of motor vehicles. While loads on shared use paths will be substantially less than highway loads, paths must be designed to sustain without damage wheel loads of occasional emergency, patrol, maintenance, and other motor vehicles.

Special consideration should be given to the location of motor vehicle wheel loads on the path. When motor vehicles are driven on shared use paths, their wheels will usually be at or very near the edges of the path. Since this can cause edge damage that, in turn, will result in the lowering of the effective operating width of the path, adequate edge support should be provided. Edge support can be either in the form of stabilized shoulders or additional pavement width. Constructing a typical pavement width of 12 feet (3.6 m), where right-of-way and other conditions permit, eliminates the edge raveling problem and offers two other additional advantages over shoulder construction. First, it allows additional maneuvering space for bicyclists. Second, the additional construction can cost less than constructing shoulders because the separate construction operation is eliminated.

5.17.3 Surface Preparation

It is important to construct and maintain a smooth riding surface on shared use paths. Shared use path pavements should be machine-laid. Soil sterilants should be used where necessary to prevent vegetation from erupting through the pavement. On portland cement concrete pavements, transverse joints should be saw cut to provide a smooth ride. Normally these joints should be spaced at twice the pavement width, i.e. 10 feet (3.0 m) wide equals 20 feet (6.0 m) space. On the other hand, skid resistance qualities should not be

Bridges combine function and form. *Above: This Dutch bicycle/pedestrian bridge is a structural and architectural work of art. Light, color, shape and separation of movement work in harmony. Below: Spokane, Washington converted a railroad bridge to a landmark. For a few dollars residents for in the next century can take delight in the skyline. Note function of decking.*

sacrificed for the sake of smoothness. Broom finish or burlap drag concrete surfaces are preferred over trowel finishes, for example.

5.17.4 Driveways and Crossings

At unpaved highway or driveway crossings of shared use paths, the highway or driveway should be paved a minimum of 10 feet (3.0 m) on each side of the crossing to reduce the amount of gravel being scattered along the path by motor vehicles. The pavement structure at the crossing should be adequate to sustain the expected loading at that location. In areas where climates are extreme, the effects of freeze-thaw cycles should be anticipated in the design phase.

5.18 Structures

An overpass, underpass, small bridge, drainage facility or facility on a highway bridge may be necessary to provide continuity to a shared use path.

5.18.1 Width

On new structures, the minimum clear width should be the same as the approach width of the paved shared use path. The desirable clear width should include a minimum 2 foot (0.6 m) wide clear area. Carrying the clear areas across the structures has two advantages. First, it provides a minimum horizontal shy distance from the railing or barrier. Second, it provides needed maneuvering space to avoid conflicts with pedestrians and other bicyclists who are stopped on the bridge. Access by emergency, patrol, and maintenance vehicles should be considered in establishing the design clearances of structures on shared use paths. Similarly, vertical clearance may be dictated by occasional motor vehicles using the path. Where practical, a vertical clearance of 3 m (10 feet) is desirable for adequate vertical shy distance.

Bridge designs to support maintenance and emergency vehicles can be prohibitively expensive. Barriers to prevent

motor vehicle crossings, and alternate access should be provided to keep bridge costs affordable.

5.18.2 Railings, Fencing, Barriers

AASHTO recommends railings, fences or barriers on both sides of a shared use path structure be a minimum of 3.5 feet (1.1 m) high. Also, smooth rub rails should be attached to the barriers at handlebar height of 3.5 feet..

5.18.3 Bridges

Bridges designed exclusively for bicycle and pedestrian traffic may be designed for pedestrian live loadings. On all bridge decks, special care should be taken to ensure that bicycle safe expansion joints are used.

Where it is necessary to retrofit a shared use path onto an existing highway bridge, several alternatives should be considered in light of what the geometrics of the bridge will allow.

One option is to carry the shared use path across the bridge on one side. This should be done where:

- The bridge facility will connect to a shared use path at both ends,
- Sufficient width exists on that side of the bridge or can be obtained by widening or restriping lanes, and
- Provisions are made to physically separate bicycle and pedestrian traffic from motor vehicle traffic as discussed above.

A second option is to provide either wide curb lanes or bicycle lanes over the bridge. This may be advisable where:

- The shared use path transitions into bicycle lanes at one end of the bridge, and
- Sufficient width exists or can be obtained by widening or restriping.

Because of the large number of variables involved in retrofitting existing bridges to include bicycle facilities, compromises in desirable design criteria are often inevitable. Therefore, the width to be provided is best determined on a case-by-case basis, after thoroughly considering all the variables.

5.18.4 Tunnels

Tunnels are often considered less successful than bridges for reasons of security, confinement, drainage and other factors. The problems associated with tunnels can often be

Ramps for overpasses. *Trail overpasses and tunnels must be designed to comply with the ADA standards. The maximum ramp slope is 1:12. Every 30 feet (10 m) there must be a level area 5 feet (1.5 m) long. For a bridge18 feet (5.5 m) over the roadway each ramp would be over 240 feet (75 m) long.*

Dark and Scary Places? *They don't need to be. The rail yard underpass tunnel in Missoula, Montana (above) can be a frightening place. In contrast, the Mercer Island, Washington (below) tunnel is enjoyed by hundreds of bicyclists a day. The tunnel was built wide enough to get a police cruiser into. The tunnel is monitored by the same staff that monitors the auto tunnel below. Police can be inside the tunnels within minutes. Good lighting, art on the entrance approaches, and the video security have eliminated all graffiti. When this photograph was taken, there had never been an attempted crime in the six years since the tunnel was first opened.*

mitigated in large part by splitting the elevation change with the roadway to be crossed, submerging the tunnel half way and raising the roadway the other half. If a multi-lane highway is being crossed, a skylight can be used to flood the tunnel with light at midsection.

5.19 Drainage

The recommended cross slope of 2% adequately provides for drainage. Sloping in one direction instead of crowning is preferred and usually simplifies the drainage and surface construction. A smooth surface is essential to prevent water ponding and ice formation.

Where a shared use path is constructed on the side of a hill, a ditch of suitable dimensions should be placed on the uphill side to intercept the hillside drainage. Such ditches should be designed so that no undue obstacle is presented to bicyclists. Where necessary, catch basins with drains should be provided to carry the intercepted water. Drainage grates and manhole covers should be located outside the travel path of bicyclists. To assist in draining the area adjacent to the shared use path, the design should include considerations for preserving the natural ground cover. Seeding, mulching, sodding of adjacent slopes, swales and other erodible areas should be included in the design plans.

5.20 Lighting

Fixed-source lighting reduces crashes along shared use paths and at intersections. In addition, lighting allows the bicyclist to see the path direction, surface conditions and obstacles. Lighting for shared use paths is important and should be considered where riding at night is expected. Paths receiving nighttime usage commonly serve college students or commuters. When lighting is used, the *Plans Preparation Manual* gives the following standards:

Illumination level (Average initial lux) = 25
Uniformity ratio:
avg./min. 4:1 or less

max./min/. 10:1 or less

AASHTO recommends 5 - 22 lux depending on the location.

Lighting is essential at highway/path intersections. Lighting should also be considered through underpasses or tunnels and when nighttime security could be a problem. Although not an FDOT standard, a lighting standard as high as 53 lux has been suggested for long underpasses.

Light poles should meet the recommended horizontal and

vertical clearances. Luminaries and poles should be at a scale appropriate for a shared use path. Lighting should be placed wherever there is signage and accessible electricity. This is particularly important for warning signs. All intersections should be lit far enough back from the intersection in order to allow the bicyclist and motorist enough time to see the intersection and act appropriately. The effect of incidental lighting on the path and on cyclists also needs to be considered. The most common example occurs when a path parallels a road. The lights of oncoming traffic will shine directly on bicyclists. This can cause momentary blindness that is dangerous on a curving path or in the face of oncoming bicycle traffic. In this case low level path lighting is recommended. The designer should keep in mind that in certain areas lighting is prone to high levels of vandalism.

Drainage details are essential. *Above: A woman became a paraplegic when her wheel dropped into the channel.*
Trail lighting. Below: European trail lighting and, Bottom: Inset trail lighting in a Vancouver, Washington development.

5.21 Restriction of Motor Vehicles

Shared use paths often need some form of signing, curbing, or other physical barrier at highway intersections to prevent unauthorized motor vehicles from using the facilities. When using medians, path medians, separators or islands, use permanently reflectorized materials for nighttime visibility and paint a bright color to improve daytime visibility. Advanced chevron markings and a center line should also be used to alert the bicyclist approaching the intersection. Curbing with tight radii leading up to the roadway can often prevent motorists from attempting to enter the path. Medians should be set back from the intersection 8 m (25 feet) to permit bicyclists to exit the roadway fully before navigating the reduced pathway width.

An alternative method of restricting entry of motor vehicles is to split the entry way into two 1.5 m (5 foot) sections separated by low landscaping. Operators of emergency vehicles know they can still enter if necessary by straddling the landscaping. The higher maintenance costs associated with landscaping should be acknowledged, however, before this alternative method is selected.

5.22 Path Heads and Rest Stops

Any long shared use path or path network needs rest stops. These should be at intermediate points, scenic lookouts, or near amenities such as restaurants, convenience stores, beaches, picnic areas, parking lots, etc. Any rest stop should be away from the path so bicyclists can pull off the path and not block traffic. A rest stop should have, as a minimum, a bench, shade, a parking rack, and a trash receptacle. In addition, water fountains and washroom facilities should be included at one or more rest stops on the pathway.

Below: London, Ontario provides rules for trail etiquette; including "go slow when there are crowds, keep to the right except when passing, warn others when passing".

Other amenities which should be considered include interpretive signage, informational kiosks, emergency call boxes (pay phones where cost-effective), emergency weather instructions, shelters, watering facilities for horses (where applicable), hitching posts, rest rooms, and intermodal connections (including airboats).

"Too many cities in America have become places to survive. We need more places to thrive."

Dan Burden

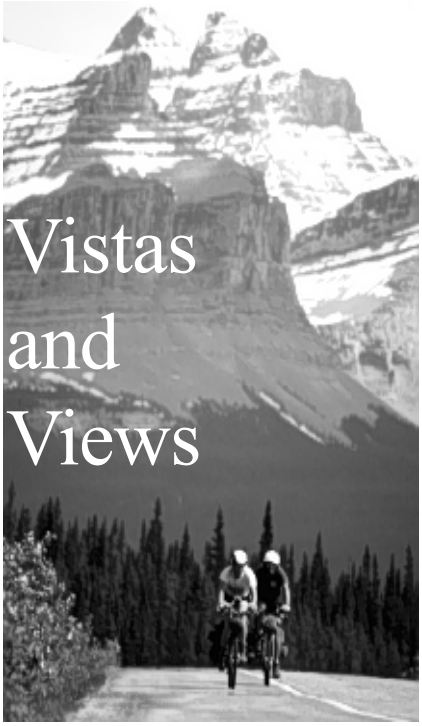
West Orange Trail's "Mother of all Trailheads"

***It's the "Mother of All Trailheads"**, claims Dan Burden. Orlando area designers deserve special praise for thinking through all details, from the shaded southern plantation style porch complete with rocking chairs, to the water bottle spigot on the backside of the drinking fountain, to the porous parking lot for autos, to the nicely worded temporary trail end. It's all there. An inspiration to all present and future trail designers.*

Plenty of Seating Please. *Place seats or benches wherever a person walking your trail may like to rest. Water, restrooms, shady picnic spaces, bike repair shops, telephones, and markers all make more sense after you've walked and ridden your trail a dozen or so times. Provide frequent places to rest (every 400 m). Rest areas are best placed in a combination of scenic spots and near intersections or other activity centers.*

Navigational aids, public art, trash cans and other things of importance.

OK....so it doesn't look like a technical handbook anymore. We need ways to protect and preserve, to celebrate, to navigate. Public spaces are supposed to be fun, inviting, clean and respectful of the land. There are many details the designer must pay special attention to, including separating the trash, and making room for public art.



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6

Without the view it's not a trail. It doesn't require mountains or an ocean to be grand -- the plains, waterways, canals and swamps work just fine. The designer must define protect and preserve places of grandeur. Places like (Upper left, clockwise) (1) Banff National Park, Alberta; (2) Monteray Peninsula, California; (3) Portland, Oregon's Freeway Park, or (4-5) Seattle's Lake Washington (6-7) This majestic view along Santa Barbara, California's coast was paid for and dedicated by adjacent property owners. Center: Central park's many hiking and bike trails offer numerous spots for picnicking and reflecting back on city life.

5

4

Section 6 Supplemental Facilities

6.1 - Parking

Provision for bicycle parking facilities is perhaps the most important link in a comprehensive bicycle facilities system. This is an essential element in an overall effort to promote bicycling. If parking is not available, the incentive to use bicycles as a means of transportation is seriously undermined.

6.1.1 Need For Parking

Where adequate parking is not provided or properly designed and located, bicyclists will lock their bicycles to the nearest available object, whether it is a tree, a post, a parking meter or a handicap handrail. This random parking is undesirable, as it can damage the object, produce bicycle clutter, interrupt the normal pedestrian flow and be potentially dangerous to pedestrians.

6.1.2 Planning Details

Several factors should be considered when planning and providing bicycle parking facilities:

- Care should be given in selecting bicycle parking locations to ensure that bicycles and motor vehicles will not damage each other.
- Facilities should be designed so people parking their bicycles will not disturb other parked bicycles.
- Facilities should be able to accommodate a wide range of bicycle shapes and sizes including tricycles and trailers if used locally.
- Facilities should be simple to operate. If possible, signs depicting how to operate the facility should be posted.

Bicycle parking facilities should be provided at both the trip origin and trip destination sites and should offer protection from theft, vandalism and other damage. The amount of security needed to prevent theft should be evaluated for each area. Often racks or lockers perform best when in clear view of the main entry where any tampering would be noticed. Racks placed as little as 15 m (50 feet) out of view may go completely unused. Signs should be used to indicate the location of bicycle parking.

Single racks can be simple. One of the best is the simple hitching post, which offers ample locations for locking the bike, or simply resting the bike when seating is nearby.

This Danish circular rack is one of the most space conscious and attractive. Parking should be kept in public view, under lighting when available, and near all rest stops, attractions and scenic views.

The wide variety of bicycle parking devices fall into two categories of user needs: commuter or long-term parking and convenience or short term parking. The minimum needs for each use differ, and will affect their placement and protection.

Long-term parking is needed at locations such as employment centers, transit or subway stations and multi-family dwellings. Facilities should be provided which secure the frame, both wheels, and accessories. These facilities should offer protection from weather. Bicycle lockers and attended storage areas are good examples of long-term parking facilities.

Short-term parking is needed at locations such as the main entrance of shopping centers and outside office buildings for visitors and couriers. It is also needed at libraries, recreation areas and post offices. Facilities should be very convenient and be near building entrances or other highly visible areas which are self-policing. The facilities should be designed so they will not damage bicycles. Bent rims are common with racks that only support one wheel.

6.2 Bicycle Racks on Buses

Provisions should be considered for interfacing bicycle travel with public transit. Several manufacturers make bike racks for buses. Buses can be converted to carry bicycles aboard. Also, programs allowing bicycles on rapid rail facilities will increase bicyclists' opportunities.

Providing bicycle facilities on transit vehicles increases the opportunity for transit to serve customers. The service range of transit is increased allowing transit to better serve low density areas. Potential transit users who find the walk to the transit stop or from the transit stop to their final destination to long would be able to ride a bike to the transit stop, saving time and providing additional mobility at his destination.

Bicyclist also benefit. By using transit a commute which is too long for a bike ride may now be combined with transit. Facilities on transit can provide additional confidence to a bicyclist by serving as a secondary method of getting to a destination in case of bad weather or mechanical breakdown.

6.3 Other supplemental facilities.

There are several other improvements that encourage bicycle use. Showers and clothing lockers make it more convenient for employees to ride bicycles to work. Printing and distributing bicycle route maps is highly beneficial to

bicyclists. Maps are a relatively low cost project. Maps can help bicyclists locate bikeways, parking facilities, and identify the relative suitability of different segments of the road system. Also, maps can help bicyclists avoid narrow, high speed, or high volume roads, one-way streets, barriers and other problems. In addition, maps can provide information on Rules of the Road, bicycle safety tips, and interfacing with mass transit.

6.4 Operation and Maintenance

The agency responsible for the control, maintenance and policing of bicycle facilities should be established prior to construction. The costs involved with the operation and maintenance should be considered and budgeted for when planning a facility. Neglected maintenance will render bicycle facilities unrideable and increase risk to those who do ride. Path users should be encouraged to report paths and roadways needing maintenance.

Bikeways and roadways with bicycle traffic are often susceptible to having debris, such as glass or sand, accumulate in the area where bicyclists ride. Therefore, regular sweeping is necessary. A smooth surface, free of potholes and debris, should be provided. The pavement edges should be uniform.

Signs and pavement markings should be inspected regularly and kept in good condition. Highways with bicycle traffic may require a more frequent and a higher level of maintenance than other highways.

For shared use paths, attention should be given to maintaining the full paved width and not allowing the edges to unravel. Trees, shrubs, and other vegetation should be controlled to provide adequate clearances and sight distances. Trash receptacles should be placed and maintained at convenient locations. Seeded and sodded areas in the vicinity of shared use paths should have a regular schedule of mowing.

In colder climates, winters may warrant snow removal. It should be in the form of plowing, since deicing agents and abrasives can damage bicycles.

The routine maintenance of roadways provides an excellent opportunity to improve the bicycle travel on those roads. Several bicycle facilities described in this handbook can be implemented during routine maintenance activities.

6.5 Laws and Other Principles

Bicycle programs must reflect applicable state laws and ordinances. Bicycle facilities must not encourage or require

Getting There. *Paths work better when you don't need lots of auto parking. Consider a long term investment in land, water, rail and air transportation. Today there are many paths that have limited ways to get there. Even when there are buses or trains, there may not be a way to transport bicycles.*

bicyclists, pedestrians, or motorists to operate in a manner inconsistent with the adopted rules of the road as described in Chapter 11 of the Uniform Vehicle Code (UVC).

The UVC and state and local laws and ordinances should be reviewed before decisions are made on the type of facilities desired.

The design of paths and bicycling facilities is a relatively young science. A successful path typically calls for a multidisciplinary team of engineers, planners, architects, environmentalists, path users, neighbors and other stakeholders.

Design should be an interactive and fun process. We hope and trust that this handbook has given you the basics and some new ideas to advance the state of the art.

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Appendix A - F.S. 335.065 Bicycle and pedestrian ways along state roads and transportation facilities.

335.065 Bicycle and pedestrian ways along state roads and transportation facilities.--

(1)(a) Bicycle and pedestrian ways shall be given full consideration in the planning and development of transportation facilities, including the incorporation of such ways into state, regional, and local transportation plans and programs. Bicycle and pedestrian ways shall be established in conjunction with the construction, reconstruction, or other change of any state transportation facility, and special emphasis shall be given to projects in or within 1 mile of an urban area.

(b) Notwithstanding the provisions of paragraph (a), bicycle and pedestrian ways are not required to be established:

1. Where their establishment would be contrary to public safety;

2. When the cost would be excessively disproportionate to the need or probable use;

3. Where other available means or factors indicate an absence of need.

(2) The department shall establish construction standards and a uniform system of signing for bicycle and pedestrian ways.

(3) The department, in cooperation with the Department of Environmental Protection, shall establish a statewide integrated system of bicycle and pedestrian ways in such a manner as to take full advantage of any such ways which are maintained by any governmental entity. For the purposes of this section, bicycle facilities may be established as part of or separate from the actual roadway and may utilize existing road rights-of-way or other rights-of-way or easements acquired for public use.

History.--ss. 1, 2, 4, 5, ch. 73-339; s. 5, ch. 84-284; s. 38, ch. 84-309; s. 26, ch. 85-180; s. 163, ch. 94-356.

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Appendix B - Trail Intersection Research

The University of North Carolina Highway Safety Reserarch Center (HSRC) studied 60 Florida trail intersections to learn essential principles to retrofit these intersections and to apply the same principles to future trail crossings.

B1 Key Findings

The following conclusions are reached and have applications statewide.

B2 Four Way Stops

Four-way stops are ineffective and can constitute a hazard. Motorists tend to stop, and bicyclists rarely do. This creates a false sense of security that can lead to a collision.

B3 High Speed Roadways

Assignment of right-of-way is critical. For higher speed crossings of 40 and greater right-of-way is always assigned to the motorist.

B4 Medium Speed Roadways

Right-of-way can be assigned to trail users when their volumes are highest and motorist speeds are at 30 mph. Use traffic calming to further slow the speed of motorists.

B5 Low Speed Roadways

Right-of-way can be assigned to trail users when their volumes are highest and motorist speeds are 20 mph or less without using traffic calming.

B6 Solutions to Common Intersection Crashes

The following are suggested techniques for preventing crashes at trail/roadway intersections:

- Provide adequate stopping sight distances for motorists and trail users.
- Reduce conflict speeds by controlling the approach speed for either or both the trail user and motorist.
- Turning conflicts are reduced by placing the trail crossing as close to the intersection as possible.
- Medians are helpful, even on 2-lane roads, to act as a traffic calming feature, and to separate conflicts in time and place.
- Trail crossings should be at 90 degrees. But, when needed, it is possible to skew the crossing to 75 degrees and still only add 4% to the crossing distance.
- Properly placed overpasses on trails will be well used, especially if at-grade crossings are complex, require excessive waits, or pose high speed conflicts.
- Signal cycles must be responsive to bicyclists, and should not require an excessive wait.

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Appendix C - Bicycle lane/paved shoulder and intersection pavement marking guidelines

BICYCLE LANE/ BICYCLE SHOULDER AND INTERSECTION PAVEMENT MARKINGS

FDOT, District 4, 3400 W. Commercial Blvd., Ft. Lauderdale, FL

July 22, 1997

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Prepared by:
Richard Young

Approved by:
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Detail of bike lane markings

DETAIL OF DESIGNATED BIKE LANE AND BIKE SHOULDER MARKINGS

Markings in or adjacent to bike lanes shall be preformed marking film or thermoplastic. Preformed materials and installation procedures shall conform to the requirements of the Standard Specifications for Road and Bridge Construction dated 1996 (Sections 713 and 971-18).

Thermoplastic markings shall have a mixture of 50 percent glass spheres and 50 percent sharp silica sand applied at a rate of 1 kg/sq.m (two lbs. for each ten square feet).

The sharp silica sand shall meet the following gradation requirements:

Sieve Size	Percent Passing
850 μm (#20)	100
300 μm (#50)	0-10

(1996 Florida Standard Spec. 711-6)

Raised pavement markings and raised barriers can cause steering difficulties and should not be used to delineate bicycle lanes.

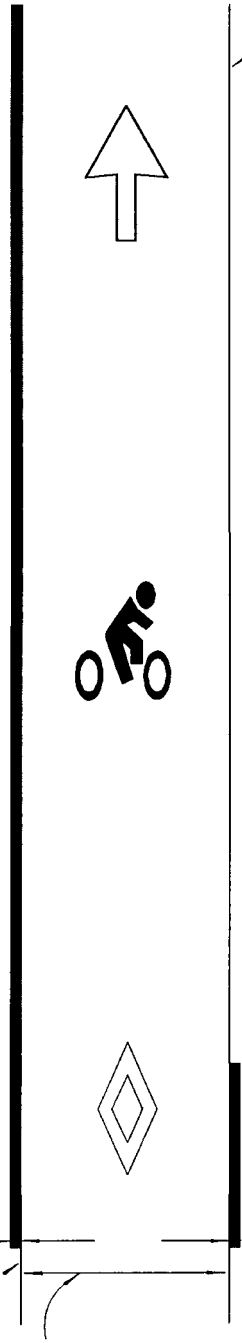
FC - 3 should be specified when bike lanes are adjacent to the curb & gutter to provide a smoother riding surface and transition at the lip of the gutter. A drop-off greater than 6mm (0.25") can pose a hazard to bicycles.

Recommended spacing of diamond symbol: immediately after signalized intersections and at a maximum spacing of 182 meters (600 feet) for urban sections and 400 meters (1320 feet) for rural sections.

Bike Lane signs, R-3-17, should be placed adjacent to the diamond symbol immediately after signalized intersections or at a spacing of approximately 800 meters (2640 feet).

R3-17
24" X 30"
700-40-1
600 X 750
2700-40-1

Signs shall not be placed adjacent to every pavement marking.



1.2 m(4 feet) For Bike Lanes in urban curb & gutter sections.

1.5 m(5 feet) For Bike Lanes adjacent to parking & separate Right Turn Lanes

1.5 m(5 feet) For Designated Shoulders in rural sections.

(NOT TO SCALE)

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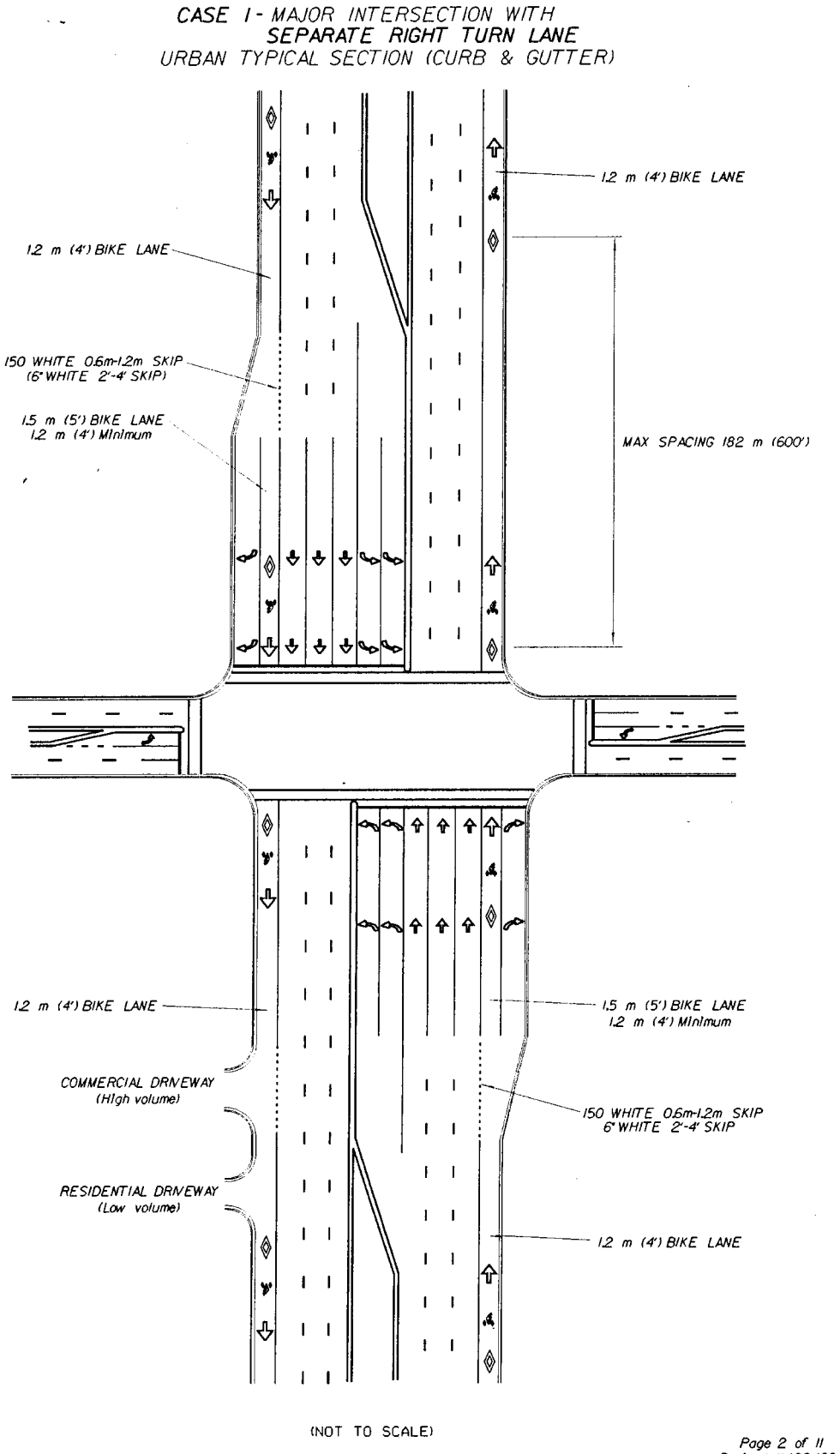
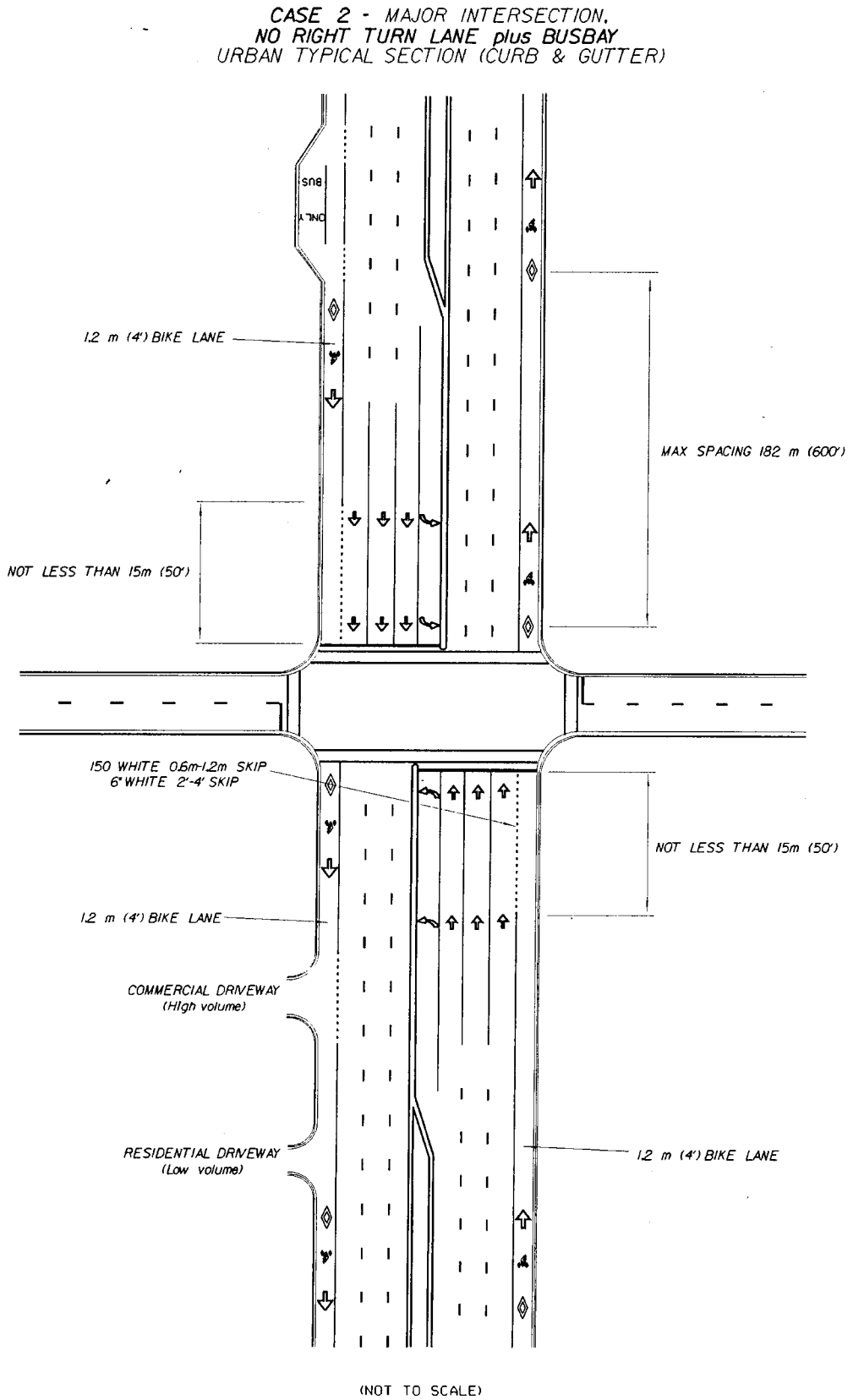
Major intersection with right turn lane (C&G)



Major intersection without right turn lane + busbay (C&G)



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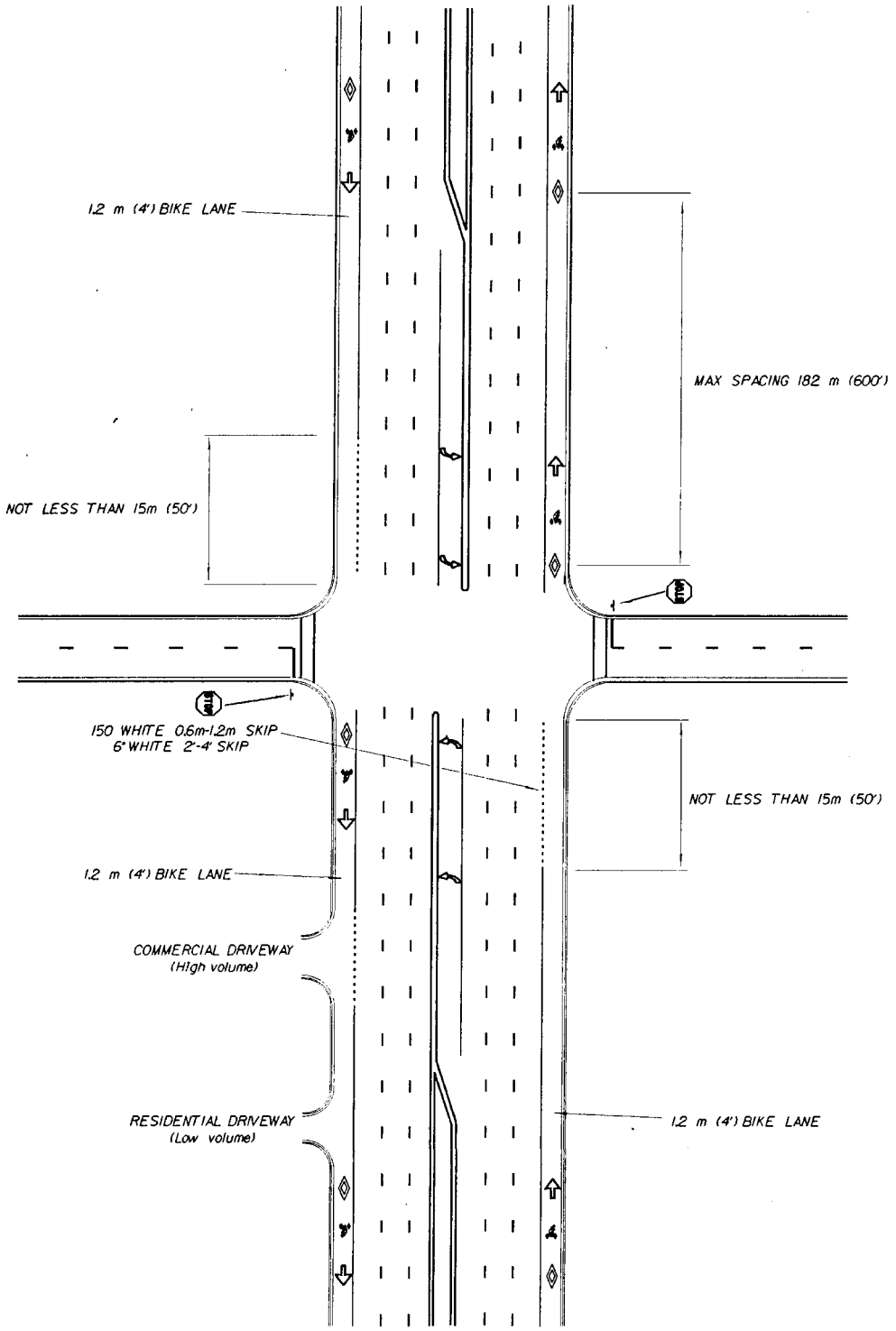
Stop controlled intersection without right turn lane (C&G)

CASE 2A - MAJOR WITH LOCAL STREET INTERSECTION, NO RIGHT TURN LANE
URBAN TYPICAL SECTION (CURB & GUTTER)



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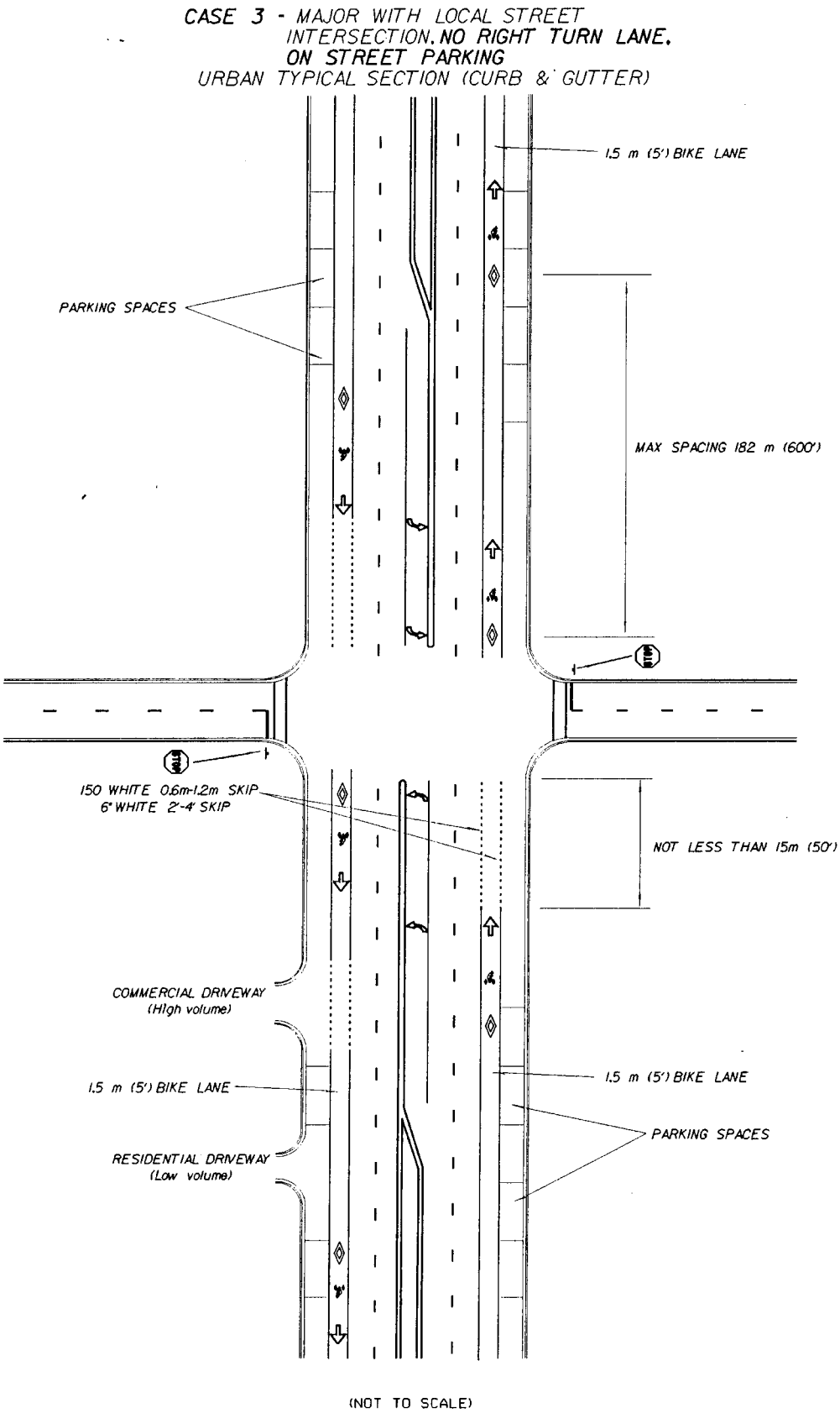
Stop controlled intersection with parking (C&G)



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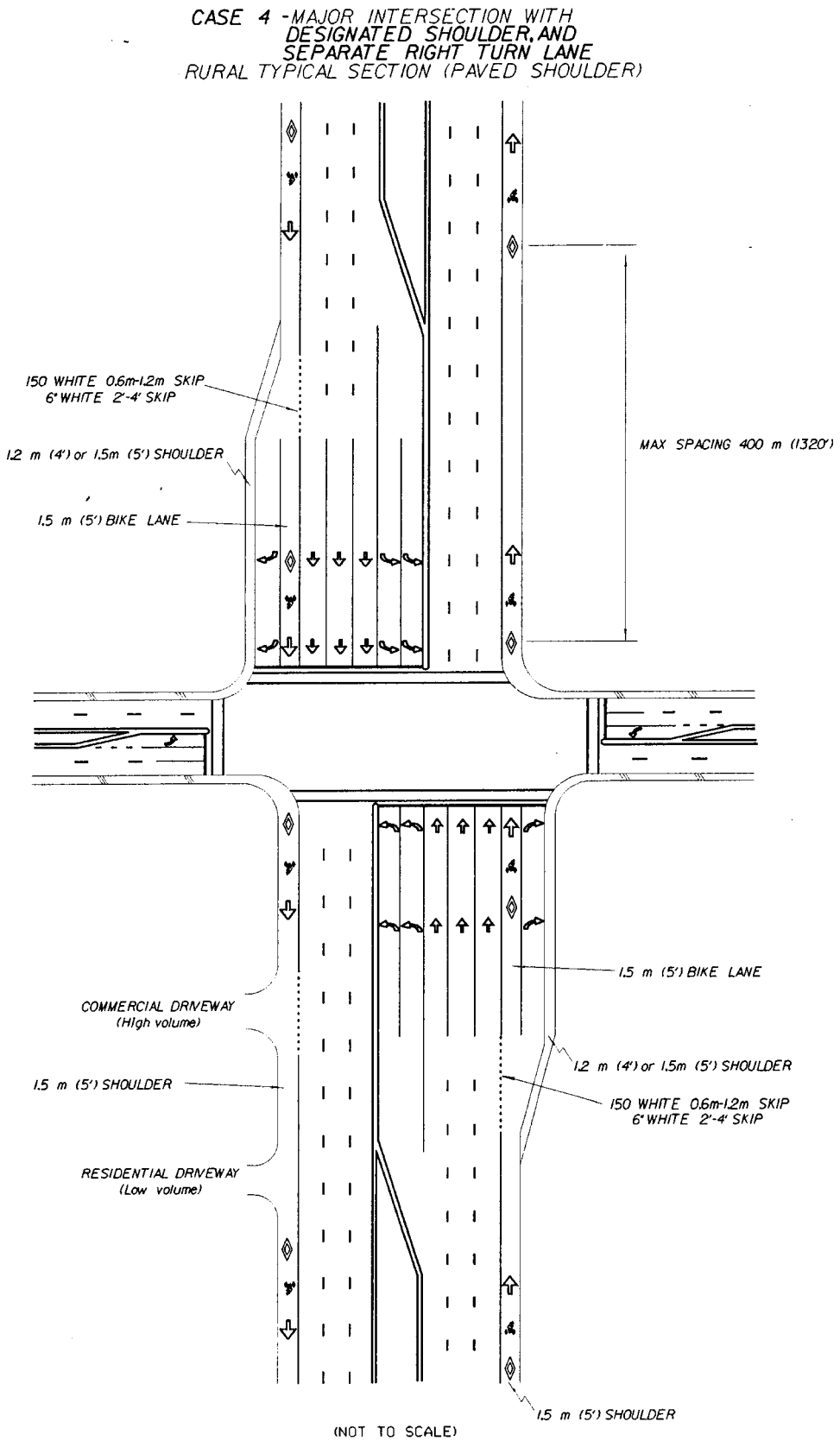
Major intersection with right turn lane (no C&G)



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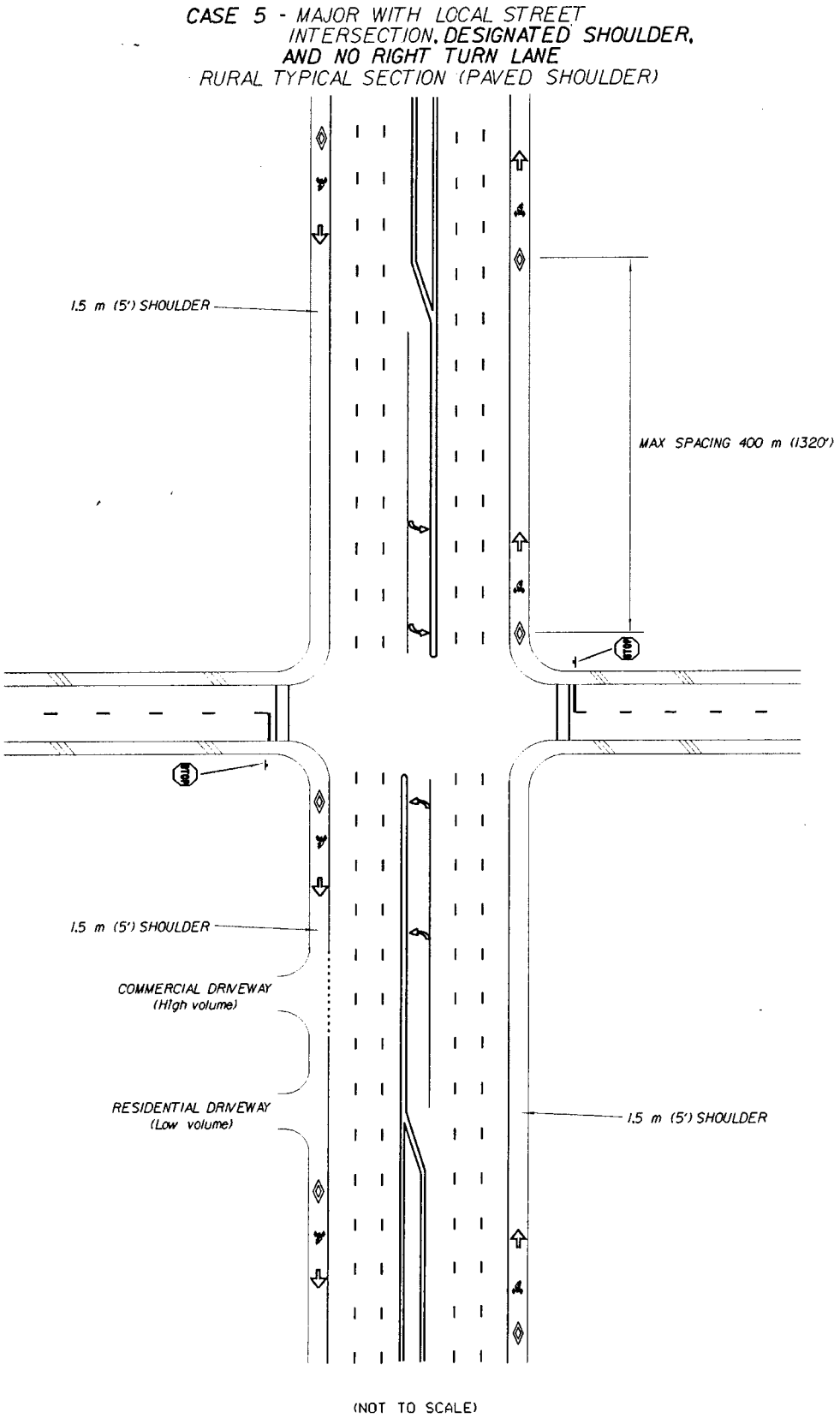
Major intersection without right turn lane (no C&G)



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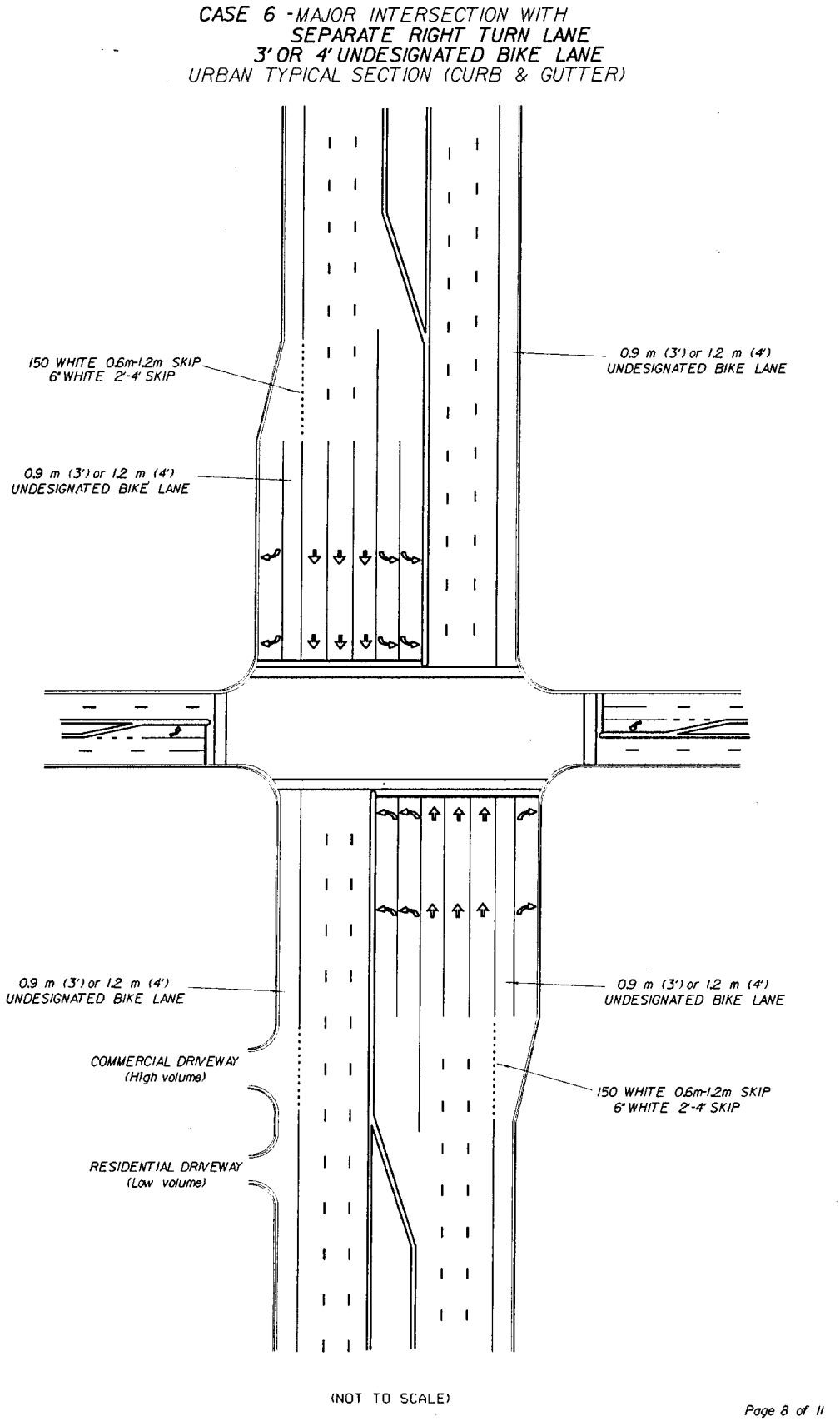
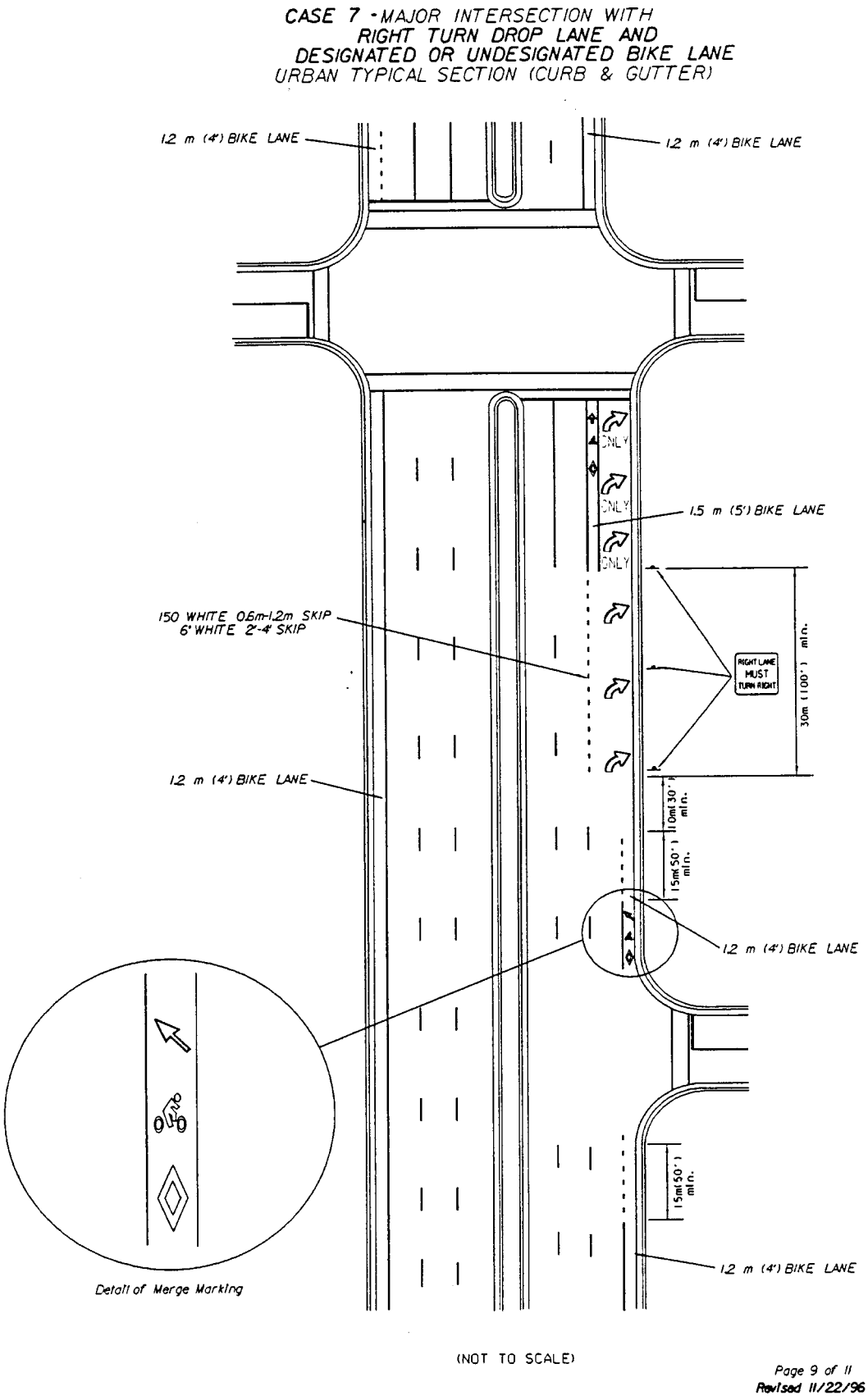
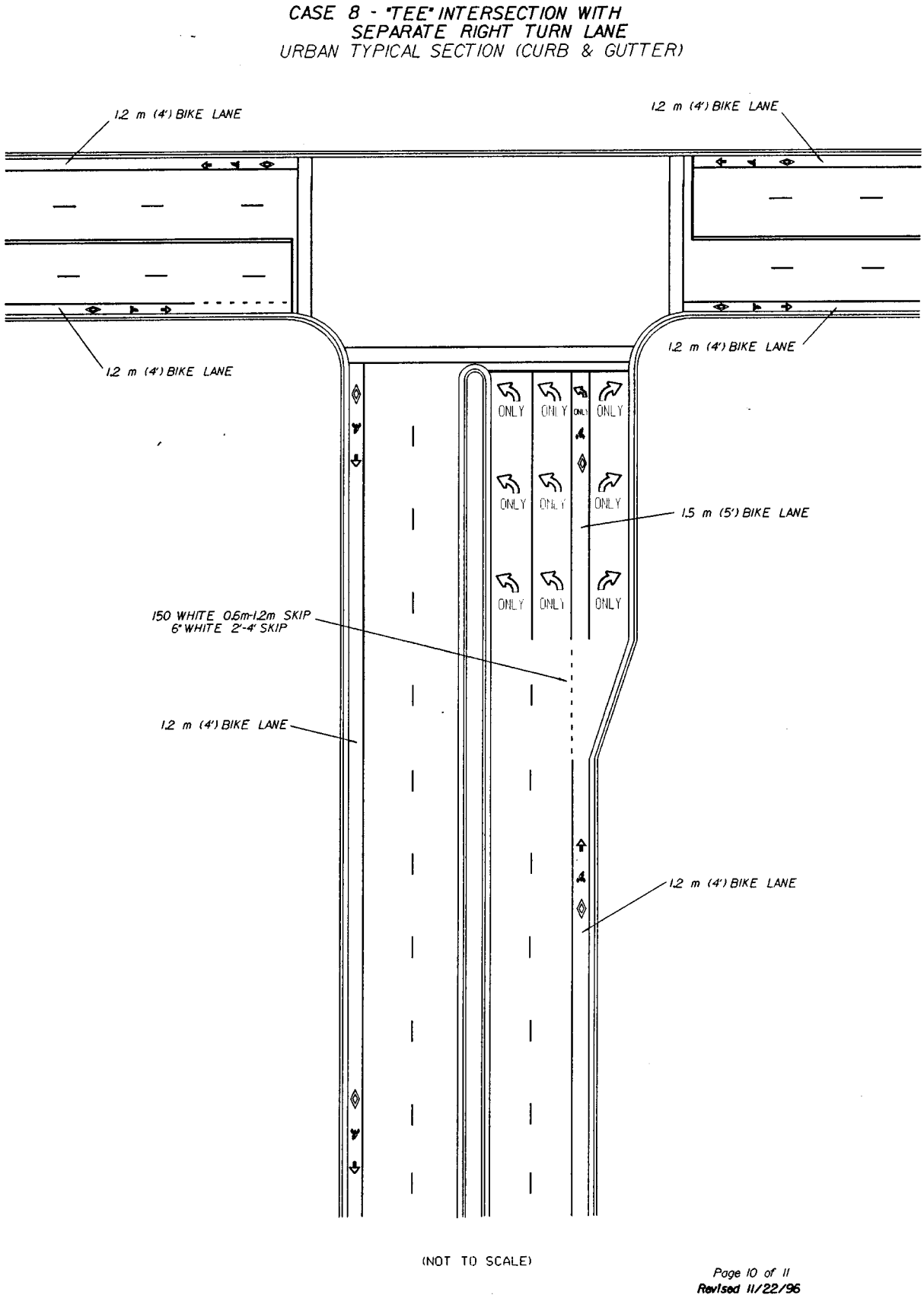
Stop controlled intersection with right turn lane & undesignated bike lane (C&G)



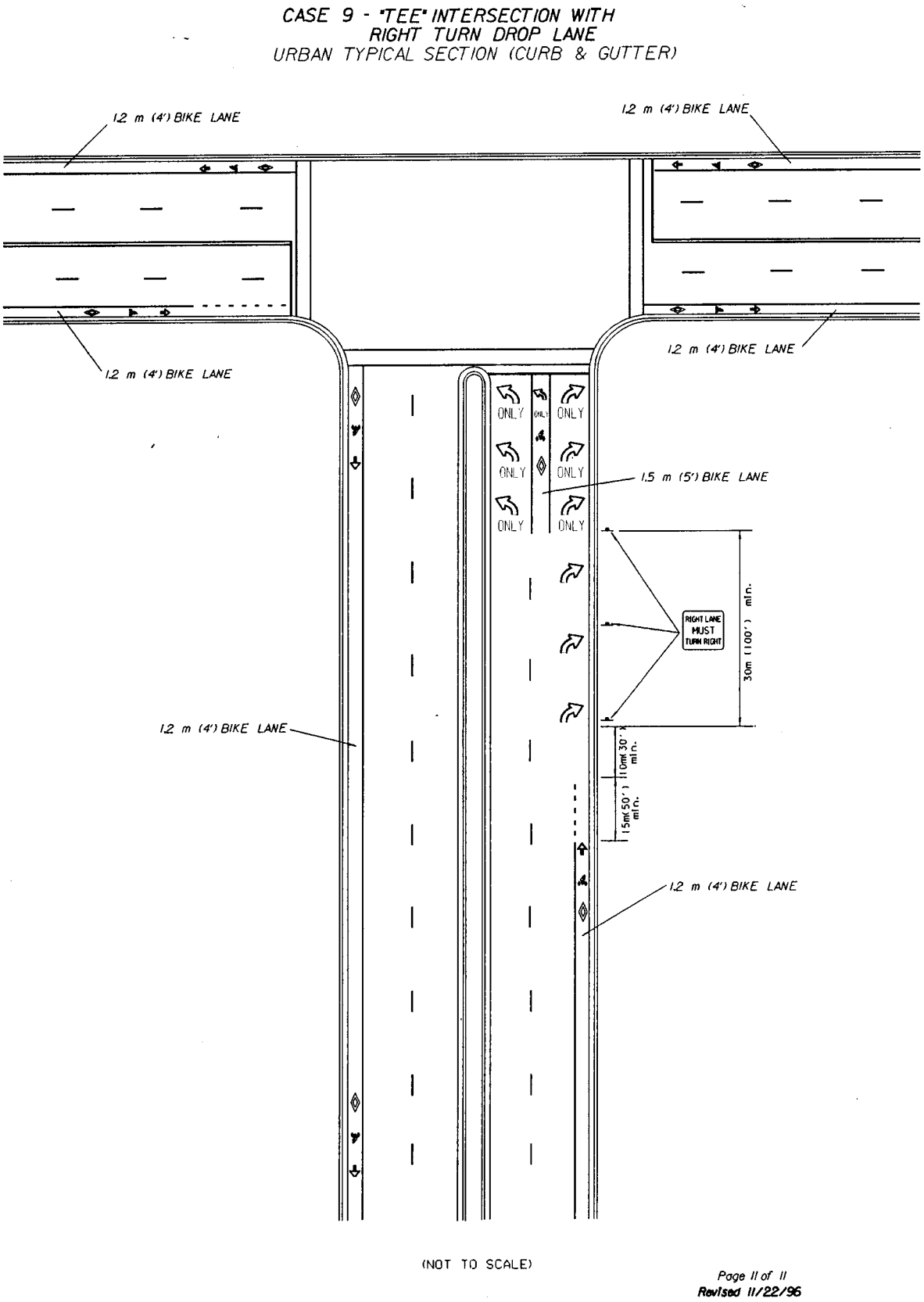
Major intersection with right turn drop lane



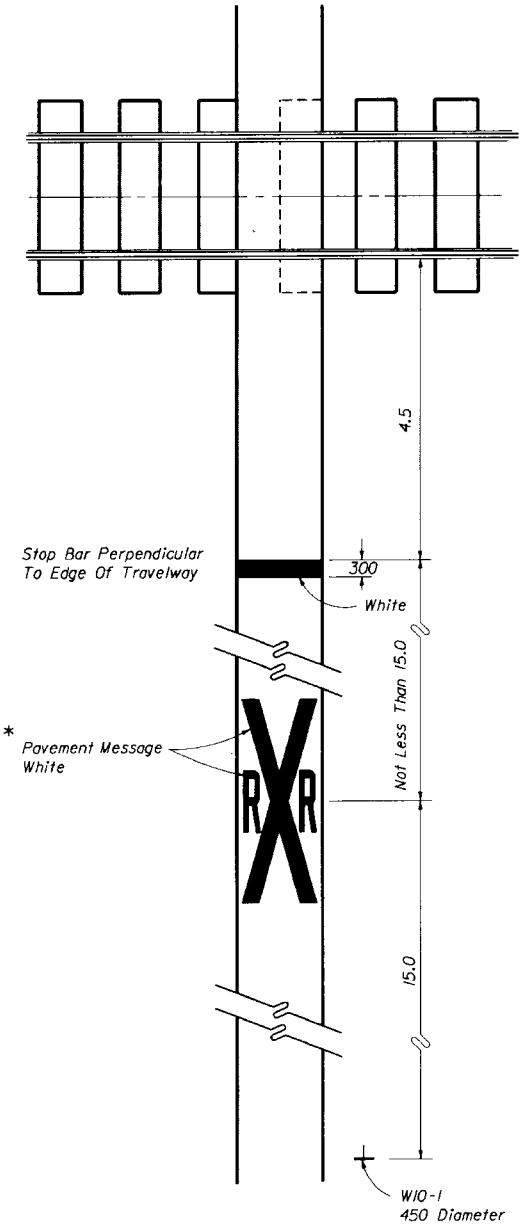
"Tee" intersection with right turnlane

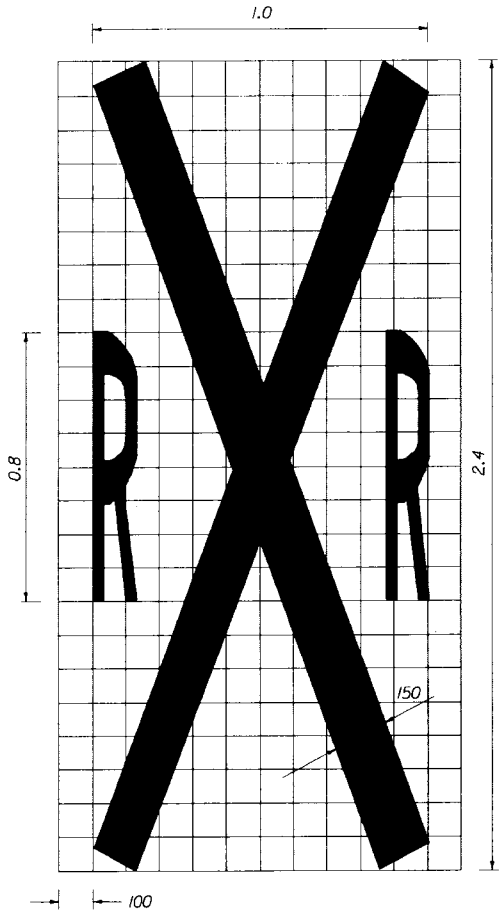


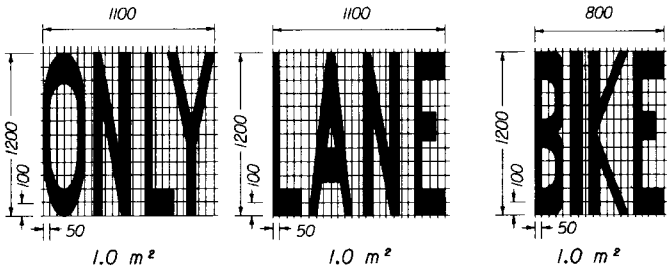
"Tee" intersection with right turn drop lane



Standard Index # 17346







PAVEMENT MESSAGE DETAILS

* NOTE
When used on a bike lane (adjacent to vehicle lane) markings shall be placed adjacent to markings for vehicles & W10-1 sign shall be sized and placed for vehicles.

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION
TRAFFIC DESIGN

SPECIAL MARKING AREAS
(BICYCLE)

	Names	Dates
Designed By		08/84
Drawn By		08/84
Checked By		08/84

Approved By Charles A Scott
State Traffic Plans Engineer

Revision No.	Sheet No.	Index No.
94	8 of 9	17346

F.H.W.A. Approved:

Markings in or adjacent to bike lanes should be thermoplastic with a mixture of 50 percent glass spheres and 50 percent sharp silica sand applied at a rate of .907 kg for each .929 m².

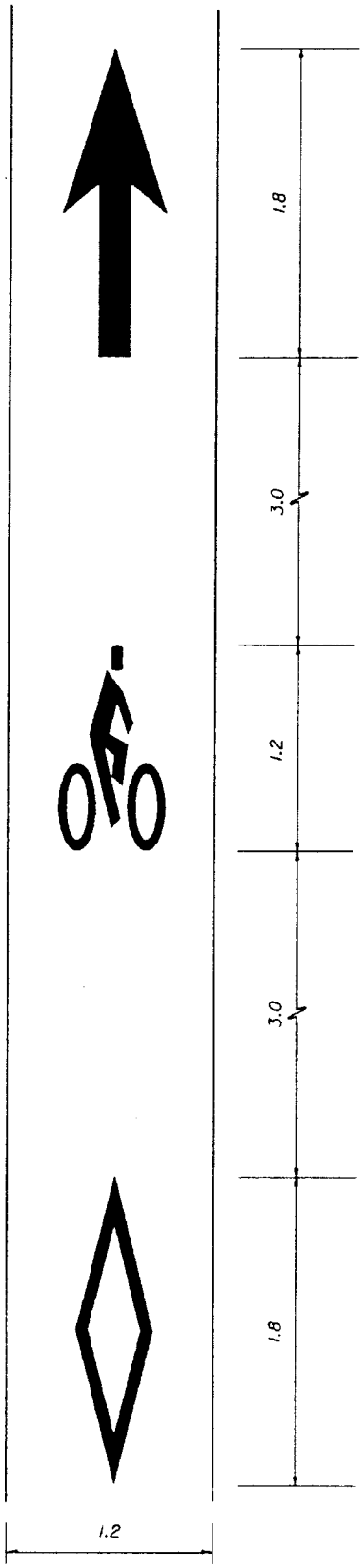
The sharp silica sand shall meet the following gradation requirements:

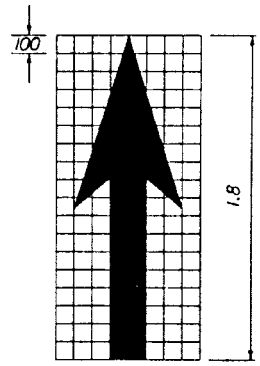
U.S. Sieve Number	Percent Passing
20	100
50	0-100

(Florida Standard Spec. 711-4.6)

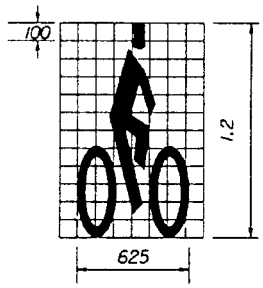
Recommended spacing of diamond symbol: immediately after intersections and major driveways and at a maximum spacing of 182 meters for urban sections and 400 meters for rural sections.

Raised pavement markings and raised barriers can cause steering difficulties and should not be used to delineate bicycle lanes.
All pavement markings and pavement messages shall be white.

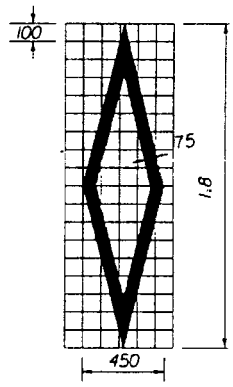




0.39 m²



0.21 m



0.60 m²

DETAIL OF BIKE LANE MARKINGS

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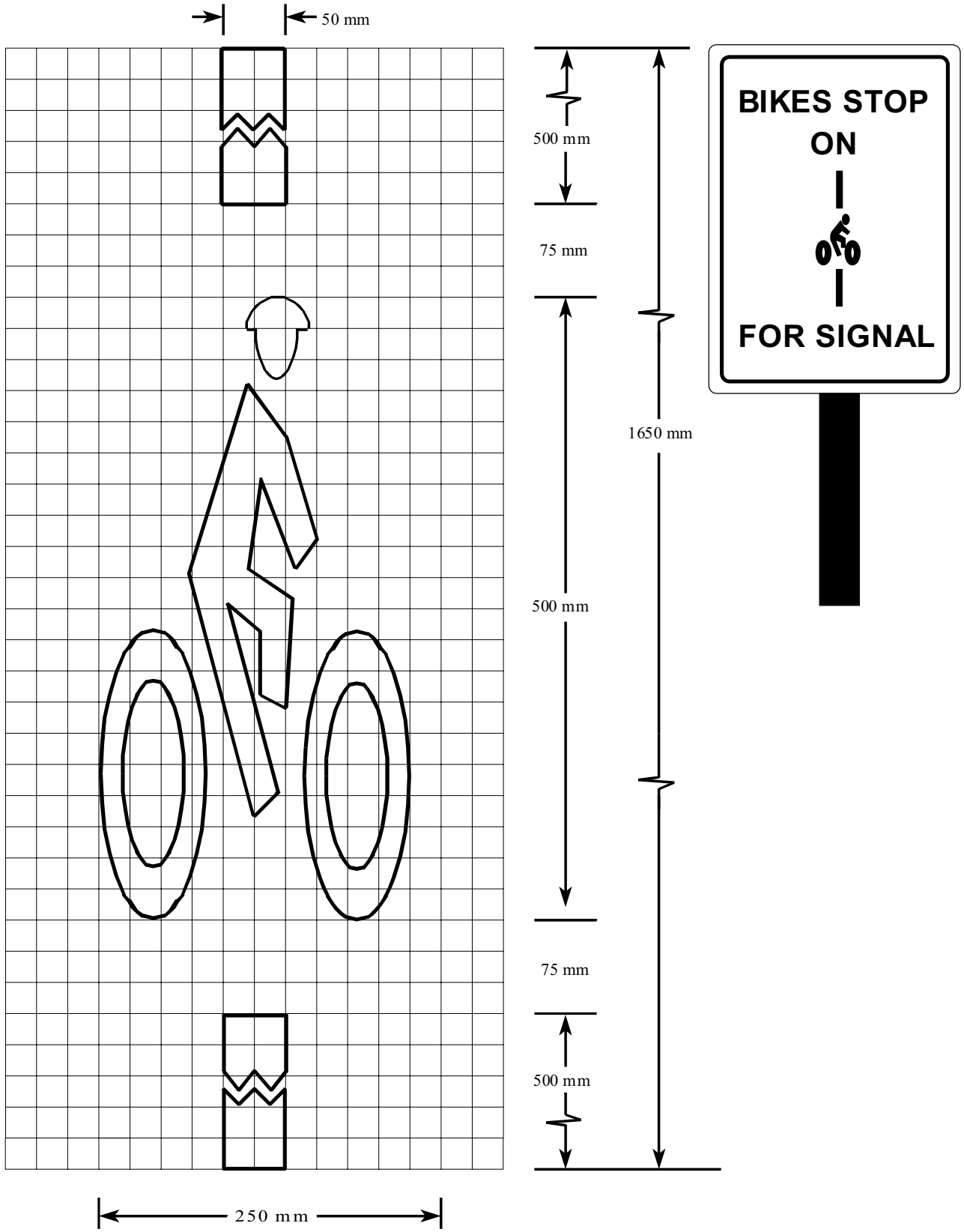
Appendix D -Symbol and proposed sign for marking traffic signal loops for bicycles.



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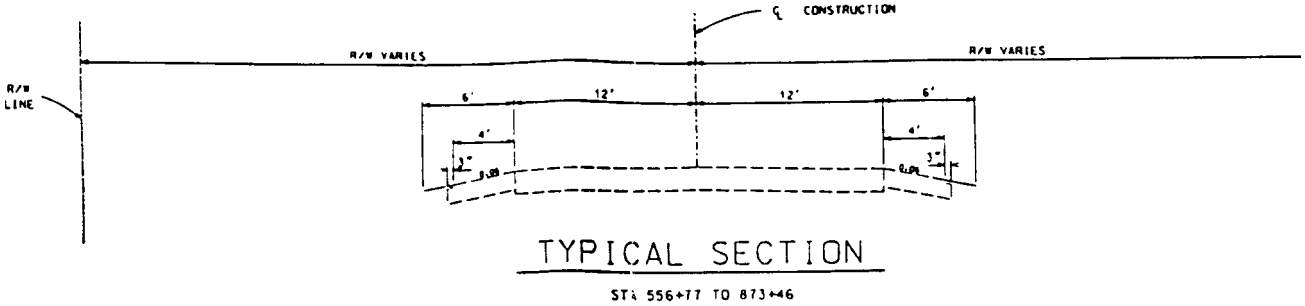
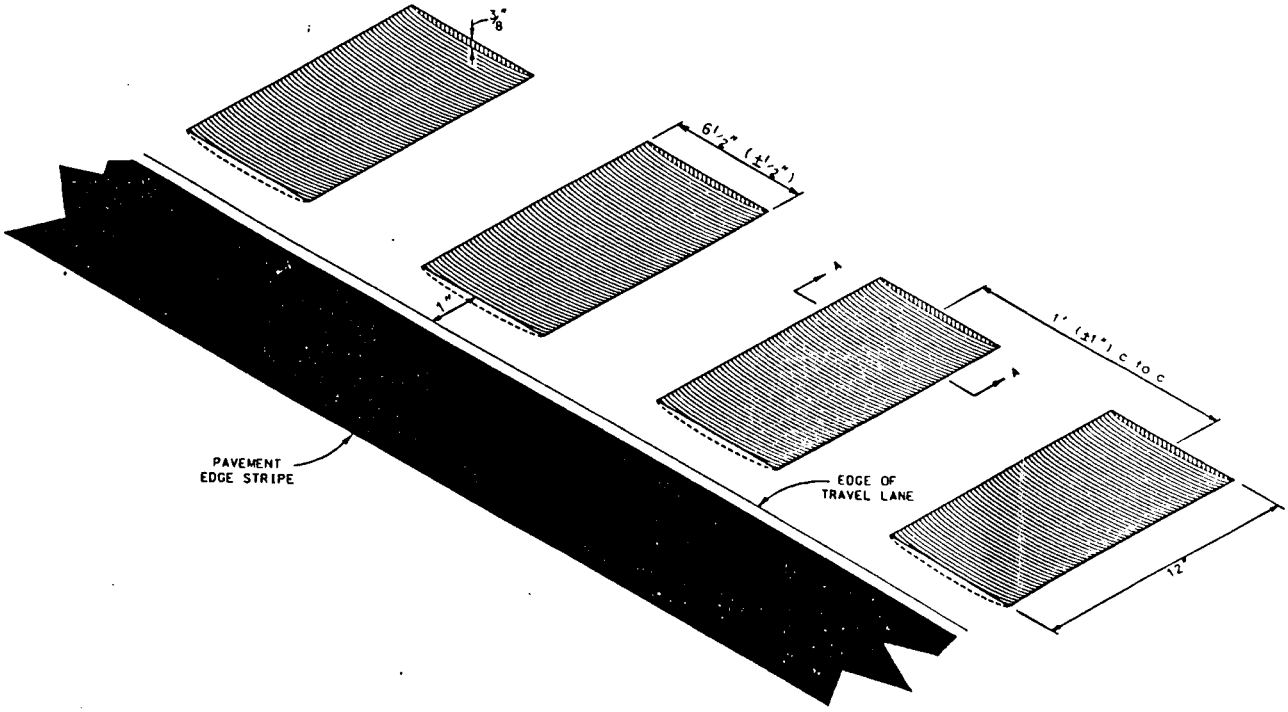
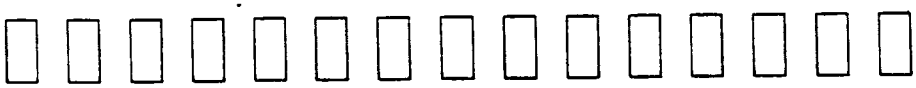
Appendix E - Low impact rumble strips



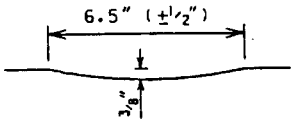


SHOULDER GROUND-IN RUMBLE STRIPS

CONTINUOUS CUTS (1' c to c)



CONTINUOUS ARRAY



SECTION AA
LONGITUDINAL CUT

MAINTENANCE OF TRAFFIC NOTES

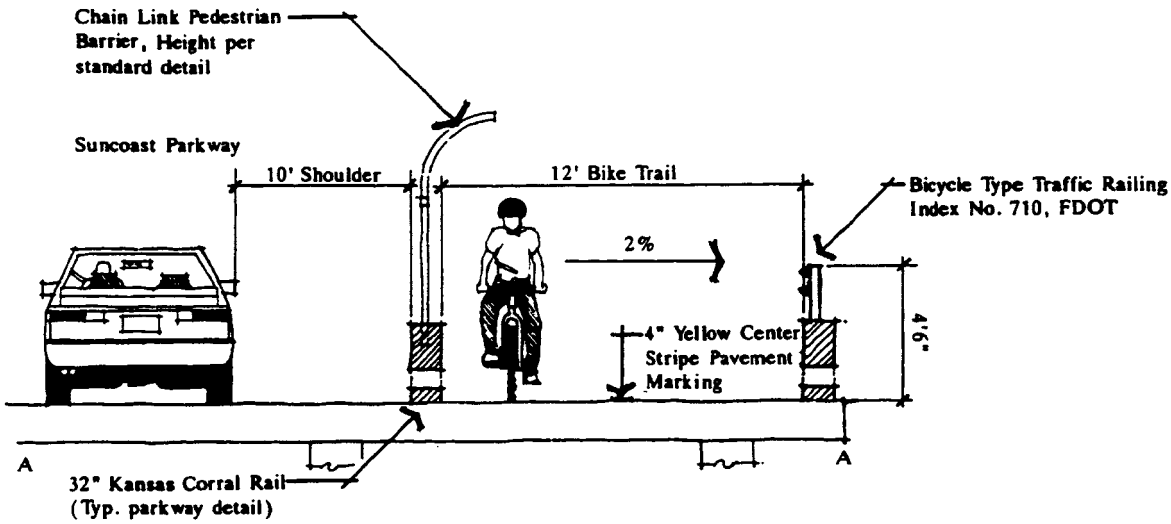
1. TRAFFIC SHALL BE MAINTAINED IN ACCORDANCE WITH THE FDOT ROADWAY AND TRAFFIC DESIGN STANDARDS, DATED 1994. INDEX 600 SERIES.
2. WORK ZONE POSTED SPEED DURING CONSTRUCTION WILL BE EXISTING POSTED SPEED. (SEE GENERAL NOTE No. 1 BELOW)
3. THERE ARE NO LANE CLOSURE TIME RESTRICTIONS, HOWEVER, A LANE MAY BE CLOSED ONLY DURING ACTIVE WORK PERIODS AND LIMITED TO 1/2 MILE IN LENGTH.
4. VARIABLE MESSAGE SIGNS SHALL BE LOCATED 1/2 MILE BEFORE FLAG PERSON. SIGNS DISPLAY SHALL INCLUDE "REDUCE SPEED" AND "ONE LANE ROAD AHEAD".

GENERAL NOTES

1. EXISTING POSTED SPEED IS 50 MPH FROM MILEPOST 10.546 TO 10.641 AND 55 MPH FROM MILESPOST 10.641 TO 16.543.

Appendix F - Suncoast Parkway Drawings

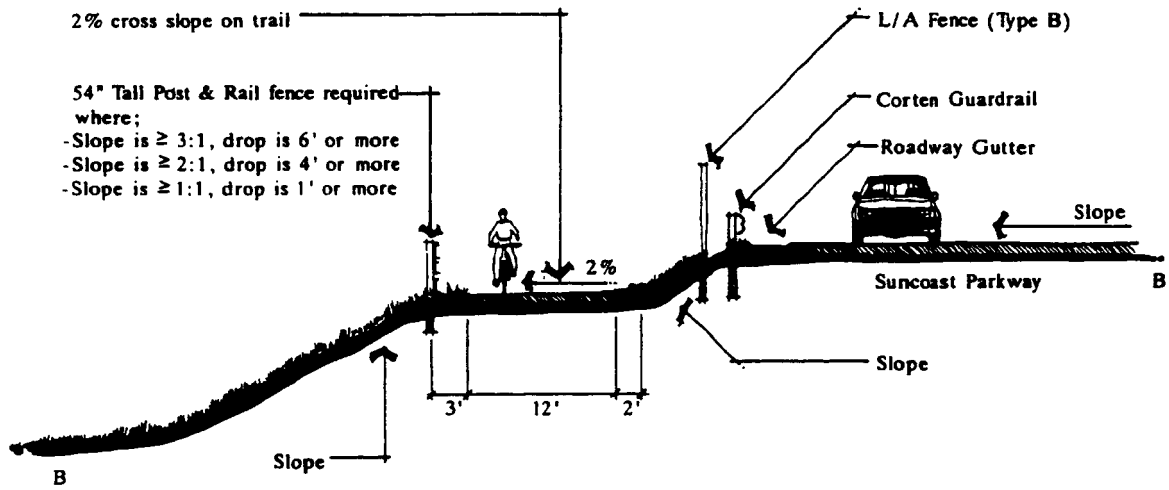
SUNCOAST PARKWAY



Section AA'

Refer to Fig. 2.3-1

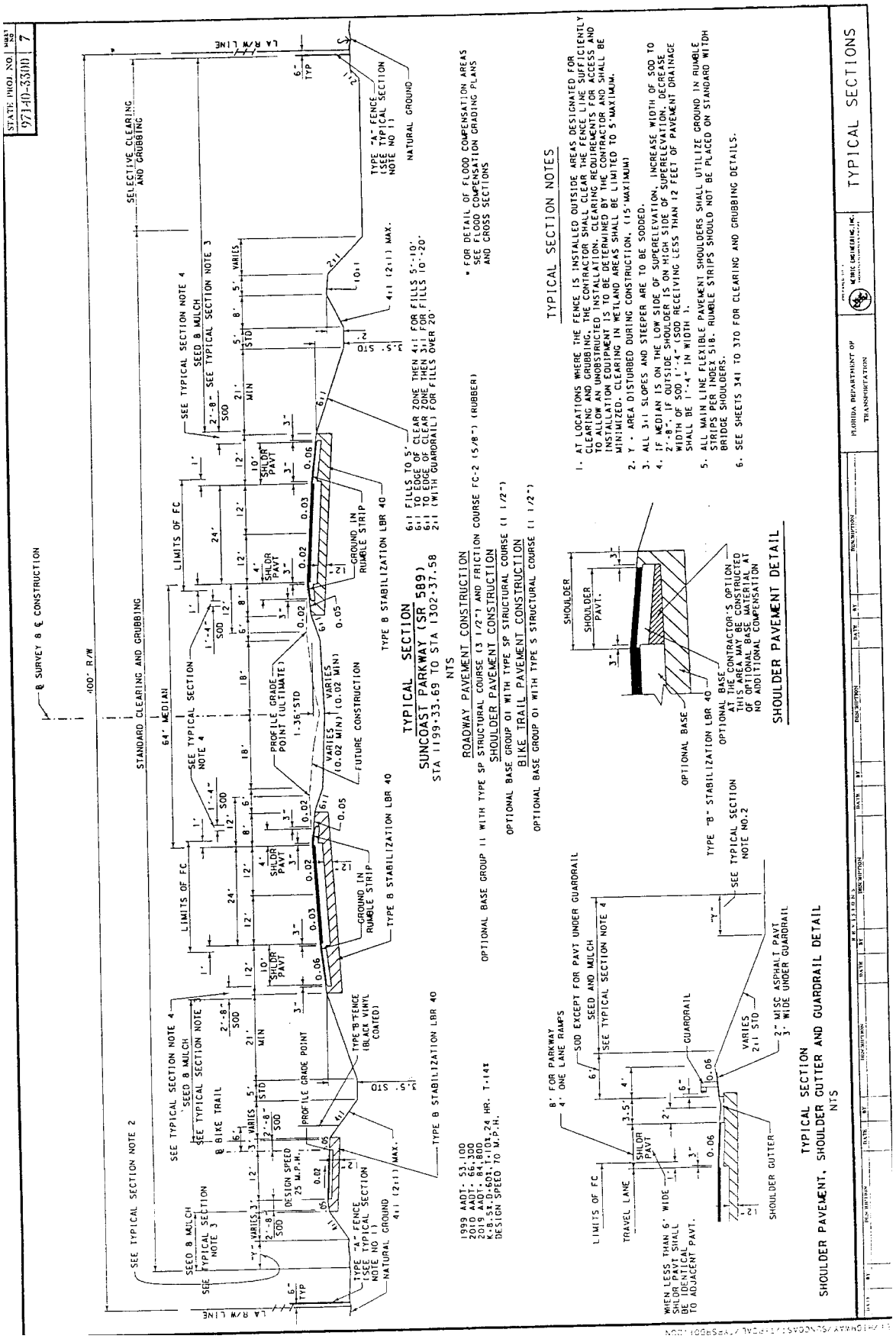
Figure 2.3-2, River and Wildlife Crossing Bridge Cross Section

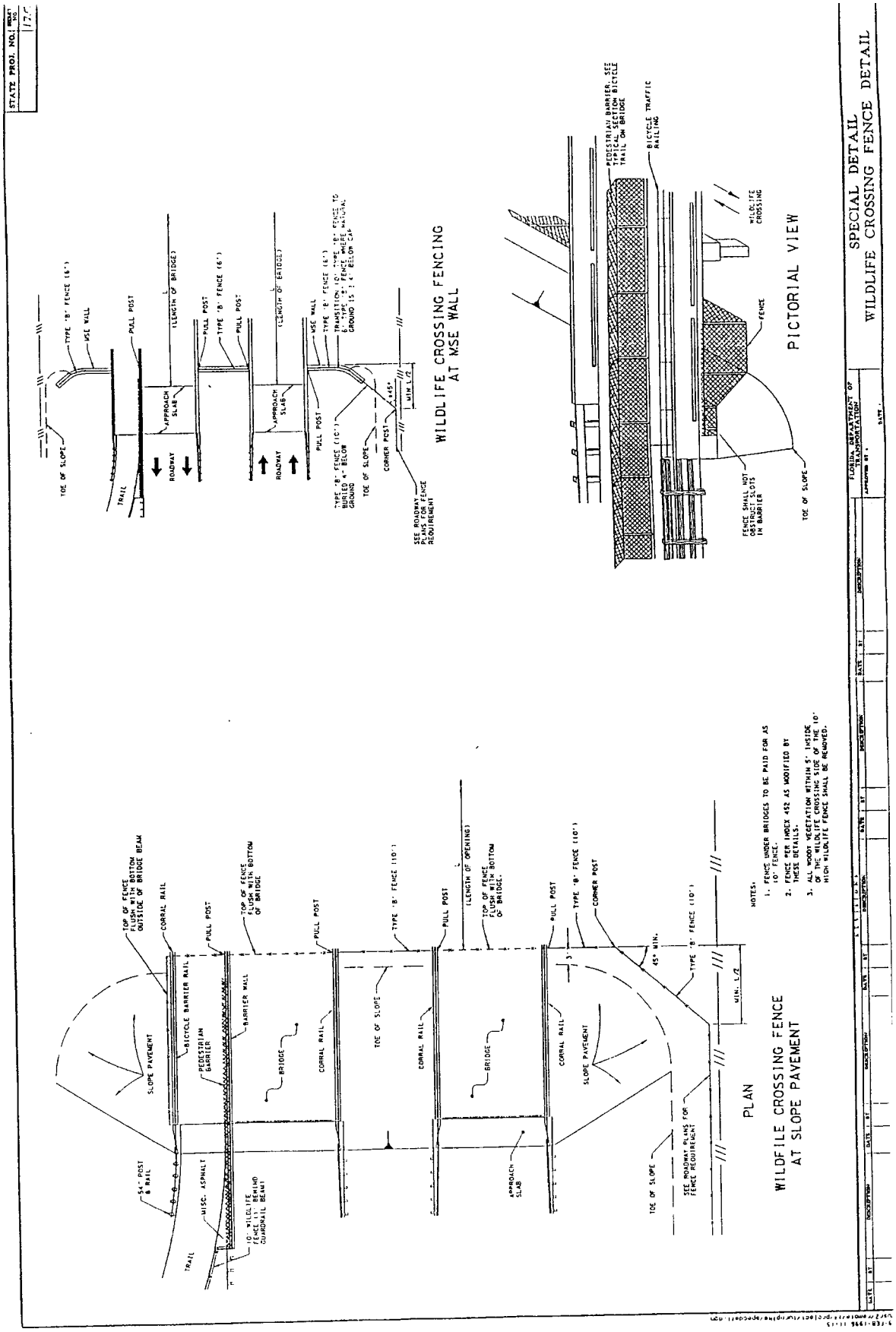


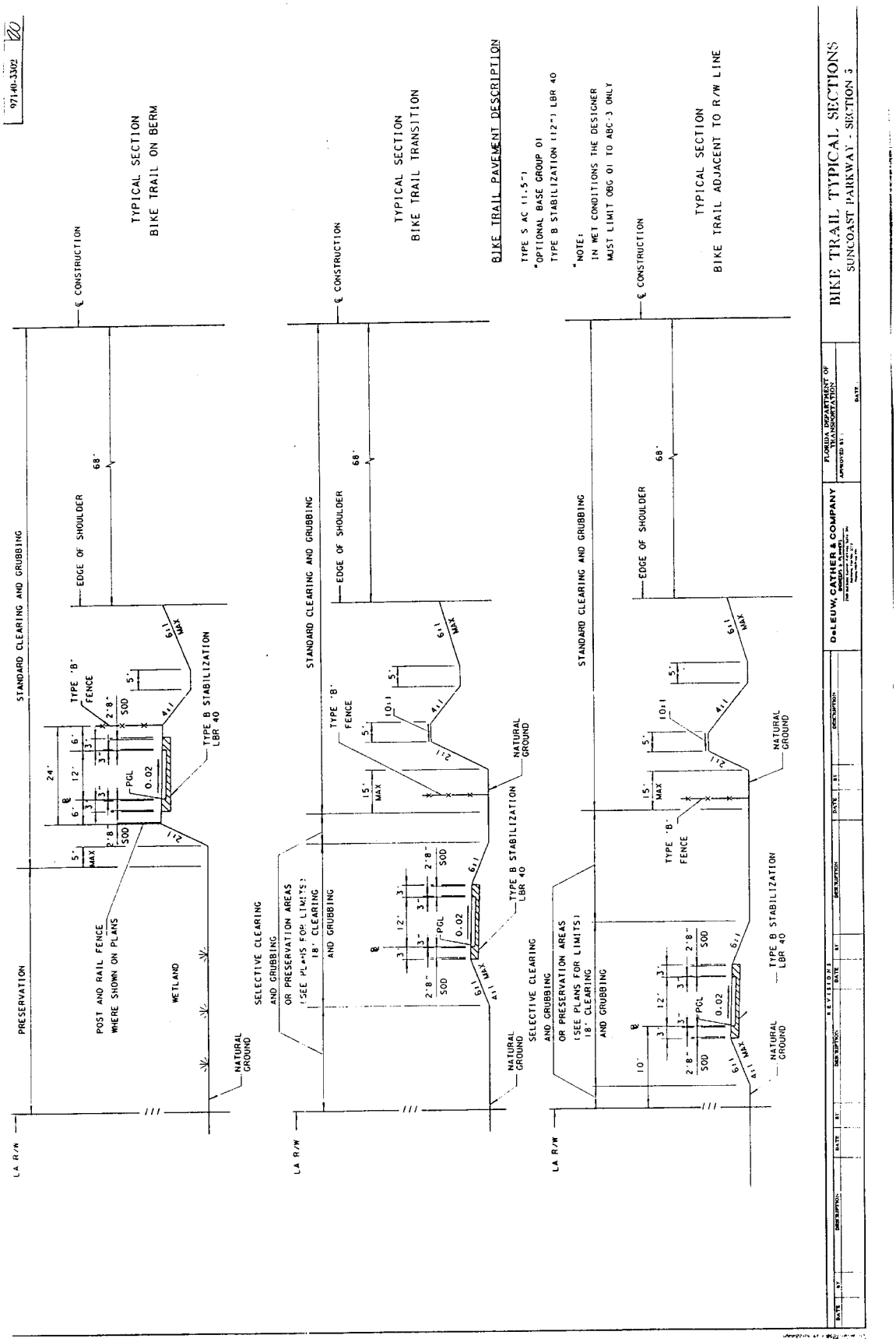
SECTION BB'

Refer to Fig. 2.3-1

Figure 2.3-3, River and Wildlife Crossing Bridge Approach Cross Section


TYPICAL SECTIONS
TYPICAL SECTION
SUNCOAST PARKWAY (SR 589)
STA 1199+33.69 TO STA 1302+37.58
NTS
ROADWAY PAVEMENT CONSTRUCTION
OPTIONAL BASE GROUP 11 WITH TYPE SP STRUCTURAL COURSE (3 1/2") AND FRICTION COURSE FC-2 (5/8") (RUBBER)
SHOULDER PAVEMENT CONSTRUCTION
OPTIONAL BASE GROUP 01 WITH TYPE SP STRUCTURAL COURSE (1 1/2")
BIKE TRAIL PAVEMENT CONSTRUCTION
OPTIONAL BASE GROUP 01 WITH TYPE S STRUCTURAL COURSE (1 1/2")
TYPICAL SECTION NOTES
1. AT LOCATIONS WHERE THE FENCE IS INSTALLED OUTSIDE AREAS DESIGNATED FOR CLEARING AND GRUBBING, THE CONTRACTOR SHALL CLEAR THE FENCE LINE SUFFICIENTLY TO ALLOW AN UNOBSTRUCTED INSTALLATION. CLEARING REQUIREMENTS FOR ACCESS AND INSTALLATION EQUIPMENT IS TO BE DETERMINED BY THE CONTRACTOR AND SHALL BE MINIMIZED. CLEARING IN WETLAND AREAS SHALL BE LIMITED TO 5' MAXIMUM.
2. T - AREA DISTURBED DURING CONSTRUCTION. (15' MAXIMUM)
3. ALL 3:1 SLOPES AND STEEPER ARE TO BE SODDED.
4. IF MEDIAN IS ON THE LOW SIDE OF SUPERELEVATION, INCREASE WIDTH OF SOD TO 2'-8". IF OUTSIDE SHOULDER IS ON HIGH SIDE OF SUPERELEVATION, DECREASE WIDTH OF SOD 1'-4" (SOD RECEIVING LESS THAN 12 FEET OF PAVEMENT DRAINAGE SHALL BE 1'-4" IN WIDTH).
5. ALL MAIN LINE FLEXIBLE PAVEMENT SHOULDERS SHALL UTILIZE GROUND IN RUMBLE STRIPS PER INDEX 518. RUMBLE STRIPS SHOULD NOT BE PLACED ON STANDARD WITDH BRIDGE SHOULDERS.
6. SEE SHEETS 341 TO 370 FOR CLEARING AND GRUBBING DETAILS.
SHOULDER PAVEMENT DETAIL
TYPICAL SECTION
SHOULDER PAVEMENT, SHOULDER GUTTER AND GUARDRAIL DETAIL
NTS
FLORIDA DEPARTMENT OF TRANSPORTATION
STATE PROJ. NO.
9731-10-3310
SHEET NO. 7
100' R/W
℄ SURVEY & ℄ CONSTRUCTION
STANDARD CLEARING AND GRUBBING
64' MEDIAN
LIMITS OF FC
SEE TYPICAL SECTION NOTE 2
SEE TYPICAL SECTION NOTE 4
SEED & MULCH
SEE TYPICAL SECTION NOTE 3
SEE TYPICAL SECTION NOTE 1
SEE TYPICAL SECTION NOTE 4
SEE TYPICAL SECTION NOTE 3
SEE TYPICAL SECTION NOTE 1
SEE TYPICAL SECTION NOTE 2
℄ BIKE TRAIL
PROFILE GRADE POINT
PROFILE GRADE POINT (ULTIMATE)
FUTURE CONSTRUCTION
GROUND IN RUMBLE STRIP
TYPE B STABILIZATION LBR 40
TYPE "B" FENCE (BLACK VINYL COATED)
TYPE "A" FENCE (SEE TYPICAL SECTION NOTE NO 1)
NATURAL GROUND
SELECTIVE CLEARING AND GRUBBING
LA R/W LINE
DESIGN SPEED 25 M.P.H.
1999 AADT: 53,100
2010 AADT: 66,300
2018 AADT: 82,800
K=8.5% D=60% T=10% 24 HR. T-14%
DESIGN SPEED 70 M.P.H.
* FOR DETAIL OF FLOOD COMPENSATION AREAS SEE FLOOD COMPENSATION GRADING PLANS AND CROSS SECTIONS
6:1 FILLS TO 5' OF CLEAR ZONE THEN 4:1 FOR FILLS 5'-10'
6:1 TO EDGE OF CLEAR ZONE THEN 3:1 FOR FILLS 10'-20'
2:1 (WITH GUARDRAIL) FOR FILLS OVER 20'
4:1 (2:1) MAX.
OPTIONAL BASE
OPTIONAL BASE GROUP 01 WITH TYPE S STRUCTURAL COURSE (1 1/2")
AT THE CONTRACTOR'S OPTION THIS AREA MAY BE CONSTRUCTED OF ORGANIC MATERIAL AT NO ADDITIONAL COMPENSATION
TYPE "B" STABILIZATION LBR 40
SHOULDER PAVT.
SHOULDER
8' FOR PARKWAY
4' ONE LANE RAMPS
SOD EXCEPT FOR PAVT UNDER GUARDRAIL
SEE TYPICAL SECTION NOTE 4
GUARDRAIL
TYPE "B" STABILIZATION LBR 40
SEE TYPICAL SECTION NOTE NO.2
VARIES 2:1 STD
2" MISC ASPHALT PAVT
3' WIDE UNDER GUARDRAIL
SHOULDER GUTTER
TRAVEL LANE
WHEN LESS THAN 6' WIDE SHLDR PAVT SHALL BE IDENTICAL TO ADJACENT PAVT.


WILDLIFE CROSSING FENCING AT MSE WALL
PICTORIAL VIEW
SPECIAL DETAIL
WILDLIFE CROSSING FENCE DETAIL
WILDFILE CROSSING FENCE AT SLOPE PAVEMENT
PLAN
NOTES:
1. FENCE UNDER BRIDGES TO BE PAID FOR AS 10' FENCE.
2. FENCE PER INDEX 452 AS MODIFIED BY THESE DETAILS.
3. ALL WOODY VEGETATION WITHIN 5' INSIDE OF THE WILDLIFE FENCE SHALL BE REMOVED.
TOE OF SLOPE
TRAIL
ROADWAY
APPROACH SLAB
PULL POST
TYPE 'B' FENCE (6')
MSE WALL
CORNER POST
WILDLIFE CROSSING
FENCE
BICYCLE TRAFFIC RAILING
PEDESTRIAN BARRIER - SEE PEDESTRIAN BICYCLE TRAIL ON BRIDGE
FENCE SHALL NOT OBSTRUCT SLOTS IN BARRIER
TYPE 'B' FENCE (10')
(LENGTH OF OPENING)
TOP OF FENCE FLUSH WITH BOTTOM OF BRIDGE
TOP OF FENCE FLUSH WITH BOTTOM OF BRIDGE BEAM
CORRAL RAIL
BICYCLE BARRIER RAIL
PEDESTRIAN BARRIER
BARRIER WALL
BRIDGE
SLOPE PAVEMENT
APPROACH SLAB
SEE ROADWAY PLANS FOR FENCE REQUIREMENT
MISC. ASPHALT
10' WILDLIFE FENCE (1' BEHIND GUARDRAIL BEAM)
STATE PROJ. NO.


97140-3302
TYPICAL SECTION
BIKE TRAIL ON BERM
TYPICAL SECTION
BIKE TRAIL TRANSITION
BIKE TRAIL PAVEMENT DESCRIPTION
TYPE S AC (1.5")
*OPTIONAL BASE GROUP 01
TYPE B STABILIZATION (12") LBR 40
*NOTE:
IN WET CONDITIONS THE DESIGNER
MUST LIMIT OBG 01 TO ABC-3 ONLY
TYPICAL SECTION
BIKE TRAIL ADJACENT TO R/W LINE
BIKE TRAIL TYPICAL SECTIONS
SUNCOAST PARKWAY - SECTION 3
DeLEUW, CATHER & COMPANY
FLORIDA DEPARTMENT OF TRANSPORTATION
STANDARD CLEARING AND GRUBBING
PRESERVATION
EDGE OF SHOULDER
68'
TYPE 'B' FENCE
TYPE B STABILIZATION LBR 40
POST AND RAIL FENCE WHERE SHOWN ON PLANS
WETLAND
NATURAL GROUND
SELECTIVE CLEARING AND GRUBBING OR PRESERVATION AREAS (SEE PLANS FOR LIMITS) 18' CLEARING AND GRUBBING
LA R/W

Appendix G - Minimum Radius for Bicycle Paths

Minimum Radius for Bicycle Paths				
Design Speed	Friction Factor	Minimum Radius, m		
km/hr	f	e = 0.02 m/m	e = 0.04 m/m	e = 0.06 m/m
25	0.30	15.4	14.5	13.7
30	0.28	23.3	21.9	20.6
35	0.27	33.6	31.4	29.5
40	0.25	46.4	43.3	40.5
45	0.24	62.5	56.0	54.1
50	0.22	82.5	76.1	70.6
55	0.20	107.1	98.2	90.7
60	0.19	137.4	125.3	115.1
65	0.17	175.1	158.4	144.6

$$R = V^2 / 127 (e+f)$$

Where:

R = Minimum Radius of Curvature (m)
V = Design Speed (km/h)
e = superelevation rate, m/m
f = coefficient of friction

Values of f taken from AASHTO, *Guidelines for the Development of Bicycle Facilities,* August 1991.

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Appendix H - Florida Pedestrian and Bicycle Program Procedure

Approved:

Effective: January 16, 1997
Office: Safety
Topic No. : 625-010-050-a

Ben G. Watts, P.E.
Secretary

FLORIDA PEDESTRIAN AND BICYCLE PROGRAM
PURPOSE:

To establish uniform requirements and guidelines for conducting the Department's Pedestrian and Bicycle Program. To incorporate pedestrian and bicycle features in all phases of appropriate Department programs and projects.

AUTHORITY:

Sections 20.23 (3)(a), 334.044, 334.048(3), and 335.065, Florida Statutes.

SCOPE:

This procedure is to be used by all applicable Central and District offices of the Florida Department of Transportation, including [but not limited to] Roadway Design, Planning, Environmental Management Office, Traffic Operations, Structures, Right of Way, Construction, Maintenance, Public Transportation Office, and Safety. It is to be used by all appropriate offices within the Central Office as well as by the Pedestrian/Bicycle Coordinators and other designated District personnel or consultants assigned and authorized by the District Secretary or otherwise in a position to carry out the Department's responsibilities for safe, efficient, effective, convenient facilities and services for bicyclists and pedestrians in Florida.

REFERENCES:

- Plans Preparation Manual (PPM), Metric and English Versions, Topic No's. 625-000-005 and 625-000-101
- Project Development and Environment Manual, Topic No. 650-000-001
- Roadway and Traffic Design Standards (Standard Index), Topic No. 625-010-003
- Traffic Engineering Manual, Topic No. 750-000-005

- Construction Project Administration Manual, Topic No. 700-000-000
- Structures Design Guidelines, Topic No. 625-020-150
- Transportation Enhancement Projects Procedure, Topic No. 525-030-300
- Elder Roadway User Program, Topic No. 000-750-001
- Highway Landscape, Beautification, and Plan Review Procedure, Topic No. 650-050-001
- Florida Bicycle Planning and Design Handbook
- Florida Pedestrian Planning and Design Handbook

DEFINITIONS:

BAC, PAC, B/AC, B/PAB means Bicycle Advisory Committee, Pedestrian Advisory Committee, Pathways Advisory Committee or combined Bicycle/Pedestrian Advisory Committee or Board; a working group normally created and selected by Metropolitan Planning Organization (MPO) members, or a local city or county commission. For simplicity, the term B/PAC used in this document refers to the B/PAC, B/PAB, BAC or PAC, whichever group is appointed in the community/region.

Bicycle Boulevard means any connection of local/collector roadways forming a route of travel where bicycle and

pedestrian movements are given operational and low speed support.

Bicycle or Pedestrian Facilities means any facilities that provide access and support for pedestrians and/or bicyclists. These include, but are not limited to, paved shoulders, bike lanes, bicycle boulevards, wide curb lanes, multi-use paths, bicycle parking, lockers and showers, sidewalks, walkways, crosswalks, pedestrian signals, median refuge islands, features that slow traffic, overpasses, and special tunnels or bridges.

Commuter Assistance Organization means any organization responsible for developing programs to assist commuters; whether located in a DOT office, district or local government office, or private office. A Traffic Management Association would be an example of this.

Community Traffic Safety Team (CTST) means a comprehensive, multi-jurisdictional, multi-disciplinary group working to reduce fatalities, injuries, and the severity of injuries caused by traffic crashes within a community. Multi-disciplinary means integrating the efforts of the various disciplines that work in highway safety, including engineering, enforcement, education/public information, and emergency services (the 4 "E's"), to reduce trauma caused by traffic crashes relating to the driver, vehicle and roadway.

District Coordinator means the Florida Department of Transportation District Pedestrian/Bicycle Coordinator or other designee as assigned and authorized by the District Secretary.

Metropolitan Planning Organization (MPO) means one of the metropolitan areas covered pursuant to Section 339.175, Florida Statutes. The MPO is established by agreement between the Governor and units of local government from the urbanized area. The purpose of an MPO is to establish a continuing, cooperative and comprehensive transportation planning process within each metropolitan area of the state.

Regional Planning Council (RPC) means one of the planning districts created by the Florida Regional Planning Council Act (SS 186.501-186.513, F.S.). They are responsible for developing a "Strategic Regional Policy Plan" which includes a transportation subject area.

State Pedestrian/Bicycle Coordinator means the Central Office Pedestrian and Bicycle Coordinator or other designee as assigned and authorized by the Secretary of Transportation.

Urban Area means any geographic place of 5,000 or more persons.

Urbanized Area means any geographic place of 50,000 or more persons.

BACKGROUND:

Section 334.044, Florida Statutes, grants the Department powers and duties.

Section 335.065, Florida Statutes, sets forth requirements regarding bicycle and pedestrian ways along state roads and transportation facilities.

Section 20.23(3)(a), Florida Statutes, provides that the Central Office shall establish departmental policies, rules, procedures and standards and shall monitor the implementation of such in order to ensure uniform compliance and quality performance by the District and Central Office units that implement transportation programs.

With respect to accountability, Section 334.048(3), Florida Statutes, provides that the Central Office shall adopt policies, rules, procedures and standards which are necessary for the Department to function properly, including establishing accountability for all aspects of the Department's operations.

PROCEDURE:

(1) Each District, and the Central Office, shall ensure the needs of pedestrians and bicyclists are integrated into all relevant programs under their supervision. District Secretaries shall ensure the requirements of this procedure are fully incorporated into appropriate portions of the Work Program and all relevant Department programs.

(2) Each District Secretary shall ensure dissemination of this procedure on pedestrian and bicycle facilities to all relevant FDOT staff, consultants, MPO's, B/PAC's, RPC's, commuter assistance organizations, CTST's, and other appropriate government officials.

(3) District Secretaries shall ensure staff coordination for safety, planning and commuter assistance with appropriate local agencies/regional agencies /organizations to assure achievement of appropriate bicycle and pedestrian accommodations. Coordination with local/regional agencies or groups such as CTST's, MPO's, Commuter assistance organizations, B/PAC's and RPC's as well as other groups such as Scenic Highway and Highway Beautification groups will help to identify pedestrian and bicycle issues, programs, routes and projects, and locate roadways where bicycle/pedestrian facilities are most needed. District and local collaboration may lead to identification of local, nongovernmental and other federal resources that might supplement state funding sources.

(4) District Coordinators, or other designees, shall act as liaisons with district and local staff on function and performance issues related to pedestrian and bicycle features. This includes topics related to safety, education, planning, transit links, commuter assistance, design, maintenance, and working with Metropolitan Planning Organizations on their Bicycle/Pedestrian Plans. District Coordinators shall maintain effective contact with B/PAC's, other relevant citizen groups and local pedestrian and bicycle coordinators. Effectiveness is based on attendance at meetings, coordination of planning and design features on state roadway and bridge projects, responsiveness to questions and concerns of local coordinators, or other communications.

(5) District Coordinators shall coordinate with the District Safety Engineers to contribute to effective programs and projects to reduce pedestrian and bicycle crashes and related trauma. Examples include supporting local helmet campaigns, identifying needed operations features, and other efforts to enhance roadway sharing.

(6) The District Director of Production and/or the District Director of Operations shall ensure that bicycle and pedestrian facilities are given full consideration on all proposed projects (this includes 3R, safety, and intersection improvements) in accordance with Section 335.065, Florida Statutes.

The decision on appropriate pedestrian and bicycle facilities shall be determined with input from the District Coordinator. Input will be sought from the District Coordinator at the inception of the project either at the PD&E stage or other early design phase. The project shall also be reviewed by the District P/BC at appropriate phases of design to assure that it provides the function and performance needed to address pedestrian and bicycle access and safety.

These reviews shall ensure that pedestrian and bicycle features are fully integrated into these projects to the maximum extent practicable in accordance with the requirements of the Plans Preparation Manual, Roadway & Traffic Design Standards, the Bicycle Facilities Planning and Design Manual, and the Traffic Engineering Manual.

District Coordinators shall provide input into the review of projects with requested design variances that omit pedestrian/bicycle features or which negatively impact pedestrians and bicyclists.

(7) Central Office Construction and Maintenance staff shall ensure that their practices and procedures address pedestrian and bicycle issues.

(8) All FDOT Central offices shall coordinate with the State Pedestrian/Bicycle Coordinator regarding new or refined procedures, criteria and research projects which affect pedestrians and bicyclists.

(9) District Coordinators shall notify the State Pedestrian/Bicycle Coordinator of needed changes to procedures and criteria.

(10) The State Pedestrian/Bicycle Coordinator and staff shall gather, coordinate and share technical written information with Central Office staff and District and local coordinators. District Coordinators shall, in turn, provide technical assistance to planners, designers, local coordinators and others in their districts.

(11) District Coordinators shall attend training and arrange for other District staff to attend relevant training (See Training below).

(12) District Coordinators shall take part in statewide pedestrian/bicycle coordinator telephone conference calls and any special or regularly scheduled District Coordinator meetings. Coordinators shall also attend appropriate statewide meetings on related topics, and invite other affected parties.

(13) The State Pedestrian/Bicycle Coordinator shall work with the District Coordinators, Central Office Staff, and other appropriate staff to develop a system to maintain inventories of pedestrian and bicycle features within the state Roadway Characteristics Inventory.

(14) The State Pedestrian/Bicycle Coordinator, in coordination with the District Coordinators, shall assure that appropriate pedestrian/bicyclist issues are addressed within the Safety Management System (SMS), Bridge Management System (BMS), State Enhancement Program and Intermodal Management System (IMS), where applicable.

(15) TRAINING:

All District Coordinators and/or other designees will be provided sufficient technical training to become proficient in their discipline. District Coordinators should take part in additional training offered by the Department and through state, local, regional and national conferences that will expand their expertise, especially as it relates to design, planning, safety and education. The State Pedestrian/ Bicycle Coordinator or other experienced trainer, certified and approved by FDOT, shall provide annual and other periodic training to District Coordinators, District Design Engineers and staff, District Environmental Management Office (EMO) staff, District Safety Engineers and staff, District planners, and others.

Each District Coordinator shall schedule, promote and assist with Pedestrian or Bicycle Facilities Planning and Design courses for his/her district as appropriate. These courses are to be delivered by the State Pedestrian/Bicycle Coordinator or other experienced trainer.

(16) FORMS ACCESS:

No forms required by this procedure.