

**BICYCLE COMPATIBILITY OF URBAN STREET NETWORKS:  
A CASE STUDY OF MADISON, WISCONSIN**

by

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## PROLOGUE

### **P.1 Madison Department of Transportation/ Bicycle Federation of Wisconsin Bicycle Compatibility Project**

This thesis is based on work done as part of a collaborative project between the Madison Department of Transportation (MadDOT) and the Bicycle Federation of Wisconsin. MadDOT is updating Madison's bicycle map. As part of this process, the department wants to evaluate the bicycle compatibility of all arterial and collector street segments in Madison. Alex Sorton (1994), Deputy Director of the Transportation Engineering Division of the Traffic Institute at Northwestern University, recently proposed a model for evaluating the bicycle compatibility of individual road segments. Sorton collaborated with Tom Walsh at the Madison Department of Transportation to conduct a pilot study in Madison, Wisconsin, testing the validity of the proposed evaluation model (Sorton and Walsh, 1994) [see Section 3.4.2 for further discussion of this study]. Given the success of the pilot study, MadDOT was interested in applying Sorton's model in a broader planning context to evaluate all the arterial and collector street segments in Madison to facilitate the city's efforts to update its bicycle map. MadDOT received a National Highway Safety Administration grant through the Wisconsin Department of Transportation Office of Transportation Safety to conduct the study. MadDOT subcontracted the work through the Bicycle Federation of Wisconsin (BFW) and I was hired by BFW as a researcher for the project.

### **P.2 Personal Dedication to Bicycle Compatibility and Involvement in the Bicycle Compatibility Project**

My interest in transportation planning has been inspired by an academic year abroad (IHP, 1991), during which time I experienced a great diversity in transportation systems ranging from chaos and extreme congestion in New Delhi, Bangkok and Cali, to the elegance and human scale of the canal network in rural Thailand. Upon my return to the United States, I had a heightened awareness of the intimate connections between development and transportation patterns as well as the resulting implications for likely modal choices by people. As a result, I have decided to dedicate my career to working toward creating a human-scale, multimodal transportation system.

I am an avid year-round bicycle commuter for health, life style and environmental reasons. I am member of the League of American Bicyclists, Bicycle Federation of Wisconsin and the Dane County Bicycle Transportation Alliance. In addition, I have been elected to the Bicycle Federation of Wisconsin's board of directors and have been instrumental in making it a viable organization. I have focused my contributions on increasing public awareness of bicycle transportation issues through my work as the production manager for the *Wisconsin Bicyclist*, BFW's quarterly newsletter.

In addition to my commitment to commuting by bicycle and my advocacy involvement, I am also keenly interested in bicycle transportation planning and research. Therefore, when I heard the Madison Department of Transportation was receiving a grant to research the bicycle compatibility of Madison's roadway network, I was very interested in being involved in the project. The team includes three others in addition to myself: Arthur Ross, Steve Cayford, and Marcia Miquelon. Arthur Ross, Madison's Bicycle Pedestrian Coordinator, oversaw the central project management, including submitting bills and reports to the granting agency, as well as supervising my work. Steve Cayford helped with data collection and entry efforts and also did most of the field checking that was required. Marcia Miquelon, then Executive Director of the Bicycle Federation of Wisconsin, in addition to managing paperwork for the project, assisted with some of the field checking. I was involved in all phases of the project from methodology refinement to data collection to data analysis to user manual development.

## CHAPTER 1

### TRANSPORTATION SYSTEMS, BICYCLE COMPATIBILITY AND THESIS OVERVIEW

#### 1.1 Transportation Systems and the Landscape

Transportation systems provide corridors for movement across the landscape.

At the core of transportation are access to activity sites—proximity to places of work, recreation, socializing, shopping, medical care—and mobility, the ability to move between these activity sites. The spatial separation of activity sites demands mobility for a city to function. The urban landscape consists of spatially distinct, highly specialized land uses—food stores, laundromats, hardware stores, banks, drug stores, hospitals, schools, post offices, and so on—which people must get to if they want to obtain necessary goods and services. Moreover, home and work are now in the same location for very few people (about 2.3 percent of the American work force in 1979), so that to earn an income as well as to spend it, one must travel. As a result people select a place to live not only for the characteristics of a housing unit itself (for example, a two-bedroom apartment in an old three-story brownstone) or for the characteristics of the neighborhood in which the apartment is located (such as a good school district, the presence of many other families with young children), but also for the set of linkages to activity sites that a particular location affords. (Hanson, 1986, p. 3)

Trips may be on a regional scale traversing rivers, mountains, plains, prairies, forests or corn fields. Or trips may be on a very local scale, visiting a neighbor or shopping at the corner grocery store. Whatever the scale of travel, trips across the landscape do not follow random paths. Rather, transportation corridors are created to facilitate convenient access between desired destinations.

When the pioneers were settling the Great Plains, paths through the tall prairie grasses developed naturally, guided by significant landscape features that included the location of water, wetlands and steep topography. In today's urban areas, on the other hand, these natural guiding features are largely ignored. Bridges are readily built over rivers no matter how wide, wetlands are filled in and motor vehicles have many fewer problems with big hills than did horse-drawn buggies. Instead of being guided by natural landscape features, transportation corridor development today is instead shaped by policy

mandates, ordinances, and where developers want to build. In particular, the mandates established in developing the interstate highway system have shaped these patterns.

Until recently, policy mandates and ordinances have largely focused on developing a motor vehicle oriented transportation system. However, environmental degradation and congestion trends are increasingly refocusing on a multimodal transportation system. If implementation of this reorientation is to be successful, comprehensive planning methodologies for alternatives to privately owned motor vehicles must be developed. This thesis focuses on a comprehensive approach to planning for bicycle compatible roadway networks.

## 1.2 What is Bicycle Compatibility?

Because bicyclists need and want to access the same houses, businesses, offices, work sites, parks, etc. that motorists do, the existing street network will naturally be the backbone of any bikeway system. Therefore, it is important to be able to evaluate roadways with respect to their desirability as places to bicycle. Bicycle compatibility refers to how well a roadway accommodates bicyclists. The assumption is that streets on which bicyclists feel less stress, or risk, are more bicycle compatible than streets on which bicyclists feel higher levels of stress or risk.

## 1.3 Thesis Overview

### 1.3.1 Purpose and Objectives

The **purpose** of this thesis is to provide information to facilitate Madison, Wisconsin's efforts "to develop and maintain an all-mode transportation system that offers convenient alternatives to private motor-vehicle travel" (DCRPC, 1991).

The **objectives** are to:

- 1) Propose a conceptual framework for bicycle transportation planning;
- 2) Apply the roadway compatibility module of this framework to the street network in Madison, Wisconsin; and

- 3) Evaluate the usefulness of the roadway compatibility module in planning for bicycle transportation.

### 1.3.2 Description of Study Area

The case study portion of this thesis is conducted in Madison, Wisconsin's capital city and home to just under 200,000 people in 1990, according to the US census data. It is the largest urban area in Dane County, Wisconsin's fastest growing county, and the second largest city in the state (Dane 2020 Task Force, 1992). The combination of the city's rapidly expanding suburbs and its unique beauty resulting from its placement among five lakes has heightened interest in and concern about land use and transportation patterns in Madison and Dane County and how changes in these patterns impact quality of life for residents (Dane 2020 Task Force, 1992). With respect to bicycling in Madison, the city has a reputation for being one of the more "bicycle friendly" cities in the country and in 1995 was ranked by Bicycling Magazine as the fourth best bicycling city in North America for cities with a population over 100,000 (Martin, 1995). [For a more detailed discussion of bicycling in Madison see Chapter 4].

**Figure 1: Location Map for Madison, Wisconsin**



*This thesis analyzes the bicycle compatibility of the arterial and collector street network in Madison, Wisconsin.*

### 1.3.3 Research Products

This thesis contains several **products**: a proposed conceptual framework for bicycle transportation planning; a roadway and traffic characteristics spreadsheet for Madison, Wisconsin; a bicycle compatibility rating map for Madison, Wisconsin; a bicycle compatibility warning map for Madison, Wisconsin; a discussion of further applications of bicycle compatibility evaluation results; and the identification of research needs to refine the proposed bicycle planning methodology. Although each of these products is described in much greater detail in subsequent chapters, each is briefly introduced here to provide an overview of the overall thesis.

#### 1.3.3.1 Proposed Conceptual Framework for Thinking About Bicycle Transportation Planning

Federal, state and local policies mandate that bicycles be accommodated in transportation systems and make general recommendations about desirable conditions to attain. However, for the most part they do not identify specific planning procedures to achieve these conditions. An objective of this project therefore is to propose and test a conceptual framework for achieving these mandates based on a review of planning, transportation and bicycling literature. The proposed conceptual framework for bicycle transportation planning outlines significant factors that must be considered if the bicycle compatibility of a transportation system is to be maximized. The roadway compatibility module of this proposed conceptual framework is then developed in greater detail. [See Sections 3.3 and 3.4 for a more detailed discussion of the proposed planning framework.]

#### 1.3.3.2 Bicycle Compatibility Planning Tools Applied in Madison, Wisconsin

The roadway compatibility module of the proposed conceptual framework for bicycle transportation planning is tested in a case study in Madison, Wisconsin. The methodology collects data about the cross-section and traffic characteristics of a roadway and then uses Sorton and Walsh's (1994) model to derive a bicycle compatibility index for the roadway based on its particular combination of cross-section and traffic

characteristics. [See Sections 4.2, 4.3 and 4.4 for a more detailed discussion of the roadway and traffic characteristics spreadsheet.]

A roadway and traffic characteristics spreadsheet is created and includes a bicycle compatibility index for every collector and arterial street segment in Madison, Wisconsin. To better understand how these ratings interact in the transportation system and to be able to more readily analyze the ratings at a glance, a bicycle compatibility rating map is created to represent graphically the rating data presented in the roadway and traffic characteristics spreadsheet. [See Sections 4.3.2 and 4.4.2 for a more detailed discussion of the bicycle compatibility rating map.]

A bicycle compatibility rating map provides a graphical representation of the compatibility of the collector and arterial streets. Each rating is based on the interplay between the curb lane width, speed of traffic in the curb lane and traffic volume in the curb lane. A bicycle compatibility warning map is also created to map roads which are at risk of changing from moderate to poor compatibility due to increases in traffic volume alone in the next five to ten years. [See Sections 4.3.3 and 4.4.3 for a more detailed discussion of the bicycle compatibility warning map.]

#### **1.3.3.3 Critique of the Roadway Compatibility Module of the Proposed Conceptual Framework for Thinking About Bicycle Transportation Planning**

The bicycle compatibility rating map and the bicycle compatibility warning map are useful tools upon which to base planning decisions. By combining the information provided in the maps with information about other aspects of the transportation system, comprehensive planning decisions which account for the needs of all transportation modes as well as for political and fiscal realities are possible. An objective of this project has been to develop a conceptual framework for adequately considering bicycle compatibility within this comprehensive planning process. This section discusses how the bicycle compatibility rating results obtained from the roadway compatibility module of the proposed bicycle transportation framework can be applied to lead to bicycle sensitive planning decisions. [See Section 5.1 for a more detailed discussion of potential planning decision applications of the bicycle compatibility evaluation results.]

Results from the case study in Madison, Wisconsin suggest the proposed roadway compatibility evaluation module of the proposed bicycle transportation planning framework is a useful planning tool for encouraging planning decisions that are sensitive to bicycles. However, the proposed methodology is far from perfect. This section discusses further research which would be useful to help refine the proposed conceptual framework for bicycle transportation planning. [See Section 5.2 for a more detailed discussion of recommendations for further research.]

## CHAPTER 2

### **THE BICYCLE'S NICHE IN THE TRANSPORTATION SYSTEM: YESTERDAY, TODAY AND TOMORROW**

#### **2.1 Historical Roots of Bicycling and Transportation\***

Until the early to mid 1800s, American cities were typically small and compact, often being referred to as walking cities. Cities in this era had a number of characteristics relevant to understanding the historical role which bicycles have played in American urban transportation systems. Walking was by far the most common mode of transportation and only the wealthy had horses and buggies. Because walking imposes a natural limit on a person's mobility, these cities by necessity had very high development densities. Land-use segregation was vertical rather than horizontal as it is today. Businesses were typically on the street level, the shop owners lived directly above the shops and the apprentices, employees and servants lived on the third floor.

High development density allowed people to access the goods and services they desired in spite of the inherent mobility limitations walking imposes. However, the social implications of this development pattern led many people to want to escape. For example, because there was no spatial separation between industrial and residential areas, people constantly had to contend with the noise and air pollution associated with industrial factories. High densities also meant disease was an inevitable part of life since sewage and garbage processing systems had not yet been developed. In addition, high densities with vertical land segregation meant that people from different social and economic classes and cultural backgrounds lived in very close contact with each other. Such close proximities aggravated economic class and cultural tradition conflicts.

As a result, when transportation technology provided people with greater mobility, those city workers who could afford it rapidly fled to the urban fringe, and so began the American suburbanization process. Several technological breakthroughs initially facilitated this flight from the crowded, noisy, dirty downtowns: the omnibus,

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\* Discussion in this section is based on Carter (1995) and Judd and Swanstrom (1994) unless otherwise noted.

trains, the horse car, the trolley and the bicycle. Omnibuses, introduced in about 1830, were horse drawn buggies that carried up to 12 passengers. Steam train lines were constructed in several large cities in the late 1830s. The trains were very expensive to construct and as a result the fares were also very high, thereby limiting ridership to the wealthy. In addition, steam trains are more conducive to fewer rather than frequent stops and therefore were more commonly used for travel between rather than within urban areas. In the 1850s the horse car, an omnibus on steel rails, was introduced. Although the horse car, like the omnibus, was uncomfortable to ride, the horse car still provided a major transportation breakthrough because it was twice as fast as the omnibuses and much less expensive to ride than the steam train. In 1888, the trolley car provided another technological transportation breakthrough that further facilitated geographical differentiation of urban areas.

Bicycles also played a role in providing urban residents greater mobility beginning in the mid 1800s when they were first introduced in the United States (Woodforde, 1970). Initially bicycles were very expensive and therefore it was the rich who were able to use bicycles to flee factory noise and pollution and cultural and class conflicts. The lower and even middle class citizens were left behind to continue living in the city center. However, as bicycles rapidly gained popularity and were produced on a larger scale, prices dropped, allowing their popularity to expand even further.

Interest in the bicycle rose rapidly and by the 1880s bicycling was considered one of the most viable means of transportation available.

A well-made tricycle constitutes one of the most agreeable, quickest and cheapest means of transport it is possible to conceive.

-Letter to *The Times*, 1882 (Woodforde, 1970, p. 67)

A very suitable means of transport for those who are obliged to travel a great deal...light luggage such as most travelers require is supported behind.

-*Cassell's Magazine*, 1881 (Woodforde, 1970, p. 68)

The growing popularity of bicycling led to the inception of the League of American Wheelmen (LAW) in 1880, the organization responsible for winning the first battles for improved streets and highways in the United States. The organization grew rapidly, and during the 1880s it was considered to be the most powerful citizen group in the United States (Fichter and Kingbay, 1972).

As in many communities across the United States, the bicycle played a significant role in the history of Madison, Wisconsin. Bicycle races were first introduced at the Dane County Fair in 1869 (Mollenhoff, 1982). The popularity of bicycling in Madison grew rapidly and Sunday afternoon rides around Lake Monona were soon a common activity. By the 1890s, Madison boasted a bicycle factory and had an active bicycle club that sponsored races that attracted participants from as far away as Milwaukee and Chicago (Mollenhoff, 1982).

Introduction of the automobile in the late 1890s meant that the bicycle was no longer the fastest, most mobile transportation available. At first, as with the bicycle, automobiles were expensive and so only the rich could afford them. As a result, the wealthy fled even farther from the city center. By this time bicycles were cheaper and trolley lines had been constructed to many of the original suburbs, so the middle class moved out to these areas.

By the 1910s, new mass production processes made automobiles much more affordable. In addition, the demand for better roads initiated by bicyclists was continued by the new motorists. As a result, the automobile rapidly gained popularity while interest in bicycling for transportation declined (Mollenhoff, 1982).

## **2.2 The Bicycle and Today's Transportation System**

Today, people in the United States are incredibly mobile and make by far the majority of their trips by automobile. The National Personal Transportation Survey (NPTS) (USDOT, 1990, p. 2-2) estimates that each year the total vehicle miles traveled by automobiles and motorcycles for trips 75 miles or less in the United States is 1.2 billion miles. This estimate represents a 37 percent increase over the 1983 estimate.

To better understand the transportation implications of these figures, consider the lengths of most trips. About 25 percent of all trips are less than a mile (USDOT, 1990). In fact, it is estimated that three percent of all trips made by automobile are no greater than 500 meters (Ullrich, 1990, p.106). In addition, over 65 percent of all trips are five miles or less. Therefore, the estimated 1.2 billion miles that Americans travel each year are largely comprised of many short trips rather than few long trips.

The automobile is far and away the transportation mode most often chosen. The NPTS reports that of the more than 242 billion person trips made in 1990, 87.4 percent of these trips were made in privately owned motor vehicles. This percentage was up from 81.8 percent in 1983 (USDOT, 1990). To demonstrate the automobile's extreme dominance, consider that in 1990 walking was the second most common choice, but walking represented only 7.4 percent of all person trips made. Increases in automobile ownership between 1945 and 1990 also underscore the dominance of the automobile in the US transportation system. Whereas the US population has grown by 87% (from 133 million to 249 million) during this period, the number of registered autos has risen by 479% (from 25 million to 143 million) (Levy, 1994, p. 195). As a result, whereas in 1945 there were 5.3 people for every car, in 1990 this figure had dropped to 1.7 people per every car owned.

This extreme mobility and dominance of the automobile in the transportation system is a significant contributing factor to the nearly equally extreme congestion problem that some urban areas face today. Simonds (1994, p.142) offers an interesting traffic congestion analogy: "Since transportation is the life blood of commerce, it would seem wise to sustain its vital flows. Why is it then that most cities have a chronic case of hardening of the arteries?" In Los Angeles, for example, it is estimated that 100,000 hours are wasted in traffic jams every day (Lowe, 1991). Further, it is estimated that by the turn of the century almost 2,000,000 hours every day will be wasted in traffic congestion in California alone (Lowe, 1991). The United States Department of Transportation (USDOT) estimates that in 1984, nearly three billion gallons of gasoline were consumed as a result of traffic congestion, accounting for roughly four percent of the nation's annual gasoline consumption (Renner, 1988).

Burtenshaw et al. (1991, cited in Carter, 1995) summarize issues related to transportation and land use:

Above all [the automobile] is profligate in its use of space, precisely where space is scarcest, both when in use and also for 98 percent of its existence when it is stationary. Estimates of the numbers of cars parked for periods up to eight hours on working days in the central areas of cities such as Paris or London are around a million, and whether on- or off-street, legal or not, the result is an enormous consumption of the scarcest of urban resources, space. Most European cities devote between 10 and 20 percent of the total land area to accommodating cars. In Cologne, for example, road and parking space took up twice the area of the city's parks and almost half as much as was devoted to buildings of all types.

The impacts of these collective transportation choices are far reaching. To park a single automobile at home, the office and the shopping mall requires on average 4,000 square feet of asphalt (Renner, 1988). As a result, in most cities one third of the total land area is consumed by roads and parking lots. In Los Angeles the figure is two thirds of the total land area (Lowe, 1991). Collectively in the United States, 38.4 million acres (60,000 square miles) are dedicated to the automobile infrastructure—more than the area of the entire state of Georgia (Renner, 1988). Another way to summarize this fact is that about two percent of the United States' total surface area and 10 percent of all arable land is dedicated to infrastructure for the automobile.

Hillman (1990) has documented connections between lower residential densities, wider spread of desired destinations, increased car usage and dramatically lower bicycle usage. Despite the extreme dominance of the automobile in the present transportation system, 96 million Americans bicycled at least once in the last year (BIA, 1991). Although only 0.7 percent of all trips are made by bicycle, this figure has quadrupled in the last decade with virtually no public policy push, suggesting that official encouragement could inspire a more dramatic changeover (USDOT, 1990; Lowe, 1991, p. 259).

### 2.3 Visions of Bicycling and the Future of Transportation in the United States

Achieving a desired goal requires attention to three components: comprehensive understanding of current conditions, a carefully articulated vision of the desired goals and an exploration of mechanisms for making the transition from the current conditions to the desired future conditions. The previous section briefly summarized the present extreme automobile focus of most US urban areas and some of the environmental, geographical, social and economic consequences of this orientation. This section describes a possible vision of the future, summarizes processes which influence the vision, suggests possible mechanisms for achieving this future, and finally discusses the potential vital role the bicycle might have in achieving and maintaining this vision.

Many writers have indicated a desperate need to redirect our communities away from the present extreme automobile, massive highway dominance, and current approach to modifying the landscape:

By and large, our present problem is one of attitudes and implements. We are remodeling the Alhambra with a steam-shovel, and are proud of our yardage. We shall hardly relinquish the shovel, which after all has many good points, but we are in need of gentler and more objective criteria for its successful use. (Leopold, 1949)

The automobile once promised a dazzling world of speed, freedom, and convenience, magically conveying people wherever the road would take them. Given these alluring qualities, it is not surprising that people around the world enthusiastically embraced the dream of car ownership. But societies that have built their transport systems around the automobile are now waking up to a much harsher reality. The problems created by over reliance on the car are outweighing its benefits. (Lowe, 1990, p. 5)

Eighty percent of everything ever built in America has been built in the last fifty years, and most of it is depressing, brutal, ugly, unhealthy, and spiritually degrading—the jive-plastic commuter tract home wastelands, the Potemkin village shopping plazas with their vast parking lagoons, the Lego-block hotel complexes, the "gourmet mansardic" junk-food joints, the Orwellian office "parks" featuring buildings sheathed in the same reflective glass as the sunglasses worn by chain-gang guards, the particle-board garden apartments rising up in every meadow and cornfield, the freeway loops around every big and little city with their clusters of discount merchandise marts, the whole destructive, wasteful, toxic, agoraphobia-inducing spectacle that politicians proudly call 'growth.' (Kunstler, 1993, p. 10)

Along with this articulated need for change, there is a widespread optimism that there is a great potential to achieve change:

Within the next 30 to 50 years—as in the past 30 to 50—most buildings, roads, and other structures in the United States will have been replaced as worn out or obsolete. We will thus have been given another chance. As a guideline in the reshaping-rebuilding process there is need by every jurisdiction for a comprehensive long-range plan. These, if they are worthy, will be designed to the underlying topography and around an open space frame. (Simonds, 1994, p. 127)

Given the established need, desire and potential for change, the next critical step in achieving change is defining a vision of the desired endpoint to work toward. With respect to the transportation component of a vision of our future urban areas, Lowe (1990, p. 39) succinctly offers one possible vision that integrates multiple transportation modes in a balanced manner by emphasizing the strengths of each mode without overemphasizing any particular mode:

What would the future look like, if cities were not dominated by cars? The very heart of a city would be reserved for people on foot and

passengers arriving by metro or trolley. Proceeding outward from the center, streets would become the shared domain of pedestrians, cyclists, trolleys and buses. Slow automobile traffic would be allowed beyond the city's densest core, but convenient bus and rail services—running between stops placed within walking or cycling distance of most points—would offer a faster mode of travel. Express public transport routes would link outlying areas to each other and to the downtown. Car parking would be progressively less restricted as one moved away from the city center.

People would make most short trips by foot or bicycle, and longer urban trips by walking or biking to transport stops, then continuing by bus, metro, or trolley. Many long drives and short airplane flights between cities would be replaced by train trips. The automobiles' main function would be to make trips for which these other modes are inconvenient, such as transporting loads of things or groups of people, traveling at odd hours when public transport is running infrequently, and certain recreational uses. (Lowe, 1990, p. 39)

The vision of the future can also be approached from a broader perspective that views urban areas more comprehensively and considers the transportation system as but one element in a larger system. Within this framework, environmentalists, economists, sociologists and architects each offer a possible component in this broader vision. Broadly, environmentalists are interested in minimizing urban impacts on the landscape. For example, Lewis (1996) emphasizes higher living densities to minimize land consumed and alternative transportation options to reduce air and water pollution. Economists add another component to this vision. In particular, E.F. Schumacher (1973) emphasizes "appropriate technology" advocating that we must pay close attention to scale—the physical scale of effort, financial scale, and resource consumption scale to mention a few. If the scale of any of these elements gets too large, Schumacher argues the technology used to achieve that goal is inappropriate. As a result, Schumacher argues that bicycles are a much more appropriate transportation technology than automobiles for creating human scale livable communities.

In addition to environmentalists and economists, sociologists provide another perspective about a vision of the future. For example, Appleyard and Lintell (1975) argue that walking and bicycling facilitate social interaction. Conversely, they have found the presence of large numbers of motor vehicles degrades the physical and psychological environment in urban areas in terms of noise, vibration and visual intrusion they cause. Appleyard and Lintell compared lightly and heavily trafficked streets and found that in the latter, residents' privacy and their network of acquaintances were reduced, their sense of

personal territory was diminished, and their activity in the street was curtailed by the streams of motorized traffic. In addition, Cleary (1992) notes instances where people have been forced to vacate the rooms in their home that front the road due to intolerable traffic noise and vibration. As a result, some sociologists advocate a vision of the future that reduces automobile travel and increases bicycling and walking travel in order to improve the social orientation of neighborhoods as well as to reduce the negative impact on the residents' psychological well-being from the noise, vibration and visual intrusion of heavy motor vehicle traffic.

Finally, architects and designers such as Duany (1991), Calthorpe (1993) and Katz (1994) also contribute to a possible vision of the future. The neotraditional development principles they advocate emphasize that everything in the community should be accessible by a five minute walk. To accomplish this goal, they tout design characteristics such as dense development, small setbacks, front porches, alleyways, narrow streets, and combined living and working quarters. They argue that the result of adhering to these design principles is a community where residents actively interact with their neighbors, spend little time commuting, and have choices other than the automobile to go about their daily business. By encouraging walking to meet their travel needs, residents are encouraged to integrate commuting with exercise, socializing and enjoying their natural surroundings.

Environmentalists, economists, sociologists and architects/designers clearly approach the future from divergent backgrounds. However, despite such diversity, this discussion has also revealed some common themes. All agree that less motor vehicle traffic will result in an environmentally, economically and sociologically healthier community. With respect to mechanisms to achieve this vision of the future, there is a common theme focusing on understanding the transportation-land use connection. Development density, spatial distribution of activity centers and the physical space required for different transportation modes are components of this connection that should be considered in designing strategies to implement the vision of the future outlined above. To summarize the significance of the transportation-land use connection, Renner (1988) describes it as follows:

There is a symbiotic relationship between land use patterns and transportation networks. Public transit systems can facilitate and reinforce more compact land use, while land use patterns frequently determine transportation needs. For example, car dependency can be decreased by

zoning ordinances that encourage a higher density of urban activity while slowing development at the urban perimeter. The more concentrated both population and jobs are, the shorter are travel distances, the more mass transit becomes viable, and the more walking and biking occurs. In short, more compact cities foster less individual motorized transport. (Renner, 1988, p. 51)

Density of development is one important factor of the transportation-land use connection to consider in developing strategies to implement this vision. Several studies suggest that when the density of people in urban area drops below 30-40 people per hectare, reliance on the automobile escalates (Lowe, 1990). For example, Newman and Kenworthy (1989) found that in 32 of the world's major cities, there are substantially higher levels of bicycling, walking and public transit use in cities which have more people and jobs on every hectare of land (Table 1). In addition, they found that in cities where there were more parking spaces in the downtown area, there was also a greater reliance on automobiles. These findings suggest encouraging higher development densities would be one mechanism to help facilitate reaching the vision of the future outlined above.

Spatial distribution of activity sites is another component of achieving the vision of the future. Hanson and Schwab (1986) point out that "several decades ago numerous small food stores dotted the urban landscape; these stores, which were easily accessible on foot, have now given way to fewer, larger, more widely spaced stores surrounded by parking lot moats." In addition, Cervero (cited in Lowe, 1990) argues "there is no longer a strong case for separating homes from jobs, because today's workplaces are not the smokestack factories and slaughterhouses of the industrial era".

Finally, the physical space required to accommodate different transportation modes is also an important factor to consider in developing strategies for implementing the vision of the future. When it comes to land consumption for transportation infrastructure, bicycles are by far more efficient than cars. For example, ten bicycles can be parked in the same space required for parking one car (Cleary, 1992). In addition, a bridge that can accommodate 40,000 people in an hour would require 12 lanes for cars, 4 lanes for buses and 2 for trains, whereas to accommodate the same 40,000 people on bicycles would require only a single lane (Lowe, 1991, p. 254).

**Table 1: Urban Densities and Commuting Choices for Selected World Cities, 1980**

City	Land Use Intensity (pop + jobs/ha)	Private Car			Public Transport			Walking and Cycling		
		(percent workers using)			(percent workers using)			(percent workers using)		
Phoenix	13	93	3	3						
Perth	15	84	12	4						
Washington, D.C.	21	81	14	5						
Sydney	25	65	30	5						
Toronto	59	63	31	6						
Hamburg	66	44	41	15						
Amsterdam	74	58	14	28						
Stockholm	85	34	46	20						
Munich	91	38	42	20						
Vienna	111	40	45	15						
Tokyo	171	16	59	25						
Hong Kong	403	3	62	35						

*Newman and Kenworthy (1989) found that in 32 of the world's major cities, there are substantially higher levels of bicycling, walking and public transit use in cities that have more people and jobs per hectare of land. [Source: Newman and Kenworthy, 1989]*

Clearly, the bicycle has the potential to play a central role in implementing this vision of the future. The environmental, health and convenience benefits of bicycling relate directly to the visions of the future expressed by environmentalists, economists, sociologists and architect/designers alike. Bicycles have several distinct advantages over automobiles: they do not emit exhaust fumes, they are much less expensive to own and operate, they combine exercise with transportation, and they provide greater opportunities to talk to neighbors, hear the birds and smell the flowers than do automobiles. In addition, bicycles provide greater mobility than walking because one can travel farther in the same amount of time. Integrated engineering, education, enforcement and encouragement efforts will be crucial in maximizing the bicycle's impact on efforts to

achieve this vision. For example, if efforts to redirect our communities focus exclusively on bicycle ownership, hypothesizing that if more people own bicycles, dependence on the automobile will drop and many of the goals in the vision will be achieved. However, Lowe (1991, p. 250) points out that bicycle ownership does not necessarily mean use: "One in four Britons has a bicycle, yet only one transport trip out of 33 is made by bike. Only one out of 50 bikes in the United States is used for commuting; most of the rest are ridden by children and sports enthusiasts, or are collecting dust in the basement."

If bicycles are to play an increased role in our transportation system, transportation facilities must better accommodate bicyclist needs. Accomplishing this goal on a widespread basis will require that bicycles be adequately considered in transportation planning efforts. Therefore, an objective of this thesis is to propose a conceptual framework for bicycle transportation planning to facilitate this process.

### CHAPTER 3

## **BICYCLE COMPATIBILITY MAXIMIZATION: PROPOSED APPROACH FOR URBAN BICYCLE TRANSPORTATION PLANNING**

This thesis stems from an interest in addressing issues related to federal, state and local policy mandates that call for greater levels of bicycling and a transportation system that safely accommodates bicycles (See Section 4.1.2.1 for further discussion of these mandates). Since transportation planning was institutionalized earlier in this century, the primary emphasis has been on facilitating automobile mobility (Levy, 1994). Bicycles have typically not been considered in transportation planning and when they have, there has been no accepted planning process to guide efforts to integrate bicycle concerns into the planning process (Antonakos, 1994). As a result, efforts to integrate bicycle concerns into transportation planning have been sporadic and unorganized at best. However, the policy mandates at all levels of government will require fundamental transformations in the way transportation systems are planned, designed, implemented and managed. Such fundamental changes, if they are to have any chance of being successful, will require a comprehensive, carefully planned effort.

A standard methodological framework for approaching bicycle transportation planning would be useful for facilitating efforts to achieve the mandated policy goals. Because most transportation planning today is so strongly oriented toward accommodating motor vehicles and because this approach has been accepted, praised and unquestioned for so many years, there is considerable momentum to continue in this direction despite the overwhelming evidence of the need for change (Tolley, 1993). Without a comprehensive alternative to replace present methods, momentum will likely result in the maintenance of the present auto-dominated approach. Just as hitting a fast moving bowling ball with ping pong balls is unlikely to produce enough force to change its direction, haphazard or piecemeal attempts to re-direct transportation planning are unlikely to have a substantial lasting impact.

For this reason, one of the goals of this thesis is to propose a conceptual framework to guide bicycle transportation planning efforts. This framework will outline transportation system elements critical to accommodating bicycles in the transportation system. Brief discussions about each element are offered to raise some of the issues that should be considered in developing performance standards for a bicycle compatible transportation system. The roadway compatibility element of this conceptual framework will then be developed in greater detail to propose a complete methodology for evaluating bicycle compatibility of roadways. The roadway compatibility module of the proposed conceptual framework for bicycle transportation planning is then tested in a case study application in Madison, Wisconsin. Summaries of typical contemporary transportation planning model elements as well as of published bicycle transportation planning guidelines provide a context for understanding and interpreting the proposed conceptual framework.

### 3.1 Typical Transportation Planning Model Elements

Most transportation planning models are based on four components: trip generation, modal split, trip destination and traffic assignment (Clark, 1995; Levy, 1994; Pas, 1986). These components provide a framework for making decisions about how to meet citizen demands to have access to a transportation system that provides free and unhindered movements, preferably door to door, by the most convenient medium possible.

Trip generation involves documenting and predicting the basic reasons why people want to move about the urban area. Typical purposes for trips include work, shopping, social, recreation, school and going home. The National Bicycling and Walking Study (NBWS) (USDOT, 1994) compares the 1990 distribution of these trip purposes for all travel modes collectively with the distribution for trips made by bicycle (Table 2). The National Personal Transportation Study (USDOT, 1990) found the distribution of trip purposes for all modes to be the same in 1990 as it was in 1983, indicating the distribution is stable.

Understanding trip generation gives insight into when and where trips are likely to take place and how these patterns influence the transportation system. The temporal pattern of these trips illustrates the congestion that is problematic in so many urban areas

as a result of so many people wanting to go similar places at similar times (Carter, 1995; p. 155).

**Table 2: Trip Purpose Distributions for All Modes and for Bicycles**

Trip Purpose	All Travel Modes	Bicycle
Earning a Living	21.6%	9.9%
Personal/Family	41.5%	19.7%
Social/Recreational	24.8%	55.4%
Civic/Educational	11.4%	14.1%
Other	0.7%	1.0%

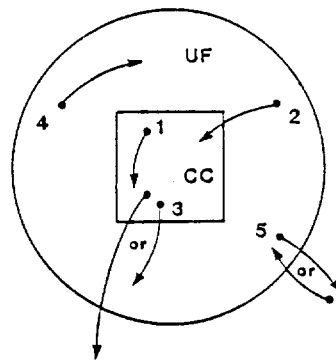
*Trip generation involves documenting and predicting the basic reasons why people want to move about the urban area. Typical purposes for trips include work, shopping, social, recreation, school and going home. Proportionally, more social/recreational and fewer work and personal/family trips are made by bicycle than by all travel modes collectively. [Source: USDOT National Bicycling and Walking Study, 1994]*

Modal split, the second element in typical transportation planning models, refers to what means of travel people use for various trips. Modal split data show the extreme reliance on the automobile in the United States. Nationally, the NPTS (USDOT, 1994, p. 4-4) reported that 87.4% of all trips are made by privately operated motor vehicles, 7.4% by walking, 1.3% by bus, 0.7% by bicycle, 0.5% by rail, 0.2% by taxi and 2.6% by some other mode. Planners often use modal split data to indicate types and quantities of various transportation facilities necessary to create a well-functioning transportation system. However, it should be noted that modal split data provide insight into current travel patterns, not what is desired. Therefore, a more appropriate use of modal split data is perhaps to help planners better understand current conditions in efforts to plan for changes to get from present to desired conditions.

Trip distribution, the third element in typical transportation planning models, focuses on identifying the locations people want to access and the flows of people in the urban area between origins and destinations. Whitelegg (1985) identified four categories

that broadly describe the possible types of movements in an urban area: from outside the urban core into the Central Business District (CBD); from the CBD to the suburbs, or reverse commuting; from one suburb to another, or cross-suburb commuting; and from outside the metropolitan area either to the suburbs or the CBD, or long distance commuting. Historically, flows between the suburbs and the city center have dominated the system, and therefore the transportation system in many urban areas is based on a backbone of large arterial streets radiating from the city center to accommodate these flows (Judd and Swanstrom, 1994) (Figure 2). However, as cities have continued to grow, cross-suburb commuting has become much more common; therefore commuting patterns have become increasingly complex (Plane, 1981).

**Figure 2: Movement Patterns Between Origins and Destinations in Urban Areas**



*Historically, people moving between the suburbs and the city center have dominated transportation movements, and therefore the transportation system in many urban areas is based on a backbone of large arterial streets radiating from the city center to accommodate these flows. The above diagram depicts common movements within and between the central city (CC) and the urban fringe (UF): (1) within central city, (2) inward, (3) reverse, (4) lateral, and (5) cross. [Source: Plane, 1981]*

Trip assignment is the final element in typical transportation planning models. This planning phase involves assigning specific routes to the flows between origins and

destinations. By assigning particular trips to specific routes, decisions can be made about the size, quantity and location of various facilities needed to provide unhindered travel.

In summary, typical transportation planning models use information about trip purpose, travel mode, and routes taken to design transportation systems that maximize people's ability to get where they want to go as quickly and as conveniently as possible. Although each model element is conceptually straight forward, the implications of how all the elements can come together as a system are very complex. Due to the contemporary dominance of the automobile, understanding the nuances of these elements has focused almost exclusively on designing transportation systems to accommodate motor vehicles. Guidance available to direct transportation planning for other modes such as the bicycles is quite limited.

### **3.2 Published Bicycle Planning Guidelines**

Given that current typical transportation planning models are not designed to address bicycles adequately, bicycle transportation planners must turn to other sources to guide their planning efforts. Published bicycle planning guidelines are the primary alternative direction available today. The American Association of State Highway and Transportation Officials (AASHTO) *Guide for the Development of Bicycle Facilities* (AASHTO, 1991), the *Manual of Uniform Traffic Control Devices* (AASHTO, 1988), and Wisconsin's *Bicycle Planning Guidance* manual (WisDOT, 1991) are the primary sources for facilitating uniform, defensible bicycle transportation planning in Wisconsin. Discussion of these three documents provides a better understanding of the context within which current bicycle transportation planning in Wisconsin takes place and establishes the need for a methodology to guide planning decisions.

#### **3.2.1 American Association of State Highway and Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities**

The American Association of State Highway and Transportation Officials (AASHTO) publishes the *Guide for the Development of Bicycle Facilities* (AASHTO, 1991). The authors describe the purpose of the guide as follows:

Safe, convenient and adequate facilities are essential to encourage bicycle riding. The purpose of this guide is to provide information on the

development of new facilities to enhance and encourage safe bicycle travel. The majority of bicycling will take place on ordinary roads with no dedicated space for bicyclists. Bicyclists can be expected to ride on almost all roadways; and sometimes they use sidewalks as joint bicycle and pedestrian facilities.

This guide provides information to help accommodate bicycle traffic in all riding environments. It is not intended to set forth strict standards, but, rather, to present sound guidelines that will be valuable in attaining good designs sensitive to the needs of both bicyclists and other highway users. However, in some sections of this guide, design criteria include minimums. These are established only where further deviation from desirable values would result in unacceptable safety compromises. (AASHTO, 1991)

The AASHTO guidelines provide a framework for thinking about bicycle transportation planning. The guide summarizes aspects of the transportation network which should be considered when planning for bicycle transportation. Roadway conditions which impact bicyclists are outlined and it is recommended that access to trip generators (e.g. employment centers, schools, parks, shopping centers), bicycle crash locations and public perceptions be examined in developing facilities to enhance and encourage safe bicycle travel. The design segment of the guidelines summarizes issues related to drainage grates, railroad crossings, pavements, traffic control devices, shoulders, wide curb lanes, designated bicycle routes, bicycle lanes, and intersections with bicycle lanes. Some of these discussions, such as that for pavement, are extremely non-specific, simply pointing out that cracks and potholes are more than a bumpy ride and are a safety issue because they can cause loss of control. Other discussions include more substantive guidelines. For example, the bicycle lane width section declares "under ideal conditions, the minimum bicycle lane width is four feet."

Wisconsin Bicycle-Pedestrian Coordinator Tom Huber (1996) notes that he finds these guidelines particularly useful when justifying recommendations for bicycle facilities on a roadway. If these guidelines are not followed and an crash occurs, liability becomes a significant issue. Huber also notes the downside of the AASHTO guidelines is that although they provide minimum safety standards, there is no discussion about factors which combine to influence how comfortable a bicyclist will feel using a particular roadway. As a result, although the guidelines state that bike lanes should be at least four feet wide, no guidance is provided regarding how to decide whether or not a bicycle lane should be provided on a particular roadway. Therefore, the AASHTO guidelines are

primarily useful for developing recommendations about specific facility characteristics once the decision to provide that facility has been made.

### 3.2.2 Manual of Uniform Traffic Control Devices (MUTCD)

AASHTO publishes MUTCD to provide uniform national standards for traffic control devices including "all signs, signals, markings, and devices placed on, over, or adjacent to a street or highway by authority of a public body or official having jurisdiction to regulate, warn, or guide traffic" (AASHTO, 1988). The manual is divided into a number of sections: signs; markings; signals; traffic controls for construction, maintenance, utility and emergency operations; traffic controls for school areas; traffic control systems for railroad-highway grade crossings; and traffic controls for bicycle facilities.

The bicycle facilities section of MUTCD provides guidance about the design and placement of signs, markings and signals related to bicycle facilities. Once the decision has been made to provide a bicycle facility in a particular location with given specifications, the MUTCD provides useful guidance for providing signs, markings and signals to ensure safe, efficient functioning of the bicycle facilities. However, MUTCD does not provide methodological guidance for designing bicycle compatible roadways.

### 3.2.3 Wisconsin Bicycle Planning Guidance Manual

The *Wisconsin Bicycle Planning Guidance* manual (WisDOT, 1993) is divided into two major sections directed at metropolitan planning organizations (MPOs) and communities wishing to plan for and develop bicycle facilities. The first section focuses on discussing a planning process for bicycle planning while the second focuses on implementation strategies. The manual points out that although education and enforcement are not addressed in the manual, they are important factors to consider in conjunction with plans for establishing bicycle facilities.

The *Wisconsin Bicycle Planning Guidance* manual recommends a seven step process for developing a bicycle plan:

1. Develop goals, objectives, policies;
2. Establish/refine planning criteria for the bicycle transportation system;

3. Inventory bicycle usage, crashes, existing bikeway and roadway characteristics;
4. Identify bicycle travel corridors;
5. Evaluate, select specific route alternatives and design treatments;
6. Prepare a safety component; and
7. Evaluate the plan against pre-established planning criteria, goals, objectives.

In addition to recommending planning steps to follow in developing a bicycle plan, the manual also makes recommendations about implementing the plan. It suggests factors including funding opportunities, signing, mapping, design and land use/site planning that should be addressed when developing strategies for implementing the bicycle plan derived from the above seven step process.

For both the planning process and the implementation sections of the *Wisconsin Bicycle Planning Guidance* manual, brief descriptions of factors to consider within each component are provided. For the plan process components, several appendices are included to provide guidance about design standards. The manual also suggests the AASHTO guidelines and the MUTCD are valuable references to direct implementation of this planning process. The manual does not specifically address the concept of evaluating roadway compatibility. It does discuss different types of bicycle facilities and minimum standards that should be employed for various facilities. For example, the manual recommends "on multi-lane arterials and collectors with higher motor vehicle volumes and/or significant truck/bus traffic, a right (curb) lane wider than 12 feet is desirable to better accommodate both bicyclists and motor vehicles in the same travel lane. . . . AASHTO guidelines consider a lane width of 14 feet of usable width as being desirable on road segments where parking is not permitted in the curb lane" (WisDOT, 1993, p. 23).

These guidelines, thus, are helpful in recommending that curb lanes should not be less than 12 feet if the transportation system is to adequately accommodate bicyclists. However, the discussion in the manual does not address how curb lane width interacts with other roadway characteristics to influence bicycle compatibility, nor does the manual suggest criteria for evaluating the difference between say a 14 foot and 15 foot curb lane for bicycle compatibility.

In summary, the *Wisconsin Bicycle Planning Guidance* manual outlines a bicycle planning process and discusses some of the factors which should be considered under each step in the planning process. However, the process outlined is a conceptual framework rather than a directly implementable process. This thesis further develops the conceptual framework for bicycle transportation planning and develops a segment of the proposed framework as a step-by-step implementable process.

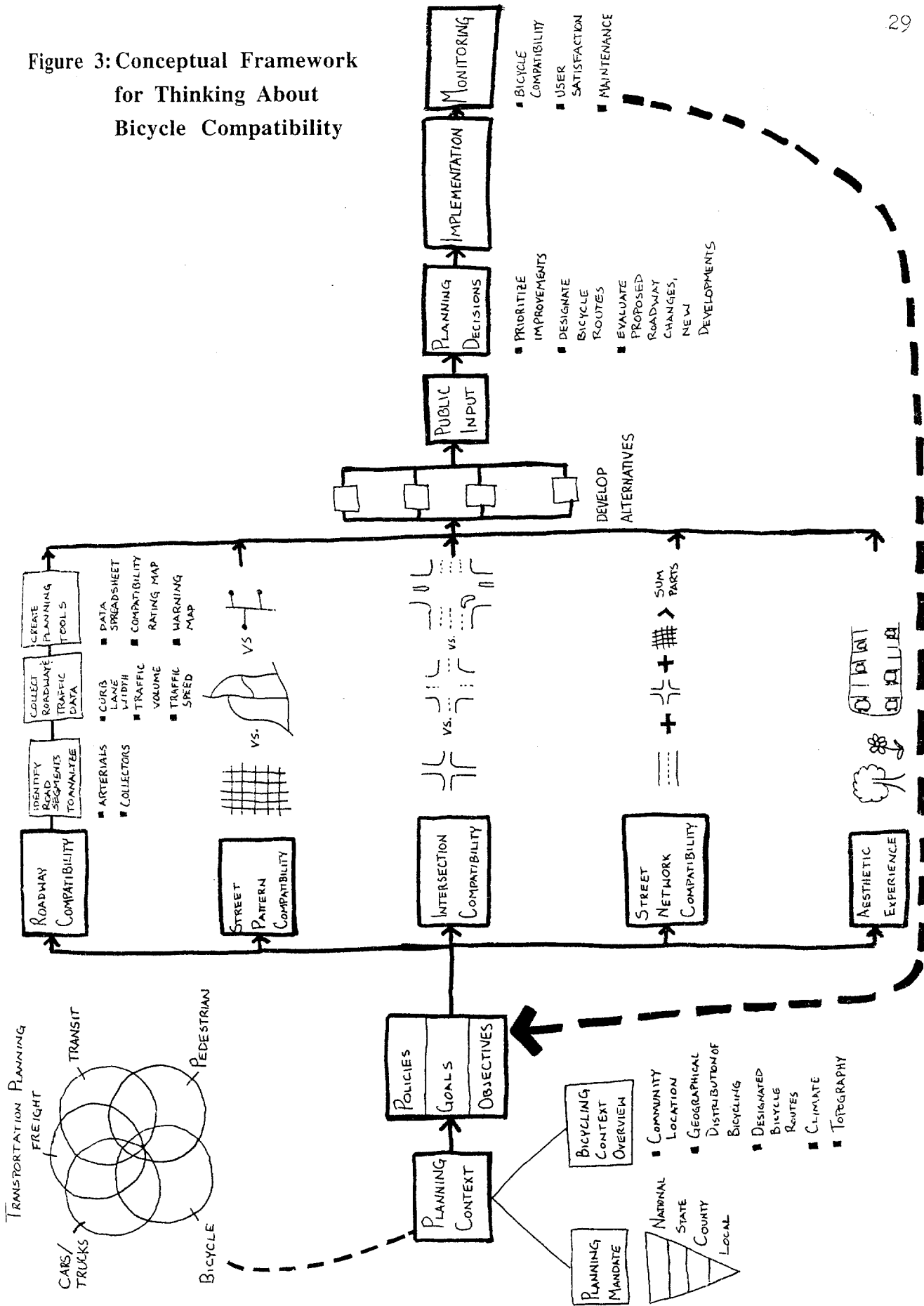
### 3.3 Proposed Framework for Thinking About Bicycle Compatibility

Two of the available published bicycle transportation planning guidelines emphasize design standards rather than establish a step-by-step process to follow to design a bicycle compatible transportation system. The *Wisconsin Bicycle Planning Guidance* manual (WisDOT, 1991) does discuss a planning process, but the discussion is general enough that it cannot be directly operationalized. Therefore, this thesis proposes a conceptual framework for bicycle transportation planning that brings the WisDOT guidelines a step closer to a directly implementable process.

In order to plan successfully for and implement a bicycle compatible transportation system, this thesis proposes that planning efforts should be guided by a logical, well-defined process (Figure 3). Before any planning takes place, the framework suggests it is important to recognize that bicycles are but one component of the broader transportation system. The first step in proposed bicycle compatibility planning framework is to describe the context in which planning is taking place. The planning context description should include:

- 1) An outline of the national, state, county and local policies mandating bicycle transportation planning;
- 2) Information about the community's climate, topographical and other natural features;
- 3) A description of currently designated bicycle routes; and
- 4) An inventory of the current levels of bicycling and a discussion of their geographical variation.

Figure 3: Conceptual Framework for Thinking About Bicycle Compatibility



Once the planning context is established, policies, goals and objectives must be developed to provide a direction for the planning process. These statements detail the desired bicycle compatible transportation system and how to get from current conditions to desired conditions. Often policies, goals and objectives will be outlined in local, county, state and federal bicycle planning mandates. If this is the case, these statements may be adopted to guide current planning efforts. On the other hand, if these statements either do not exist or do not reflect the desired vision of the future, then policy, goal and objective statements should be developed at this point.

The next phase in the proposed bicycle planning framework is to analyze five factors that are significant physical elements contributing to a transportation system's overall bicycle compatibility: roadway compatibility, street pattern compatibility, intersection compatibility, street network compatibility and aesthetic experience. Each of these modules can be thought of as an additional layer of knowledge, much like adding another layer to a series of overlay maps. Each layer leads to a more comprehensive understanding of the transportation system and thereby facilitates better informed decisions regarding maximizing bicycle compatibility.

Roadway compatibility refers to the degree of risk (both real and perceived) a bicyclist experiences on a roadway. Roads where bicyclists experience little risk are considered to have good bicycle compatibility, whereas roads where bicyclists experience much risk are considered to have poor bicycle compatibility. It is this module of the proposed bicycle planning framework that is subsequently detailed as a step-by-step process and tested in a case study in Madison. Street pattern compatibility refers to the various patterns in which streets might be laid out and how these patterns influence the likelihood a person will bicycle within or through an area. Street patterns that provide multiple, direct route choice alternatives and do not funnel bicyclists onto high speed, high volume streets are considered to be most bicycle compatible. Intersection compatibility represents how safely and straight-forwardly bicyclists can proceed through intersections. Further, street network compatibility involves evaluating how the roadway, street pattern and intersection elements come together to behave as a system to provide a transportation system that provides bicyclists access and mobility either to a greater or lesser degree. The final compatibility component suggested in the proposed conceptual framework is aesthetic experience. The intention of this component is to remember that

the spaces created by planning efforts are intended for human use and that therefore it is important to consider the degree to which the spaces created are pleasant to occupy. Each of these compatibility components is discussed in greater detail following a discussion of the derivation of the structure for the proposed conceptual bicycle transportation planning framework.

A comprehensive understanding of the planning context; the policies, goals and objectives guiding the planning; and the transportation system's bicycle compatibility are essential for making informed decisions about recommendations for transportation facility improvements that will maximize the system's bicycle compatibility. This knowledge base facilitates efforts including making roadway configuration recommendations, prioritizing improvements, designating bicycle routes, evaluating proposed road changes, and evaluating plans for new developments. Two elements that should precede making final recommendations about the above issues are the development of possible alternative solutions and public input about their preferences for the various alternatives.

The final steps in the proposed bicycle planning framework are implementation and monitoring. As with any planning process, it is important not just to recommend what should be done but also to provide guidance about how to implement the recommendations, how to monitor the success of the efforts and how to proceed depending on the outcome of the monitoring process.

This proposed conceptual framework for bicycle transportation planning is derived from three sources: planning process literature, design process literature, and bicycle literature. For example, Levy (1994) outlines a comprehensive planning process employed in much urban planning today. Typically, the comprehensive planning process begins with a research phase which emphasizes describing present conditions and future trends. Levy suggests this research phase of the comprehensive planning process might include a number of studies: a population demographics study, a land-use inventory study, an economic base study, a circulation study, an infrastructure study and a recreation study. Once the present conditions and future trends are understood, the comprehensive planning process Levy outlines recommends that community goals and objectives should be clarified. The final stages in the comprehensive planning process Levy outlines are plan formulation, plan implementation, and plan revision and review.

The second literature source upon which the proposed conceptual framework for the bicycle transportation planning model is based is the design process literature. Thiel (1981) outlined an eight-step design process:

- Identify the problem and its contextual constraints;
- Specify goals and performance criteria;
- Suggest possible alternative solutions;
- Simulate proposed solution;
- Test performance criteria on proposed solution;
- Compare evaluations of acceptable solutions;
- Implement the most suitable alternative solution; and
- Evaluate the implemented alternative against performance criteria.

The bicycle literature also contain planning process models. In particular, I considered two references: the Draft Bicycle Master Plan for Lubbock, Texas (BFA, 1995) and the Bicycle Planning and Facilities Workshop Manual (Sorton, 1994). The Bicycle Federation of America (1995) outlines a four-step planning approach it used in developing the Lubbock Bicycle Master Plan:

- Identify and understand different types of bicyclists;
- Identify and understand different bicycle facility options;
- Identify general changes to future design and implementation of transportation system to accommodate bicyclists; and
- Identify a community-wide bicycle network.

Sorton (1994) advocates a similar approach in his Bicycle Planning and Facilities Workshop Manual:

- Develop goals and objectives;
- Estimate existing bicycle use;
- Inventory existing environment;
- Establish planning and design principles;
- Develop alternative plans;
- Evaluate alternative plans;
- Detail preferred plan;
- Develop phasing and implementation plan;

- Implement plan; and
- Monitor and evaluate ongoing activities.

These planning processes outlined in the planning, design and bicycle literature provided guidance in developing the presently proposed conceptual bicycle transportation planning framework. The proposed model described above draws on each of these fields, following common themes and adapting unique aspects to the bicycle compatibility planning context. For example, common themes which were also included in the proposed conceptual framework include inventorying current conditions, establishing goals and objectives, and monitoring results. Also, Levy's recommendation about studies to include as part of the inventory process were adapted in the bicycle compatibility conceptual planning framework as the suggested compatibility studies to undertake.

The four bicycle compatibility modules suggested in the proposed bicycle compatibility conceptual planning framework as described earlier include: street patterns, intersection design, access and mobility evaluation and roadway design. Literature relating to each module is summarized to provide a more comprehensive understanding about how each might be implemented to maximize the bicycle compatibility of a transportation system.

**Street patterns** refer to the spatial pattern that the street network makes on the landscape. Streets can be straight or curved; they can either intersect or run parallel to each other; and they can be through streets or dead ends. When these variables combine in different combinations they provide either greater or lesser mobility and access to bicyclists. For example, there is a limit as to how far many people are willing to bicycle. Antonakos (1994) reports commuting distance is strongly associated with a person's decision to commute by bicycle. Ohrn (1976) reported people are much less likely to make any particular trip by bicycle if the required trip distance is greater than two miles. Street patterns have the potential to greatly influence the length of a trip irrespective of the absolute straight line distance between the origin and destination depending on if the streets provide a direct or circuitous route. Therefore, street patterns are an important element to consider in evaluating and planning for maximum bicycle compatibility.

Southworth and Owens (1993) identify three scales at which to analyze street patterns: community, neighborhood and lot scale. It is the neighborhood scale analysis that is most relevant to the street pattern element of the presently proposed bicycle

compatibility planning framework. Southworth and Owens (1993) advocate that when analyzing street patterns at a neighborhood scale, street length, and numbers of intersections, cul-de-sacs and loops are significant pattern elements to consider. They argue that the patterns created by these elements influence both the possible route options for moving through the neighborhood as well as how the neighborhood connects with the larger community. Southworth and Owens (1993) propose a five-part typology for classifying neighborhood-scale street patterns: gridiron, fragmented parallels, warped parallels, loops and lollipops, and lollipops on a stick (Figure 4).

Figure 4: Street Pattern Typology

	Gridiron (c. 1900)	Fragmented Parallel (c. 1950)	Warped Parallel (c. 1960)	Loops and Lollipops (c. 1970)	Lollipops on a Stick (c. 1980)
Street Patterns					
Intersections					
Lineal Feet of Streets	20,800	19,000	16,500	15,300	15,600
# of Blocks	28	19	14	12	8
# of Intersections	26	22	14	12	8
# of Access Points	19	10	7	6	4
# of Loops & Cul-de-Sacs	0	1	2	8	24

Southworth and Owens (1993) propose a five-part typology for classifying neighborhood-scale street patterns: gridiron, fragmented parallels, warped parallels, loops and lollipops, and lollipops on a stick. Different street patterns will provide bicyclists with greater or lesser mobility and access. The table refers to a 100-acre unit of analysis. Intersections were defined as junctions of two or more through routes. They did not treat junctions with cul-de-sacs as intersections because cul-de-sacs do not lead anywhere outside the immediate area. [Source: Southworth and Owens, 1993, p. 280]

The gridiron pattern consists of two series of parallel streets that cross each other at right angles to form a pattern of equal-sized square or rectangular blocks. This pattern creates a strongly interconnected and readily expandable system that provides the greatest number of access points and route options of the five possible street patterns. However, Southworth and Owens (1993) also note that the gridiron pattern devotes the most land to streets and is the most expensive to implement and maintain of the five patterns.

The fragmented parallels pattern stretches the gridiron pattern out into long, narrow rectangles and L shapes. Also, rather than having all streets carried through, some make L corners and some truncate at T intersections. This pattern has both pros and cons from a bicyclist perspective. On the positive side, there are fewer intersections so there are fewer potential stop signs and there are fewer possible intersection conflict collisions. On the other hand, fewer route choice options and access points mean that traffic will be concentrated on fewer streets suggesting potentially less bicycle compatible riding conditions.

The warped parallels street pattern distorts the original gridiron pattern further to bend the long blocks in the fragmented parallels pattern into a curvilinear pattern. Southworth and Owens (1993) suggest this pattern was created to shorten the street sight distance and to create a more rural character. Although the curvilinear pattern could be introduced to allow the street pattern to be more responsive to local topography, Southworth and Owens (1993) note this factor was not the primary origin of this street pattern as the neighborhoods they analyzed were in flat terrain. Southworth and Owens (1993) conclude the degree of connection, route choices and access points found in warped parallels street patterns are similar to those for the fragmented parallel pattern, but that user orientation is more confusing in the warped parallels pattern due to the curvilinear streets.

The loops and lollipops pattern even further distorts the original gridiron pattern to create a “non-directional pattern of streets that tend to loop back on themselves” (Southworth and Owens 1993). Southworth and Owens (1993) observe that in this street pattern “interconnection is limited to several through streets not readily apparent in the plan. Blocks tend to be odd-shaped and frequently penetrated by street stubs. Increased privacy is accompanied by limited route choices and few access points, and the maze-like pattern is disorienting. This pattern, with its higher percentage of lots on short streets,

succeeds, however, in creating quiet streets that are relatively safe for children.” However, although the cul-de-sac may have less traffic and therefore may be safer for children than other configurations, the mechanism for doing this is to concentrate traffic on collector and arterial streets which are much less safe than other street configurations and more difficult to cross. The safety impact of this pattern on children is similar for bicyclists. The other significant factor to consider in evaluating loop and lollipop street patterns for bicycle compatibility is how this safety implication combines with route choice implications. The only route options through these developments are typically on collector and arterial streets, thus limiting the bicyclists’ route choice options to streets which typically have poorer bicycle compatibility. Southworth and Owens (1993) identify the final street typology, the lollipops on a stick pattern, as the antithesis of the gridiron pattern. They describe this pattern as being comprised of dead end cul-de-sacs that branch off a few easily recognized through streets. The resulting pattern maximizes privacy but minimizes interconnection, access points and route choice options.

Cervero and Gorham (1995) studied differences in people's travel behaviors in different neighborhood types. Unlike Southworth and Owens, Cervero and Graham examined only two types of neighborhoods, defined primarily by their street pattern. Transit neighborhoods were defined as being primarily gridded with over 50 percent of intersections being four-way or 'x' intersections. Auto neighborhoods were identified as having primarily random street patterns in which over 50 percent of intersections are either 3-way, 'T' intersections, or cul-de-sacs.

The study examined matched pairs of auto and transit neighborhoods controlling for household income, intensity of transit service, topographic and natural features, and relative proximity to each other. Cervero and Gorham then compared commuting behaviors for each neighborhood by considering the degrees to which residents drive alone, walk, bicycle or use transit. Their findings confirm that in transit neighborhoods people walk and bicycle more and drive alone less than in auto-oriented neighborhoods. They also note that variable levels of transit usage in the two neighborhood types was much less clear. Cervero and Graham (1995) also point out this pattern of commuting behavior is much stronger in the San Francisco area than in the Los Angeles region. The authors offer a possible explanation for this finding:

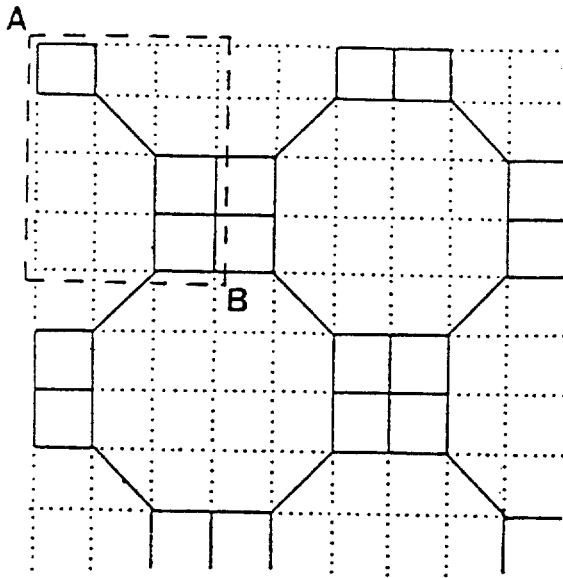
Because the Los Angeles region is so expansive, and laced by over 500 miles of freeways, it may be that the form of the region as a whole has

at least as great a role in influencing modal choice as neighborhood design or layout does, if not greater. In other words, the form of the macro-region may be too auto-dependent for the micro-pattern of any particular pattern to matter. Islands of neotraditional development in a sea of freeway-oriented suburbs will do little to change fundamental commuting habits. (Cervero and Graham, 1995, p. 222)

Clearly, the issue of understanding street patterns and their implications for the surrounding community are complex. Community goals often seem to be at odds with each other as manifested in the street pattern typologies. Street pattern typologies and their community impacts are just beginning to be understood. Additional research is required before recommendations about evaluating bicycle compatibility of street patterns can be made.

Several studies have initiated this vital process. For example, Arlinghaus and Nystuen (1991) explore street patterns from a geometric perspective to suggest possible geometrics that might improve a street network's performance for multiple transportation modes. The underlying principle of their proposal is that "characteristics inherent in the design of the underlying street geometry" provide a less costly and operationally more desirable solution to traffic congestion than legal solutions to the issue. Although Arlinghaus and Nystuen (1991) focus their discussion on simultaneously providing for pedestrian and automobile travel, expanding the principle to consider bicycle travel seems a reasonable and natural extension of their discussion. Based on geometric principles and people's desire for convenient travel (few turns for motorists and direct routes for pedestrians), Arlinghaus and Nystuen (1991) propose a street geometry that relies on people's most likely route choices to spatially separate pedestrian and vehicular traffic to minimize deadly collisions. This proposed street geometry combines a gridiron street system, diagonal block sidewalks and either full or partial-barrier street parks (Figure 5). As the figure suggests, this proposed geometry can be viewed as a two layer transportation system—one layer for vehicular traffic and one for pedestrian traffic. Clearly, a third layer describing a bicycle system street geometry could be envisioned.

Figure 5: Street Geometries that Naturally Separate Travel Modes



*Arlinghaus and Nystuen (1991) propose a street geometry to naturally spatially separate pedestrians and motor vehicles based on most likely route choices. Another layer to this system describing a bicycle system street geometry could be envisioned. In the above diagram, the dotted lines represent streets in a gridiron pattern and the solid lines represent the pedestrian facilities (a combination of sidewalks and connecting paths). A and B designate the upper left and lower right corners of the geometrical unit that can be repeated to create a transportation system that naturally spatially separates pedestrians and motor vehicles. [Source: Arlinghaus and Nystuen, 1991]*

Another study that contributes to a more comprehensive understanding of street patterns and their implications for bicycle compatibility explores the evolution of suburban residential street standards in order to better understand the process that led to today's street patterns (Southworth and Ben-Joseph 1995). The study reviews Federal Housing Administration, Housing and Home Finance Agency, Institute of Transportation Engineers and Urban Land Institute publications to trace the chain of events leading to street configuration standardization. The study also examines street standards in the context of larger development processes. Without detailing here the history of street pattern standardization they uncovered, Southworth and Ben-Joseph (1995) conclude "while standards can of course help prevent the worst conditions, they also can stifle

creativity and inhibit adaptation to local conditions." They acknowledge that although some designers such as Peter Calthorpe (1993) and Andres Duany and Elizabeth Plater-Zyberk (1991) have suggested alternative street layouts, institutionalized guidelines and standards have not changed.

In order to overcome the stagnant and stifling processes now guiding street pattern development, Southworth and Ben-Joseph (1995, p. 78) advise:

It is now time to look at what has been created with a fresh eye and to rethink suburban street standards. This is a major research task for the next decade. We must look at streets as complex community settings that serve a variety of functions—not simply as channels for moving traffic and emergency vehicles. Streets are also environments used for walking, bicycling, and jogging, for socializing and for children's play. They are the staging spaces for community interaction and neighborhood development. As such, their design requires an understanding of social behavior, architectural and urban design and general planning.... The development of explicit yet variable standards for residential street design could open up new possibilities that would induce users to alter their travel behavior, their choices of routes, and their modes of transportation.

**Intersections** are another transportation system component that influence bicycle compatibility. For the purposes of this discussion, intersections are considered to be the location where two or more roads meet and the approximately 100 feet of each road approaching this common area where turning lanes are typically located. The bicycle compatibility of intersections varies with different combinations of the number of travel lanes that have to be negotiated, the types of turning lanes provided and what, if any, traffic control device is used to guide traffic through the intersection. As intersections involve more lanes of traffic, more special turning lanes and more complicated traffic signals, generally bicyclists will consider them to have decreasing bicycle compatibility. This determination results at least partially from the fact that more traffic lanes in an intersection are connected with higher traffic volumes, which also leads to poorer bicycle compatibility. However, beyond traffic volumes flowing through an intersection, how the intersection is striped and signed will influence how comfortable a bicyclist is likely to feel going through it. An intersection in which the lane markings and signs make it very clear how bicycles and other traffic should proceed through the intersection can be more bicycle compatible even with high traffic volumes than an intersection that has low traffic volumes, but in which it is very unclear how traffic should proceed through.

It is therefore important to consider intersection configuration in the transportation planning process if bicycle compatibility of a community's transportation system is to be maximized. Little research has been done to delineate a methodology for evaluating bicycle compatibility of intersections. Landis (1994) makes reference to one proposed methodology. However, despite the lack of formal research, common sense suggests a number of intersection characteristics that should be considered in a successful bicycle compatibility planning framework. For example, the number of lanes of traffic, extent of turning traffic, clarity of lane markings, the presence/absence of traffic signals and the volume of traffic proceeding through an intersection are factors that will clearly influence the bicycle compatibility of an intersection.

**Network configuration**, the most complicated concept of the proposed bicycle transportation planning process elements, refers to how roadway configuration, intersection configuration and street patterns come together to act as a single system. The key is a systems view of the urban environment that pays particular attention to how variables interact and the resulting conditions that would not be apparent by only considering each variable in isolation. Its role in the proposed planning framework is to serve as a reminder that if a community is to be successful in maximizing bicycle compatibility, it is not enough to consider roadway configuration, intersection configurations and street patterns individually. Rather, it is vital to evaluate and consider how these elements come together to function as a single system. It should be noted that if this systems perspective is ignored, it does not mean that no strides toward improving a community's bicycle compatibility can be made. However, without the system perspective it is impossible to achieve the ultimate goal of maximizing bicycle compatibility.

So far as I have discovered, there is no bicycle transportation literature that has explored system level impacts of the transportation system on bicycle compatibility. There is however a growing literature that explores this system level perspective more generally, debating how the topic should be approached and what variables should be considered (see for example Crane, 1996; Dittmar, 1995; Ewing, 1995).

Dittmar (1995) suggests that traditional transportation planning aims to move as many vehicles as possible as quickly as possible with minimum conflict between vehicles. The function of the transportation system within this traditional perspective is seen

singularly as providing access to land and the role of the transportation planner is to supply sufficient capacity to carry the populace from where it lives to where developers choose to build. Dittmar (1995) also suggests that this perspective is evolving and that transportation planners today more commonly view transportation as influencing a society's sustainability. He outlines a number of transportation goals that transportation planners seeking to achieve this approach try to follow:

- The transportation system should conserve the natural and built environment;
- The transportation system should minimize use of nonrenewable resources including community history, open space, wildlife and farmland;
- Mobility is only one possible way to achieve accessibility;
- Transportation should be viewed as a strategic economic investment;
- The transportation system should integrate multiple modes of travel;
- Redundancy and flexibility should be built into the transportation system; and
- The transportation system should incorporate providing real-time information.

In order to achieve these goals, Dittmar (1995) concludes:

At each opportunity, we must think of transportation in the broader social context. In the end, it matters not whether the car is the sole or even the main culprit in our lack of community. What matters is that transportation leaders quit contributing to making things worse, and instead begin to contribute substantially to restoring community. This restoration should be our highest priority. The awareness that it is transportation that connects all of us can be a good starting point from which to pursue a broader vision of community.

Crane (1996, p. 57) also supports the importance of this systems approach and argues "that while it is likely that many elements of the new [suburban] designs do discourage driving for some kinds of trips, the aggregate effect is uncertain." Crane suggests the most common design approach in these new developments to reduce automobile traffic is a grid iron street pattern. He contends that what little evidence there is to support the success of this approach is weak at best and contradictory at worst. To arrive at this conclusion, Crane explored several simulation studies (Kulash, Anglin and Marks, 1990; McNally and Ryan, 1993), descriptive studies (Friedman, Gordon and Peers, 1992; Handy 1992a and 1992b), and analytical studies (Holtzclaw, 1994; 1000 Friends of Oregon, 1993). Crane's final conclusion is that conceptually it is important to increase interaction between residents and to reduce air pollution and congestion, and that

planners should be careful about employing grid iron street patterns to accomplish this goal because studies that have come to this conclusion generally have failed to isolate the independent effect of street pattern on travel behavior.

Crane (1996) argues that in developing a more comprehensive approach to creating livable communities, it is important to understand the independent effects design variables have on the system if progress is to be made toward achieving the desired ultimate goals:

The increase in access associated with neotraditional neighborhood design typically reduces the cost of travel for all modes. All things considered, people will be likely to take more trips. They could take enough new trips to more than offset the shorter trip length, resulting in more travel overall. A direct consequence is that a change in land use and street configuration that improves community access, even if transit- and pedestrian-oriented access are improved the most, may or may not reduce auto travel. It may well increase it, particularly if the demand for auto travel is relatively price-elastic and/or income-elastic. Even if car travel falls with access, ignoring the higher trip frequency associated with more open circulation patterns is misleading, and thus overstates the potential transportation benefits of the design. (Crane, 1996, p. 62)

In considering what variables a systems perspective of a transportation system should include, Ewing (1995) examines how land-use patterns affect household travel behavior. To more accurately reflect the independent impact of land use pattern, Ewing controlled his analysis for socioeconomic variables, including number of persons in a household, number of workers in a household, household income, multi-family/single family household, and number of vehicles per household member. Ewing (1995, p. 15, p. 20) concludes:

It appears that even in a sprawling sunbelt environment, land use patterns matter. However, their effect is not exactly as envisioned by the advocates. Accessibility to regional activities has much more effect on household travel patterns than does density or land use mix in the immediate area; accessibility has as much effect on the frequency and length of trips as the mode of travel; and the relationships can be best understood in terms of multi-purpose trip making...

1. Development patterns have a significant effect on household travel beyond any relationship they may have to sociodemographic characteristics of households;
2. Good regional accessibility cuts down on household vehicular travel to a far greater extent than does localized density or mixed use,

casting doubt on the value of pedestrian pockets or transit-oriented developments in remote locations;

3. Accessibility of residences to a mix of land uses is the key to vehicular travel reduction; and

4. Good accessibility of workplaces to other activities has countervailing effects on vehicular travel.

In conclusion, bicycle transportation planning has progressed beyond the 'install a couple of bike lanes and bike paths' approach. Planners are beginning to understand the need for a more comprehensive approach to bicycle transportation planning and that ultimately the entire roadway network should be bicycle compatible. However, methodologies to facilitate implementation of this more comprehensive philosophy are lacking. This section has outlined a possible conceptual framework for comprehensively approaching bicycle transportation planning and reviewed the research literature related to each framework component.

#### 3.4 **Roadway Compatibility Evaluation Module of the Proposed Framework for Thinking About Bicycle Compatibility**

Urban planners lay out roadway segments across the urban landscape in a variety of configurations to create a street network that facilitates the residents' desired movements between various points within this landscape. Where roadway segments cross each other, intersections are created. In addition, the collection of roadway segments as a whole creates a network pattern that determines possible routes and associated trip distances between various origins and destinations.

If various combinations of roadway cross sections, intersection configurations and roadway networks were completely understood with respect to how they impact different transportation modes, then planning an 'ideal' transportation system that adequately accommodates all transportation modes would be a fairly straightforward task. Although perhaps a theoretical ideal for which to strive, realistically such a complete state of understanding for such a complex system will never be achieved. Therefore, planners are forced to make decisions based on less than perfect information—not something to be alarmed about since less than perfect information is an absolute given no matter what the endeavor or field of inquiry (McAleer, 1994).

The point here is not to set a tone of doom and gloom or to suggest that planning efforts are bogus because they are based on less than complete information. Rather, the point is to suggest the importance of models in planning efforts (Levy, 1994). Depending on the variables included in an analysis, the assumptions made about variables not included, as well as assumptions about the relationships between the included variables, it is possible to create very diverse representations of reality (McAleer, 1994). As a result, depending on the model used, very different planning decisions may seem appropriate. The point of this discussion is to consider possible models that could be used to guide planning decisions to maximize bicycle compatibility of roadways. First, a brief general discussion of models will be offered. Then several bicycle compatibility models will be summarized and evaluated. Finally, these discussions will provide the basis for proposing a methodology to approach the evaluation of a roadway network's bicycle compatibility.

Models aim to represent the world around us and help us to predict outcomes of different scenarios. These models are not used just to describe the world. Often they also form the basis for many business, policy and planning decisions. It is important always to remember the distinction between models and reality. Models only approximate reality (Cadwallader, 1996). As the systems we want to model become more complex, a model's approximation becomes more approximate and thus the room for error increases. More and more variables may influence reality and the interactions between these variables may also add to the challenge of modeling this reality. However, the fact remains that despite these problems in modeling reality, predictions are usually more accurate using the models than by simply relying on guesswork.

One of the biggest modeling challenges focuses on determining how good a model is, i.e. the extent to which it improves predictions over simply guessing. Sometimes alternative proposed models are different because they are based on competing theories about the nature of reality. In other cases, however, alternative models might be based on the same underlying theory but nonetheless still may be very different as a result of differing methodologies used to generate the model or different data sets used for the analysis. There is no single accepted approach to model building and there is typically more than just one correctly specified model (from a statistical perspective) that can be built to represent a particular reality. The challenge in this situation is developing criteria to decide what variables to include, how to approach building the model, and how to choose amongst correctly specified rival models.

With these points in mind, the present goal is to develop a model that provides a uniform, defensible procedure for evaluating the bicycle compatibility of the streets in a roadway network. To do this, there is no need to begin developing a model from scratch as several mathematical models already exist: the Roadway Segment Index (RSI) model (Epperson, 1994), the Road Condition Index (RCI) model (Epperson, 1994), the Bicycle Interaction Hazard Score (BIHS) model (Landis, 1994; Landis, 1996), and the Bicycle Compatibility Evaluation (BCE) model (Sorton and Walsh, 1994). These models evaluate the bicycle compatibility of specific roadways by transforming physical measurements of roadway characteristics into a compatibility rating through mathematical formulae. These mathematical models were proposed in the context of evaluating the present condition of individual roadway segments rather than an entire roadway network. However, through repeated applications of the formulas, it seems reasonable that these models could be adapted to a network evaluation context. In addition, although discussion of these models focuses on existing roads, if the characteristics of a planned but unbuilt roadway are known, there is no reason why the models cannot be applied in this situation as well.

I evaluate each model for how well it would likely be able to serve as the basis for the roadway compatibility module of the bicycle transportation planning framework. I consider several criteria:

- Validity and reliability;
- Ease of data collection;
- Interpretation of results; and
- Planning adaptability and applicability.

The model's validity and reliability are critical to its usefulness as a planning tool. Validity refers to whether or not a model really measures what it is presumed to measure. For the models being evaluated here, validity reflects how well the model's evaluation of a roadway's bicycle compatibility represents the level of risk or stress a bicyclist perceives riding on that roadway. In other words, if a bicyclist avoids riding on a particular street because s/he feels it is a very risky place to ride, a valid model will show the road as having poor bicycle compatibility. Likewise, if a bicyclist seeks out a road as a comfortable place to ride, a valid model will evaluate it as having good bicycle compatibility. The value of a valid model for planning purposes is its ability to predict accurately the bicycle compatibility of a roadway without having to survey a sample of bicyclists every time this question is raised.

To evaluate a model's validity, I consider how accurately the model's results reflect bicyclists' stated evaluations. In general terms, if a model fails to include a variable that significantly influences bicycle compatibility, it is unlikely to do a good job of accurately evaluating the risk a bicyclist perceives in using a road. In addition, if too much or too little weight is placed on any particular variable, the model will inaccurately represent a road's bicycle compatibility. Neither of these conditions can be directly measured, so I used bicyclist judgments as indicators of validity as documented in the published papers about the models.

In addition to validity, it is also important that the model be reliable. Reliability refers to how consistently a model results in the same evaluation if repeated measurements of the same situation are made. An unreliable model will result in inconsistent evaluations of the same conditions. Therefore, if a model is unreliable, little faith can be placed in any particular evaluation obtained and its usefulness as a planning tool will be severely limited. In the bicycle compatibility context, a reliable model will lead to the same evaluation of a roadway independent of who is doing the evaluation. In addition, if the same person repeats an evaluation multiple times, s/he will get the same results each time if a model is reliable.

Ease of data collection is another criterion I considered in selecting a model upon which to base the roadway compatibility module of the proposed bicycle transportation planning framework. Time and money are the critical issues with respect to the ease of data collection. Planning budgets are always limited, so if collecting the data required to implement a methodology is too cumbersome, the chances of successfully incorporating it into transportation planning processes plummet.

To evaluate ease of data collection, I consider several factors. First, I evaluate the availability of the data the model requires. Data readily available in existing databases is much more desirable than data that must be collected in the field. Of course, if the already collected data do not measure what one is really concerned about, it might be readily available but of little value because it is not valid for the present needs. Also, I consider the number of variables for which data must be collected. The more variables there are, the more time and monetary resources that must be invested to collect the data. However, a greater number of variables may also lead to a more accurate representation of reality. Therefore, in considering the number of variables in a model and the implications for ease

of data collection, the relative benefits of the additional information provided by more variables must be weighed against the added costs of collecting the additional data.

The third aspect of the models I evaluate is how easy the model is to interpret. The first aspect of each model I consider is the model's output. Do the numbers generated by the model make sense intuitively or do they require considerable explanation? In addition, I also consider the simplicity of the model. Models that are mathematically less complicated are more simple to interpret because it is easier to determine at a glance how changing a particular variable's value will impact the bicycle compatibility rating. The more readily calculations can be performed and interpreted, the easier it will likely be to convince planners to implement the methodology. So, the more readily apparent it is how changing a particular variable's value will impact bicycle compatibility, the more useful it will be as a planning tool.

Finally, I consider the model's applicability and adaptability to a planning context. For example, the quality of a road's surface certainly impacts the current compatibility of a roadway, but the quality of the road surface is more a maintenance issue than a planning issue. Also, if the planning methodology is applied to guide decisions for a new development where roads do not exist, no road surface quality exists. An arbitrary evaluation could be used in this case, but then there would be many assumptions that would go into the decision about what road surface quality value to use, thereby raising additional questions about the model's validity in this situation.

#### **3.4.1 Evaluation of the Road Segment Index (RSI), Road Condition Index (RCI) and Bicycle Interaction Hazard Score (BIHS) Models**

In evaluating the available bicycle compatibility models I discovered in the literature, I found the models to be very similar to each other—especially the Roadway Segment Index (RSI) model (Epperson, 1994), the Road Condition Index (RCI) model (Epperson, 1994), and the Bicycle Interaction Hazard Score (BIHS) model (Landis, 1994; Landis, 1996). Because these three models are so similar and because I selected the bicycle compatibility evaluation (BCE) model as the basis of the roadway compatibility module, the RSI, RCI and BIHS models are discussed together here and the BCE model is evaluated and discussed in greater detail separately in the next section.

**Figure 6: Equations Summarizing the RSI, RCI, BIHS and BCE Models**

$$RSI = [ADT/(L*2500)] + (S/56) + [(4.25 - W) * 1.635] + SUM(PF) + SUM(LF)$$

$$RCI = [ADT/(L*3100)] + (S/48) + \{(S/48)*[4.25 - W]*1.635\} + SUM(PF) + SUM(LF)$$

$$BIHS = \{(ADT/L) * (14/W)^2 * [a_1 * (S/30) * (1 + \%HV)^2 + a_2 PF] + a_3 LU * CCF\} * 1/10$$

$$BCE = (VCR + SCR + WCR)/3$$

Definitions of Variables:

ADT=	average daily traffic
L=	number of traffic lanes
S (for RSI)=	speed limit (kph) (1 km = 0.6mi)
W (for RSI)=	width of outside traffic lane (m) (1m = 3.28ft)
SUM(PF)=	sum of pavement factors
SUM(LF)=	sum of location factors
W (for BIHS)=	usable width of outside through lane (includes width of any bike lanes; measured from pavement edge, or gutter pan, to center of road, yellow stripe, or lane line, whichever is less) [in feet]
S (for BIHS)=	speed limit [in miles per hour]
%HV =	percent heavy vehicles
LU =	land use (intensity) adjoining the road segment (commercial value = 15, non commercial = 1). Report commercial if at least 30 percent of the land use is anything other than single family residential or agricultural
CCF =	curb cut (or on-street parking) frequency. Record the number of non-controlled access points and on-street parking spaces of each segment
PF =	pavement factor as defined by the reciprocal of FHWA Highway Performance Monitoring System PAVECON factor
VCR =	traffic volume compatibility rating
SCR =	traffic speed compatibility rating
WCR =	curb lane width rating

*The RSI, RCI, BIHS and BCE models all aim to evaluate bicycle compatibility of roadways.*

The RSI, RCI and BIHS models are all quantitative models that aim to evaluate bicycle compatibility of roadways (Figure 6). The three models represent a chronological progression in model refinement proceeding from the RSI model to the RCI model to the BIHS model.

The RSI model, completed by Davis in 1987 at Auburn University, was the first systematic effort to model road conditions from a bicyclist's perspective (Epperson, 1994). The RSI model converts information about average daily traffic, speed of traffic, curb lane width, pavement surface quality and surrounding land uses to an index that can be used to predict bicycle compatibility, although the original intent of the model was to predict crashes (Landis, 1996).

In evaluating the RSI model as a possible basis for the roadway compatibility module, the model's validity and reliability, ease of data collection and planning adaptability are all concerns. With respect to validity, Landis (1996) notes that although the RSI model gives an indication of the level of risk a bicyclist is likely to perceive on a road, it does not successfully predict crashes as intended. He cites two primary reasons for this: 1) the model does not incorporate actual bicycle volumes as a normalizing factor, and 2) the model does not consider operator error, a major determinant in crashes.

The reliability of the RSI model is also of concern because the pavement and location variable values used in the model are based on subjective judgments. The pavement condition values include cracking, patching, weathering, potholes, rough road edges, curb and gutter, rough railroad crossings and drainage grates. If any of these factors are a problem, the index is adjusted to reveal a lower bicycle compatibility. The reliability issue is that different people will likely vary in their judgements as to whether or not these issues are problems. Pavement condition factors only enter into the equation additively rather than multiplicatively, so if a road has no problems with any of these factors, the compatibility index is unaffected and therefore they only impact the index to lower compatibility if there is a problem. They do not improve the compatibility index if the road has an excellent road surface quality.

The location factors consider situations that contribute to cross traffic generation, limited sight distance and land-use characteristics that limit bicycle compatibility. Unlike the pavement condition factors, the location factors can have either a positive or negative influence on a road's compatibility index. Angled parking, parallel parking, right-turn

lanes, topography, frequent curves, restricted sight distance, numerous drives, industrial land-uses and commercial land-uses are proposed as having a negative impact on compatibility. On the other hand, raised medians, center turn lanes, and paved shoulders are proposed as having a positive impact on compatibility. The subjectivity for both pavement condition evaluation and location factor evaluation lies in deciding whether or not each of these factors applies to the roadway under consideration. For example, at what point do potholes become a problem? What one person evaluating a roadway considers to be acceptable, another may consider to be a severe problem. Because it is very likely that ratings for these variables will vary considerably depending on who is doing the evaluation, the results of the model are not very reliable and therefore its usefulness as a planning tool is limited.

Interpretation of the RSI model results and the model's planning adaptability are two other concerns. Documentation of the RSI model (Epperson, 1994) does not indicate the ranges of values to expect from the RSI model or how to interpret the results. Also, the model was designed for data in metric units for the equation and since most Americans still do not readily think metrically, planners will likely not be able to quickly figure out the impact changing a particular variable's value might be. Further, there are several elements in the model (for example, pavement condition and sight distances) that are more of a concern for maintenance than planning and therefore limit the model's adaptability to a planning context.

The Road Condition Index (RCI) model is based on Davis' RSI model and was developed by the Florida DOT in order to improve the RSI model (Epperson, 1994). The variables included in the RCI model are the same as those in the RSI model. Therefore, the differences between the two models lie in the weights given to each variable and whether a relationship is additive or multiplicative. Traffic volumes in the RCI model have less impact on the compatibility rating than in the RSI model and speed has more impact. Also some of the weights assigned to each of the pavement condition and location factors differ between the two models. Another difference between the two models is that the RCI model adds an element that makes the impact of lane width directly related to the speed of the traffic, so that at higher speeds lane width is more important than at lower speeds. Landis (1996) notes an aspect of the model which was not improved over the RSI model is that the pavement and location factors are still very sensitive to subjective judgment.

Given the strong similarities between the RSI and RCI models, my evaluations were also very similar. One difference is that the documentation for the RCI (Epperson, 1994) model was more clear about interpreting results. Index values should range from zero to five or more. A score from 0-3 means excellent compatibility, 3-4 means good compatibility, 4-5 means fair compatibility and above five means poor compatibility. These ranges are easy to interpret. It is interesting to note there is no upper limit to the RCI indices, which means according to the RCI model a road can have infinitely poor compatibility, but there is a limit as to how compatible a road can be. Epperson (1994) did not evaluate the validity of this scale by comparing results from the model directly to bicyclists' stated perceptions of the same conditions, so this is another concern about selecting the RCI model as the basis of the roadway compatibility module. Instead, he only proposed the RCI model as a theoretical construct and suggested comparison of results to bicyclist perceptions as further research needed.

The BIHS model aims to provide a methodology to aid planners in establishing priorities for construction projects, forecasting travel demand, objectively measuring an urban area's "bicycle friendliness," and creating bicycle route suitability maps (Landis, 1994). The variables included in the BIHS model are similar to those for the RSI and RCI models with several notable exceptions. First, most of the location factors included in the RSI and RCI models are not included in the BIHS model. However, a commercial/non commercial land-use value and a curb cut and on-street parking frequency value are included in the BIHS model. Also, a variable for the percentage of heavy vehicles such as buses and large trucks has been added to the BIHS model. In addition, an evaluation of the pavement surface quality is still included in the BIHS model, but rather than a subjective assessment, the evaluation is based on an objective pavement quality methodology developed by the Federal Highway Administration.

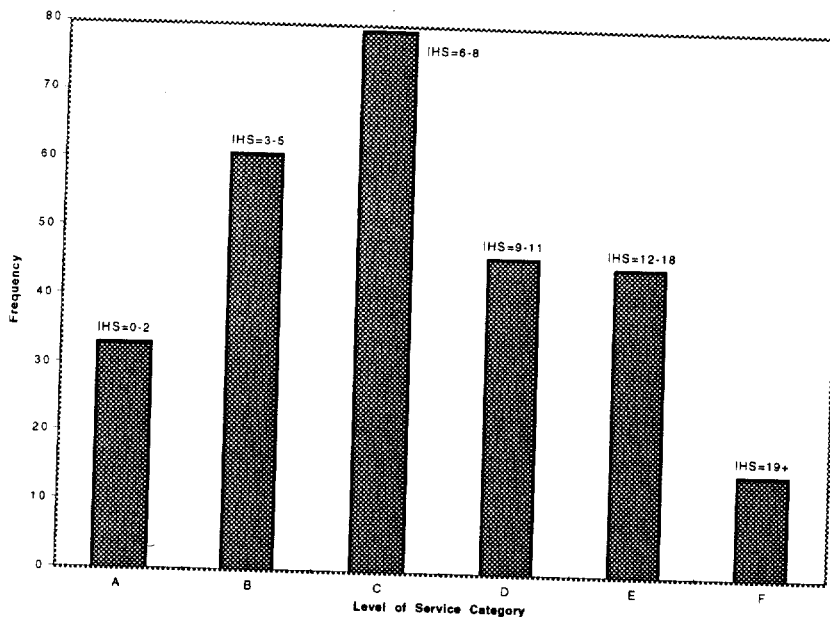
Validity is an issue for the BIHS model as well. Landis (1994) proposed the BIHS model in theory only and has yet to validate the model by comparing the model's evaluations with those of bicyclists. The reliability of the BIHS model is improved over the RSI and RCI models because the subjectivity of the data collection has been eliminated. Ease of data collection is also an issue with the BIHS model. Data for average daily traffic, number of traffic lanes, curb lane width and speed limits are readily available. However, data about the percentage of heavy trucks, land-use intensity, curb

cuts and pavement conditions would likely need to be collected in the field thereby adding to the time and money required to implement the model.

Interpreting the model's results is not a straight forward proposition. The model is calibrated so that lane width, speed and traffic volume have the most significant influences across their entire range of possible values. On the other hand, the heavy vehicle, land-use, commercial driveways and pavement variables have little influence on the overall model except in extreme conditions. The model also assumes non-linear relationships between hazard and width as well as between hazard and traffic volume. Width has a greater impact on the BIHS as the curb lane gets more narrow. In other words, changing the curb lane from 12 feet to 11 feet has a greater impact on the BIHS than changing it from 15 feet to 14 feet. This variable impact may or may not provide a more accurate evaluation, but it is also not as easy to interpret since equal changes in width do not have equal impacts on compatibility. With respect to traffic volume, higher volumes have a greater impact on the BIHS than low traffic volumes. The multiplicative relationships defined between the variables and the fact that these relationships are not linear adds to the difficulty of easily interpreting the impacts of changing a variable's value. It should be kept in mind that despite the more complicated mathematical relationships defined in the BIHS model, it may provide a better representation of reality than the RSI or RCI models. Since none of the models have been validated against bicyclists' perceptions, it is difficult to say whether the more complicated math that makes the model more difficult to interpret is a good or bad thing.

Also related to interpretation of model results, the hazard scores have a very broad range with no absolute upper limit. Landis' original publication of the model (Landis, 1994) included no discussion about how to interpret the ratings which the model generated. A more recent article (Landis, 1996), however, suggests a scale translating each hazard score into a level of service category (Figure 7). Level of service is a concept often used by traffic engineers to identify how well traffic flows on a road. Six level of service categories are identified, ranging from A to F, with A being a high level of service, or good compatibility, and F being a low level of service, or poor compatibility. Although the ranges of the BIHS scores translating into each level of service category is straight forward, I doubt bicyclists perceive 20 degrees of bicycle compatibility as defined by the scales for translating the BIHS scores to level of service categories.

**Figure 7: Typical Histogram of Bicycle Level-of-Service Categories and the Associated BIHS Scores**



*Landis (1996) identifies six level-of-service categories in the BIHS model, ranging from A to F, with A being a high level of service, or good compatibility, and F being a low level of service, or poor compatibility. [Source: Landis, 1996]*

### 3.4.2 Bicycle Compatibility Evaluation (BCE) Model

The broad goal of the bicycle compatibility evaluation model is to establish a process for recording and evaluating existing road conditions with respect to the "major factors affecting bicycle and motor vehicle operation" (Sorton and Walsh, 1994). Sorton and Walsh wanted the model to reflect the varying levels of risk bicyclists perceive under varying traffic conditions. In addition, they were interested in how these perceptions varied with different types of bicyclists (children, youth, inexperienced adults, experienced adults).

The bicycle compatibility evaluation model is based on the assumptions that bicyclists seek to:

- Minimize mental stress;
- Avoid conflict with motor vehicles;
- Avoid the mental strain of having to concentrate for long periods of riding along narrow, high speed, high volume roads; and
- Minimize physical effort with respect to topography, stopping and starting.

It is likely that the RSI, RCI and BIHS models also make these assumptions, but only the documentation for the BCE model explicitly states them.

Decisions made about the variables to include in the bicycle compatibility evaluation model were based on a review of the transportation engineering literature for motor vehicles. Based on this review, Sorton and Walsh extrapolated their findings to bicycles by assuming that problems for automobiles would be even bigger problems for bicycles. Discussion about the criteria Sorton and Walsh used to decide which variables to include in their model and which were less significant was lacking.

The three primary variables included in the bicycle compatibility evaluation model are curb lane width, traffic volume in the curb lane and traffic speed. Sorton and Walsh also discuss several secondary variables: number of commercial driveways per mile, parking turnover, and percentage of heavy vehicles using the road. They state that the present model only includes the primary variables due to limited research funds.

The BCE model evaluates the bicycle compatibility of the curb lane width, traffic volume and traffic speed individually and then combines these individual ratings into an overall compatibility rating by calculating the arithmetic mean of the three individual compatibility ratings (Figure 6). The basic idea of the BCE model is to translate physical roadway and traffic measurements into a rating scale which allows for easy interpretation of bicycle compatibility. Each of the three primary variables is translated into a compatibility index ranging from one (very good compatibility) to five (very poor compatibility). To develop an initial rating scale scheme, Sorton and Walsh (1994) defined these scales by establishing the outer limit for very poor compatibility based on their review of the transportation engineering literature. They then divided this range into five equal segments. The differences between the BCE model and the other models are that only the BCE model focuses on these primary variables, weights them equally and

assigns each variable an individual compatibility rating and then calculates the arithmetic average of the individual ratings to arrive at the overall bicycle compatibility rating.

Sorton and Walsh (1994) report that they established the traffic volume rating scale based on the process transportation engineers use to evaluate traffic capacity. Three aspects of this analysis are significant for the bicycle compatibility evaluation rating scale for traffic volume. First, capacity analysis is done using traffic counts for the peak hour volume (PHV). Clearly, if a road has a great enough capacity to handle the traffic volume during the peak hour, it will also be able to readily handle traffic volumes during the off peak hours. For bicycles, this peak hour volume represents the worst case scenario for compatibility. Streets that have good bicycle compatibility with the traffic volume at peak conditions will clearly also be compatible with off-peak conditions. On the other hand, it is possible that a street may have low compatibility during peak periods, but have good compatibility during off-peak conditions. Although this situation may influence a bicyclist's route choices at different times of day, bicycle transportation planners should strive to achieve maximum mobility and accessibility of the roadway network during all hours. Therefore, it is reasonable that peak hour conditions should be used for calculating the traffic compatibility rating.

The second significant aspect of the traffic volume rating scale is that traffic volume data are usually available as average daily traffic (ADT). ADT is directly related to PHV through a k-factor, the proportion of the ADT that occurs during the peak hour. The constant is typically about 10 percent, so this is the value Sorton and Walsh use to calculate the traffic volume for the BCE model. The other transformation of the traffic volume data required for the compatibility model is that the model is specifically interested in the traffic in the curb lane. For this transformation, the model assumes equal traffic volumes in all the lanes and therefore divides PHV by the number of lanes of traffic to derive the vehicles per hour per lane (vphpl).

The final significant aspect of Sorton and Walsh's derivation of the traffic volume rating scale is that their literature review showed curb lanes on urban streets are at maximum capacity or maximum traffic flow volume when there are 450 to 800 vphpl. Sorton and Walsh used the conservative estimate to develop the traffic volume rating scale. As a result the rating scale they propose is as follows:

Compatibility Rating	Curb Lane Volume (vphpl)
1	≤50
2	51-150
3	151-250
4	251-350
5	351-450

For the purposes of the bicycle compatibility evaluation model, Sorton and Walsh define curb lane width as the distance from the joint between the curb and gutter to the first full travel lane adjacent to it. Where parking is allowed, the curb lane measurement begins eight feet from the curb face to allow for the space occupied by parked cars at the edge of the roadway. The upper and lower limits for the curb lane width compatibility rating scale are based on research by the Maryland Department of Transportation and recommendations in the *Highway Capacity Manual*. Both the Maryland Department of Transportation and the *Highway Capacity Manual* report that curb lanes greater than 14 feet can accommodate both bicycles and automobiles together in the same lane. Sorton and Walsh (1994) suggest this recommendation is conservative and they therefore set the minimum curb lane width for the highest level of compatibility to be 15 feet. At the other extreme, the *Highway Capacity Manual* indicates that where curb lanes are 11 feet or less, a bicycle is equivalent to a car because the car must use the adjacent lane to pass the bicycle. As a result, Sorton and Walsh (1994) propose the following curb lane width compatibility scale:

Compatibility Rating	Curb Lane Width (feet)
1	≥15
2	14
3	13
4	12
5	≤11

The traffic speed measurement that is used for the bicycle compatibility rating scale is the 85th-percentile speed, which is the speed that 85 percent of the traffic does not

exceed. Typically, this value is considered to be 5 mph greater than the posted speed limit and therefore this is the value upon which Sorton and Walsh build their model. The lower limit for the traffic speed compatibility rating scale is based on the 25 mph posted speed limit on residential streets. The 45 mph upper limit is established by the speed at which turbulence from large motor vehicles starts to affect the stability of bicyclists using the roadway. Based on this information, Sorton and Walsh (1994) propose the following compatibility rating scale for traffic speed:

Compatibility Rating	Traffic Speed (mph)
1	25
2	30
3	35
4	40
5	45

Once the initial model based on a review of the transportation engineering literature was proposed, a pilot study was conducted in Madison, Wisconsin to validate the model (Sorton and Walsh, 1994). In total, 61 bicyclists were shown videotaped segments of roadways and were asked how bicycle compatible they believed them to be on a scale from one to five. Sorton and Walsh (1994) subdivided the total sample into youth, inexperienced and experienced bicyclists. In all, 23 road segments were included in the videotape, representing systematic variations of curb lane width, traffic volume and traffic speed. Sorton and Walsh (1994) fitted regression lines to the data and reported correlation coefficients for each of the variables. However, regression analysis assumes the dependent variable to be continuous and given the participants only rated the segments as even numbers, some questions arise about the appropriateness of this analysis. The regression lines were reported in graph form only and the constant and slope coefficients were not reported. In addition, no analysis of significance or tests of assumptions were reported. These omissions suggest a need for further data analysis.

The data from the pilot study confirm that as traffic volume increases, speed increases and curb lane width decreases, bicycle compatibility as stated by bicyclists decreases. Sorton and Walsh (1994) also conclude that level of bicycling experience

impacts perceptions of traffic volume the most and traffic speed the least. They state their conclusions as follows:

1. The bicycle stress level analysis procedure shows promise in evaluating urban and suburban streets for bicycling compatibility.
2. This procedure seems to indicate that different types of bicyclists can recognize the variation in the three primary on-street traffic variables from low to high. Bicyclists apparently relate their perception of the variation in the form of stress level.
3. The hypothesis that there are differences in how the various types of bicyclists perceive primary on-street variables could not be confirmed or rejected. The sample sizes of the three types of bicyclists were not large enough to be validated statistically, nor was the number of street segments used to evaluate the three primary variables.

A second pilot study (Harkey et al., 1995) attempts to confirm the validity of the videotaping methodology before conducting a much larger study to refine the BCE model calibration. The overall objective of this study was to compare how people evaluate compatibility of road segments in the field to how they rate them when they watch videotaped segments of the roadway. Harkey et al. state their research question as:

How well do the participants' comfort ratings of various geometric, traffic volume, and motor vehicle speed conditions recorded when watching a videotape compare to the participants' comfort ratings when seeing the location in the field?

The same participants rated the same road segments both in the field as well as on videotape. Thirteen study sites were chosen to represent specific combinations of traffic speed and curb lane width. In each case a videotape segment was selected to hold the traffic volume constant. For both the field (2 minutes) and videotape (40 seconds) evaluations, participants were asked to rate what they believed to be the overall bicycle compatibility of the roadway as well as to rate its compatibility with respect to each one of the primary variables individually. In all, 24 bicyclists participated in this pilot study. Data analysis included contingency matrix, chi square and Cohen's k analyses.

Harkey et al. (1995) report:

One of the objectives of the pilot study was to determine how consistent participants were in rating the same conditions. To achieve this objective, there were 26 identical pairs of video clips included in the video survey. The video ratings for the 26 matched clips were compared. Here the rows of the contingency table represented the overall rating of each of

the 24 subjects for the first time the clip was shown while the columns of the table represented the ratings of the subjects for the second time the same scene was displayed. For the overall ratings, 20 of the 26 had non-significant t-tests suggesting consistent ratings. And 20 of 25 had a positive sign (one case where  $t=0$ ), indicating that the rating was slightly higher for the second clip. The results were similar for the width, volume and speed ratings.

Another question which the pilot study addressed was whether there were characteristics of certain sites which led to inconsistencies between the video and field ratings. Paired comparison t-tests showed that for 5 of 13 tests conducted, there were significant differences between the videotape and the field ratings at a significance level of 0.05. Harkey et al. conclude this result suggests that videotape segments provide a good representation of field conditions and that it is therefore reasonable to use the videotape methodology to validate the model.

Harkey et al. (1995) conclude:

Overall, the results from the data analysis showed the video methodology to be a valid technique for obtaining realistic perspectives of bicyclists as it relates to their comfort levels under varying roadway conditions. In addition, the conduct of the pilot study resulted in several other items of useful information:

- The video survey procedures employed were efficient and resulted in no problems. Similarly, the procedures employed in the videotaping, editing, and production of the survey tape resulted in a quality product. Thus, the same procedures will be carried forward to the larger study.
- There are at least three variables, in addition to volume, speed and curb lane width, that got a strong reaction from the pilot study participants. Thus, the variables bus or truck presence, heavy right turning volumes, and number of driveways should be examined in the larger study.
- The perceived risk scale was used to indicate a bicyclist's level of comfort in this pilot effort. While the majority of the participants believed this scale accurately reflected their perception of comfort, there were individuals who preferred a scale with less of a "safety" connotation. A broader scale may be required to adequately reflect the perspectives of all three user groups (experienced, casual, and youth) that will be included in the larger study.

Based on the results of this pilot study, Harkey et al. are presently conducting the larger study (Ross, 1996).

### 3.4.3 Selection of the BCE Model as the Basis of the Proposed Roadway Compatibility Evaluation Module

Of the four models considered, the BCE model (Sorton and Walsh, 1994) fared best on each of my evaluation criteria: reliability and validity of model, ease of data collection, interpretation of model results and planning adaptability and applicability. In addition to scoring well on the model evaluation criteria, the BCE model was selected for several additional reasons. First, the pilot study for developing the model was done in Madison, Wisconsin so a more complete application of the model here is a natural next step. Also, one of the researchers for the pilot study is a Madison DOT staff member, so the Madison DOT has an interest in developing a planning methodology based on this model, testing the methodology on Madison's roadway network and critiquing the results. Finally, data about pavement condition, location factors, percentage of heavy vehicle traffic, parking turnover, and commercial driveways are not readily available in Madison, making the other three models too time-consuming to use.

### 3.4.4 Proposed Roadway Compatibility Evaluation Methodology

The methodology for the roadway compatibility module of the proposed bicycle compatibility planning framework is derived from the necessary steps to repetitively apply Sorton and Walsh's (1994) BCE model to evaluate a roadway network's bicycle compatibility.

1. Identify study area boundaries;
2. Identify all collector and arterial streets within the study boundaries;
3. Divide the collector and arterial streets into segments with uniform characteristics;
4. Collect data about curb lane width, traffic volume and traffic speed;
5. Calculate bicycle compatibility ratings using Sorton and Walsh's (1994) BCE model; and
6. Create a bicycle compatibility rating map to visually represent the bicycle compatibility ratings.

## CHAPTER 4

### **IMPLEMENTATION OF THE ROADWAY COMPATIBILITY MODULE IN MADISON, WISCONSIN**

#### **4.1 Introduction to the Madison, Wisconsin Case Study**

##### **4.1.1 Case Study Purpose**

Maximizing the bicycle compatibility of Madison's street network is a critical element toward achieving the goals outlined in the Regional Transportation Plan for Dane County and the Bicycle Transportation Plan for the City of Madison and Dane County (see next section). Several situations point to the present need for a systematic evaluation of Madison's street network with respect to bicycle compatibility. For example, most of Madison's presently designated bicycle routes were established in the early 1970s when bicycles were first formally considered in Madison's transportation planning. However, in the past twenty years, traffic patterns have changed considerably and extensive development has occurred at the urban periphery, suggesting that some currently designated routes are now inappropriate and that many areas have no designated routes at all.

In addition, the philosophy about approaching bicycle transportation planning has expanded from bicycle route designations to a desire to maximize the bicycle compatibility of every street in the network (Ross, 1996). An objective outlined in the current Regional Transportation Plan for Dane County (DCRPC, 1988) is "to develop and maintain an all-mode transportation system that offers convenient alternatives to private motor vehicle travel within and between urban areas, to the extent feasible, and provide for roadway improvements as necessary." Further, one of the Bicycle Transportation Plan's (DCRPC and MadDOT, 1991) objectives is "to recognize the role of the bicycle as an important mode of transportation and vehicle for recreation by providing for safe, convenient and pleasant bicycle travel to all major employment, education, retail, housing and recreation centers throughout the county." If these objectives are to be achieved, it is important to have a comprehensive understanding of the entire roadway network. The proposed bicycle compatibility planning framework provides a tool for accomplishing this goal.

The purposes of this case study are:

- 1) To apply the roadway compatibility module of the proposed bicycle transportation planning framework to the street network in Madison, Wisconsin, thereby identifying parts of the transportation system with poor and good bicycle compatibility; and
- 2) To evaluate the usefulness of the roadway compatibility module of the proposed bicycle transportation planning framework as a planning tool.

#### **4.1.2 Planning Context**

##### **4.1.2.1 The Policy Mandate for Bicycle Transportation Planning in Madison, Wisconsin**

As identified in the proposed framework for approaching bicycle transportation planning, the first stage of planning should involve identifying the planning context, including the national and local policies that mandate bicycle transportation planning. It is important to understand this context for two reasons. First, these policies establish a public interest in pursuing bicycle transportation planning. Second, it is valuable to understand the aspects of bicycle transportation planning these policies address. The policies range from bicycle usage, to safety, to facility provisions, to energy efficiency, to roadway network characteristics.

For Madison, Wisconsin there are a number of policies mandating bicycle transportation planning at both the national and local levels. First, several federal policies that mandate multimodal transportation are discussed including the Moving America Federal Transportation Policy (USDOT, 1990), the Intermodal Surface Transportation Efficiency Act (ISTEA) (USDOT, 1994), the Clean Air Act (1990 Amendments) (USDOT, 1994), and the National Bicycling and Walking Study (USDOT, 1994). Next, several local policies mandating bicycle transportation planning are discussed including the Regional Transportation Plan for Dane County (DCRPC et al., 1991), the Objectives and Policies Statement for the City of Madison (MDPD, 1985), the Bicycle Transportation Plan for the City of Madison and Dane County (DCRPC and MadDOT, 1991) and the University of Wisconsin Campus Transportation Plan (UW, 1996).

The **Moving America Federal Transportation Policy** was published in 1990 to outline the United States Department of Transportation's (USDOT) priorities and positions for developing the nation's transportation system. In July 1989, Samuel Skinner, US Secretary of Transportation, stated that it is a national priority to create and maintain a safe, efficient and environmentally responsible transportation system (USDOT, 1990). To achieve this goal, the policy focuses on 1) ensuring our global competitiveness, 2) successfully providing for the demands of our domestic economy, and 3) maintaining our military defense readiness (USDOT, 1990). Although these goals do not appear to focus on bicycles, in further defining these goals, the Moving America Federal Transportation Policy outlines one policy specifically mandating that bicycles be accommodated in the national transportation system:

- Promote increased use of bicycling and encourage planners and engineers to accommodate bicycle and pedestrian needs in designing transportation facilities for urban and suburban areas (USDOT, 1990).

Passage of the **Intermodal Surface Transportation Efficiency Act** (ISTEA) legislation in 1991 marked a major shift in federal transportation policy. Rails-to-Trails Conservancy (1995) notes that ISTEA is the first federal transportation legislation that explicitly recognizes bicycling as a viable transportation mode. According to a summary of the policy, ISTEA offers "greater flexibility to the States and individual localities in developing plans and programs for meeting their transportation needs" (USDOT, 1994).

This flexibility impacts bicycle transportation planning in a number of ways. First, ISTEA mandates that all states and metropolitan planning organizations (MPOs)\* have bicycle and pedestrian plans. Nationwide there are approximately 360 MPOs, so combining the state and MPO plans there are over 400 transportation plans that may or may not have previously considered bicycling issues during the planning process that are now required to consider these issues. Also, ISTEA mandates that each state establish and fund a bicycle/pedestrian coordinator. In this way, at least one person is specifically responsible for ensuring that bicycle and pedestrian issues are addressed. Finally, ISTEA makes some funding available for bicycle and pedestrian projects including National

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\* MPO boundaries are defined by urbanized areas with a population greater than 50,000 people.

Highway System Funds, Surface Transportation Program Funds (including Transportation Enhancement), Congestion Mitigation and Air Quality Improvement Program Funds, Federal Lands Highway Funds, Scenic Byways Program Funds, and National Recreational Trails Funds.

The **1990 amendments of the Clean Air Act** establish air quality standards for many potential air pollutants including ozone and carbon monoxide. Regions which do not meet the levels defined in the Act must reduce emissions to help bring them in compliance. Industries are one source of air pollutants, but especially in large cities plagued by traffic congestion, automobile emissions are important culprits in the air pollution problem.

To reduce traffic congestion in order to satisfy the specified air quality standards, the 1990 amendments of the Clean Air Act outline policies that mandate more efficient engines, better signal timing, car pooling and alternative transportation modes including bicycles. "Bicycling and walking improvements, both construction and non-construction, are approved Transportation Control Measures (TCMs) for attaining these goals and are eligible for special Congestion Mitigation and Air Quality Improvement Program (CMAQ) funding" (US DOT, 1994).

Based on the air quality standards defined in the Act, the federal government has identified urban areas nationwide which have unacceptable air pollution levels and therefore must take air quality improvement measures. In Wisconsin, the Milwaukee area is the one region which is mandated to improve its air quality under the provisions of the Clean Air Act. Although Madison is not mandated to improve its air quality under the Act, the Act has encouraged the city to take a proactive position on air quality (McCormick, 1996). In the last two years, MadDOT has been getting involved in transportation demand management (TDM) efforts. TDM involves employers encouraging their employees to commute in ways other than a single occupancy vehicle. Bicycling, walking, transit and car pooling are all encouraged alternatives to the single occupancy vehicle. Initial work involved collaborative efforts with three major Madison area employers—the University of Wisconsin, CUNA Mutual Insurance Society, and American Family Insurance. Last year, efforts expanded to include Meriter and St. Marys Hospitals.

The **National Bicycling and Walking Study** (USDOT, 1994) marked an increased congressional commitment to bicycling. In 1991 Congress passed the DOT

Appropriations Act, which mandated that the USDOT assess the present levels of bicycling and walking, outline costs and benefits of bicycling and walking, review successful programs around the world, and in light of these findings develop federal, state and local action plans to encourage bicycling and walking. As a result the USDOT oversaw 24 case studies which investigated issues related to congress' mandate [see Appendix A for list of case study titles]. The finding of these case studies were in turn synthesized and summarized in the National Bicycling and Walking Study Final Report.

The study recommends that levels of bicycling and walking should be increased to realize the health, environmental and balanced transportation benefits which these transport modes offer. The study concludes that bicycling and walking should be made more realistic transportation options so that individuals have more travel options and communities will be more attractive and pleasant places to live and work. The NBWS recommends a national policy centered around the following goals:

1. Double current levels of bicycling and walking in the United States; and
2. Decrease by ten percent the number of bicyclists and pedestrians killed or injured in traffic crashes.

In addition to these broad goals, the NBWS outlines action items for the federal, state and local departments of transportation to guide efforts to achieve the goals defined above [Appendix A].

The **Regional Transportation Plan for Dane County**, adopted in 1978 and updated in 1988, serves as a guide for developing an integrated multi-modal transportation system in Dane County and calls for "further detailed monitoring of bicycle use and bikeway facility planning throughout the county" (DCRPC and MadDOT, 1991). The overall goal of the plan is "to develop an integrated all-mode transportation system, within the framework of regional growth and development policies, which will provide for the efficient and effective movement of people and goods."

The corresponding objectives for the Regional Transportation Plan for Dane County are:

1. To provide safe, convenient and efficient transportation services to meet the needs of all residents and economic activities in the region;

2. To develop and maintain an all-mode transportation system that offers convenient alternatives to private motor vehicle travel within and between urban areas, to the extent feasible, and provide for roadway improvements as necessary;
3. To develop a transportation system which is compatible with and supportive of regional and local land use plan objectives and policies;
4. To realize the full potential of existing transportation facilities and services through effective management, maintenance and low- and no-cost improvements;
5. To develop a transportation system that produces positive impacts upon the social, economic, and physical environment and will conserve energy resources to the extent feasible; and
6. To attain an area-wide transportation planning process that is responsive to the needs and interests of area-wide residents, groups, units of government and affected agencies, with sufficient opportunity for all to participate in policy and implementation decisions.

Although the word bicycle is not specifically mentioned in the Regional Transportation Plan's goals and objectives, it should be noted that neither is any other mode. Instead of mentioning specific modes, the plan talks about an integrated all-mode transportation system. Bicycles would clearly be an element of such a system. In conclusion, by mandating planning for an all-mode transportation system, the Regional Transportation Plan also implicitly mandates bicycle transportation planning.

The **Objectives and Policies for the City of Madison** represent an "expression of the community's goals" (MDPD, 1985). The city's objectives and policies are divided into a number of categories: land-use, growth and development, residential neighborhoods, housing, transportation and parking, environmental protection, parks and open space, lake shores, historic preservation, urban design, economy and employment, and energy conservation. If the broadest possible perspective is considered, each of these categories relates to bicycle transportation planning in Madison. However, for the purposes of the present discussion and specifically considering bicycle compatibility of

roadway segments in Madison's transportation system, discussion will be limited to the city's transportation objectives and policies.

The mandate to plan and provide for bicycle transportation in Madison is outlined very clearly in the city's objectives and policies (MDPD, 1985). For example, three of the city's stated transportation objectives include:

- Create a flexible transportation system which provides several alternative modes of travel to most destinations within the City and which minimizes conflicts among different forms of transportation, such as pedestrians, bicycles, automobiles, transit and service vehicles;
- Minimize the need to use private automobiles, and maximize the availability and encourage the use of public transportation and alternative forms of private transportation such as taxis and bicycles, particularly for commuter travel; and
- Recognize the role of the bicycle as a major mode of transportation and vehicle for recreation by providing safe, convenient and pleasant bicycling facilities to all major employment, recreation, retail, housing and education centers in Madison.

Madison's objectives and policies statement also goes further to outline a number of specific bicycle transportation policies (MDPD, 1985):

- Include provision for all needed bicycle facilities when authorizing the construction or reconstruction of any street in the City;
- Consider the desirability of providing bicycle facilities when developing park, recreation and open space projects;
- Include the requirements of bicycle traffic in the design of all traffic control devices;
- Place priority for bicycle facility development upon transportation routes rather than recreation routes;
- Continue to investigate methods of satisfying the needs of bicyclists;

- Require bicycle parking facilities near all public buildings;
- Require the developer of multiple-family residential properties to provide bicycle parking facilities adequate to the needs of the residents;
- Encourage businesses to provide bicycle parking facilities for use by their employees and customers; and
- Require bicycle parking facilities in or adjacent to all pedestrian malls.

The **Bicycle Transportation Plan for the City of Madison and Dane County** focuses on policies and design standards for developing and implementing plans and facilities (DCRPC et al., 1991). Specific project recommendations are not discussed and are left to the discretion of local, county and state jurisdictions. Through the policies and design standards outlined in the plan, it is clear there is a strong mandate at the city level to plan for bicycles.

The guiding policy recommendations of the Bicycle Transportation Plan for the City of Madison and Dane County include:

1. To consider the bicycle as an important mode in the overall transportation system;
2. To recognize that education, enforcement and facilities are all important components of a successful overall bicycle safety program;
3. To address the needs for safe bicycling throughout the county;
4. To consider both utilitarian and recreational bicycling needs;
5. To provide a set of sound guidelines to be used consistently throughout the county in the design, construction, and maintenance of bicycle facilities; and
6. To build upon existing plans and extensive measures which have been undertaken over the past several years to enhance bicycle travel in the area.

In order to address these policy recommendations, the Bicycle Transportation Plan for the Madison and Dane County is divided into five sections: facilities development,

maintenance, support facilities, bicycle safety and law enforcement, and registration. The overall effect of these sections is to mandate that bicycle issues be included in all aspects of transportation planning, engineering and maintenance in Madison and Dane County.

The **University of Wisconsin Campus Transportation Plan** is another local planning mandate to consider. Because the University of Wisconsin-Madison is such a major trip generator and because the campus is centrally located in the city, understanding the context within which bicycle transportation planning takes place would be incomplete without considering the influence of how faculty, staff and students travel to and from the campus. The plan is still in its draft stages, but one of its themes is supposed to be encouraging alternative transportation modes (UW, 1996). For example, a project proposed in the draft plan is to close a major road on the west end of Campus (Linden Drive) to motor vehicle traffic and convert it to a bicycle and pedestrian mall. The draft plan also proposes to greatly expand bicycle parking facilities to satisfy the presently unmet demand. However, it should also be noted that although the draft plan proposes expanded bicycle facilities, it also proposes a number of new large parking ramps for motor vehicles.

#### **4.1.2.2 Transportation Planning Structure in Madison, Wisconsin**

In establishing the context within which bicycle transportation planning takes place in Madison, it is important to understand the relevant lines of command within the city's government structure and the planning guidelines outlined in the Madison Department of Transportation Policy Manual (MadDOT, 1993). Madison's Department of Transportation falls directly under the Mayor's office and is divided into three divisions: the traffic engineering division, the transit division and the parking division (Figure 8). The Department of Transportation, created by Section 3.51 of the Madison General Ordinances, is responsible for planning and operating a safe and effective transportation system for the City of Madison (MadDOT, 1993).

As described in the Policy Manual (MadDOT, 1993):

Transportation policy is developed and implemented by the Department in cooperation with the City Transportation Commission and its Pedestrian-Bicycle Subcommittee, the ADA Paratransit Plan Oversight Subcommittee, the City-County Telecommunications Commission, the

Mayor, the Common Council and City agencies. The Common Council provides final approval for transportation policy.

The Transportation Commission reviews staff recommendations and studies. Citizens may also ask the Commission to review issues and policies. Such requests should be directed to the Commission Secretary; the matter will then be added to the agenda of one of the Commissions' bimonthly meetings.

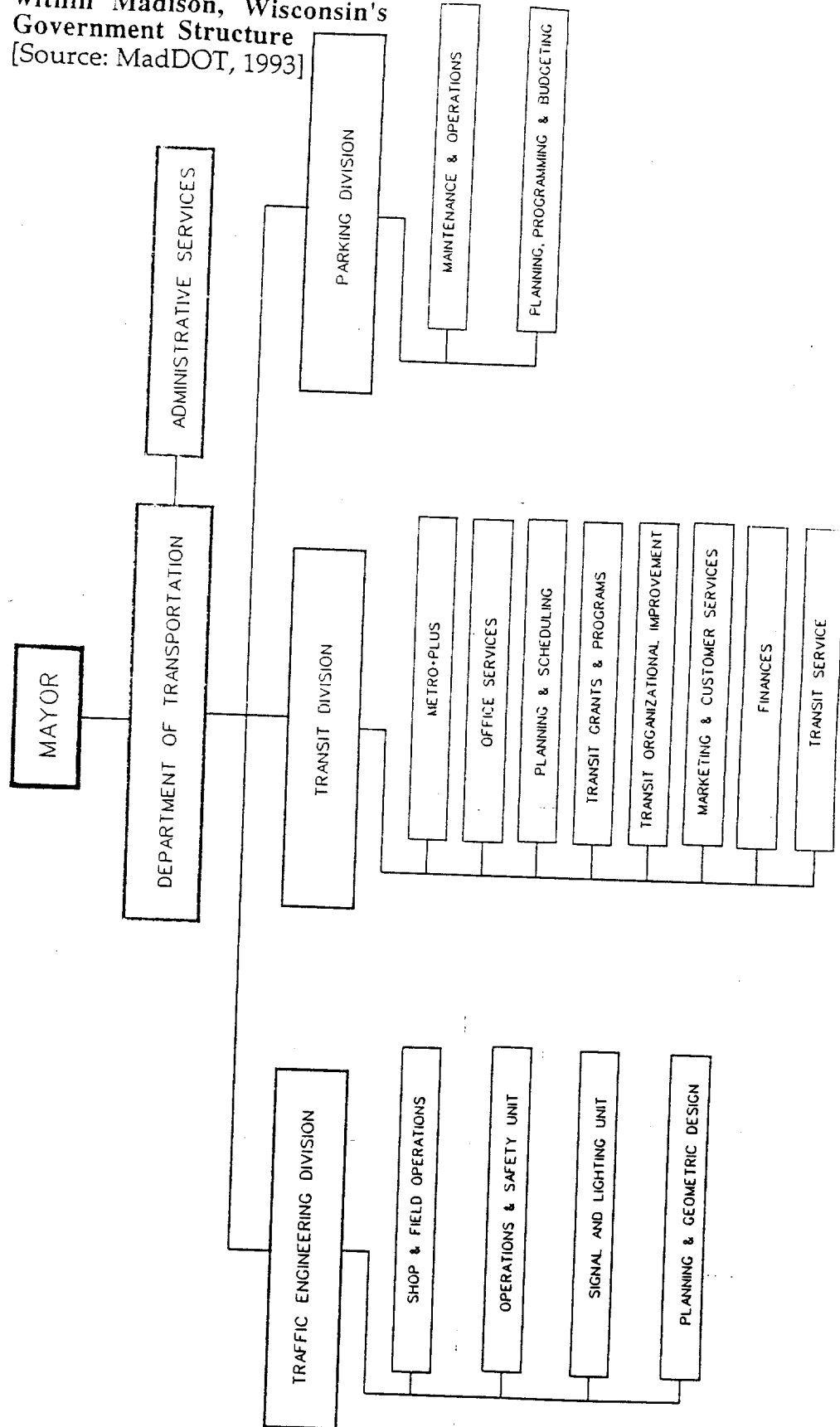
City transportation policy must be coordinated with the transportation policies of other governmental units. The Department serves as a liaison between the city of Madison and the United States Department of Transportation, Wisconsin Department of Transportation, Dane County, the University of Wisconsin and other metropolitan-area municipalities.

The Department works closely with the Dane County Regional Planning Commission, the area-wide planning organization that serves as a metropolitan clearinghouse for the federal and state governments. Most Madison transportation activities involving federal or state funds must be approved by the Regional Planning Commission. The Commission has a comprehensive planning program that includes goal-setting, extensive citizen participation activities, land use planning, environmental resource planning and transportation planning.

The Department of Transportation Policy Manual (MadDOT, 1993) outlines several policies that guide planning procedures for bicycle transportation. First, the Manual specifies that the 1990 Bicycle Transportation Plan goals and objectives should be followed in any Department of Transportation planning efforts. Second, the Manual identifies three primary documents that should be consulted to establish design criteria for accommodating bicycles in Madison's transportation system: the *Manual on Uniform Traffic Control Devices* (MUTCD) (AASHTO, 1988), the *Planning Guide for the Development of Pedestrian and Bicycle Facilities* (WisDOT, 1977) and the *AASHTO Guide for the Development of New Bicycle Facilities* (AASHTO, 1991). [Note: the *Planning Guide for the Development of Pedestrian and Bicycle Facilities* since publication of the *Policy Manual* has been updated, separated into separate pedestrian and bicycle manuals, and republished as *Wisconsin Bicycle Planning Guidance* (WisDOT, 1993).]

Figure 8: Department of Transportation within Madison, Wisconsin's Government Structure [Source: MadDOT, 1993]

CITY OF MADISON  
DEPARTMENT OF TRANSPORTATION 1993



## 4.2 Methodology

### 4.2.1 Description of Madison, Wisconsin

The City of Madison, Wisconsin, lies in south central Wisconsin on Lakes Mendota, Monona, Wingra and Waubesa (Figure 9). The downtown area developed on a narrow isthmus between Lakes Monona and Mendota. As the city has grown, the isthmus has become a transportation bottleneck and a constant headache for transportation planners. For commuters, regardless of transportation mode, the narrow isthmus means there are a limited number of possible route choices for traveling through this corridor. As a result, it is particularly vital for bicyclists that these roads are bicycle compatible so that they have mobility through the isthmus. Madison has a varied topography, which some consider to be a barrier to bicycling. The snow, ice and cold weather keep many people off their bicycles during the winter, however a significant number of people continue to ride straight through the winter. For example, University Ave., a major commuting corridor for bicyclists through the campus and downtown, has 6000 bicycles a day during the summer, but even in the winter there are 1000 bicycles a day (Univ. of N. Carolina, 1994). This study analyzes all arterial and collector streets within Madison's political boundary. The Village of Shorewood, Town of Madison, and City of Monona are generally considered to be integral parts of Madison, but are not included in this analysis because they do not fall under MadDOT's jurisdiction and therefore data were not readily available.

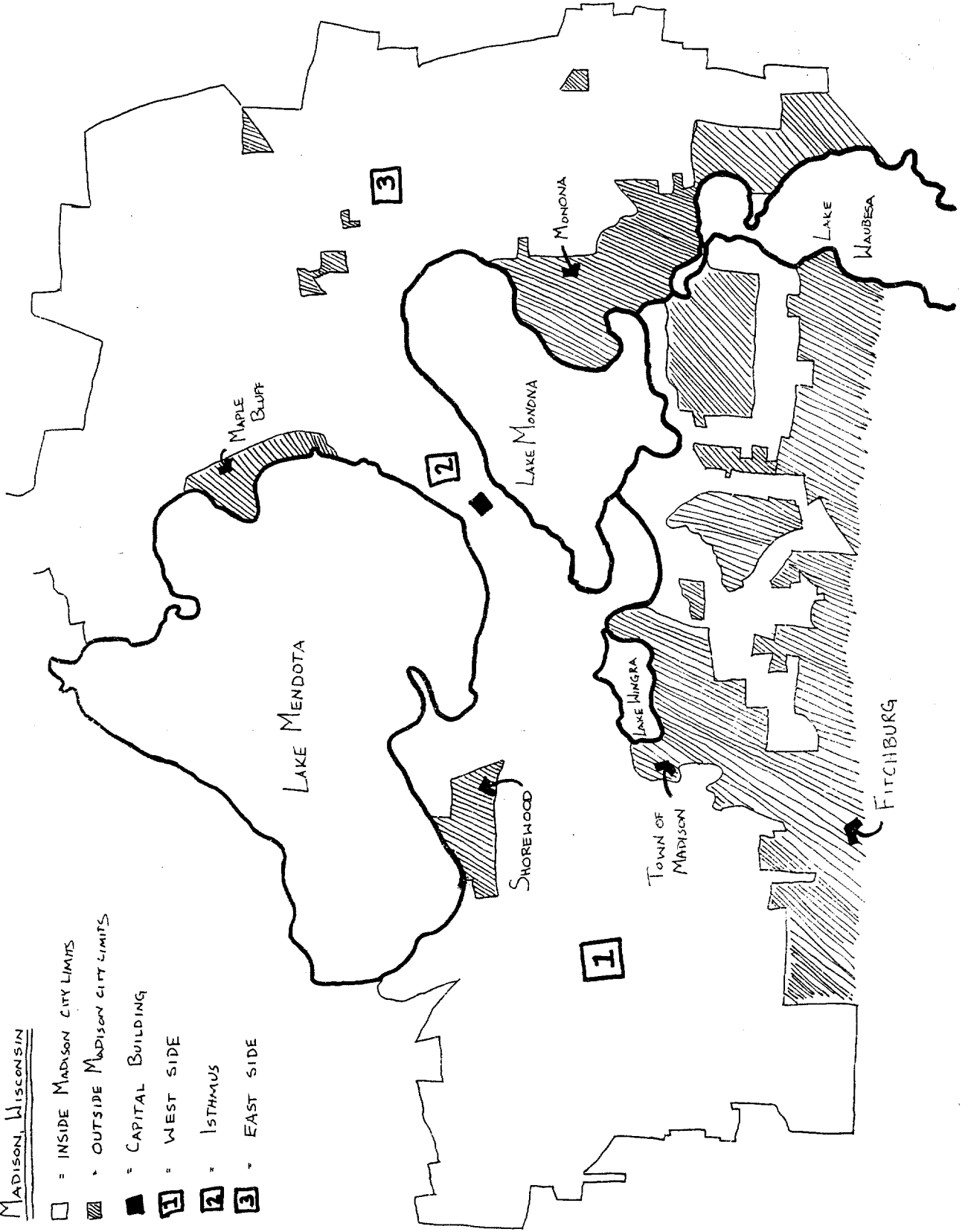
There are several characteristics of Madison residents that are worth noting to provide a better understanding of the context in which bicycle transportation planning in Madison takes place: percentage of trips made by bicycle, percentage of population which is too young to drive, and percentage of households which do not have a car. The 1990 US census is one source of information about bicycling activity in Madison. The Journey to Work section contains information about travel modes for the journey to work. Although these data are far from ideal for describing the overall levels of bicycling, they do at least provide a rough idea. The data estimate the population's travel choice behavior based on data about the primary mode of transportation that a sample of heads of households used for their journey to work during the third week in March, 1990. Non-work trips such as going to school or travel for social, recreational or shopping purposes are not represented by the data. These trips are generally shorter and less structured than work trips, and are therefore easier to do by bicycle suggesting that work trips may not be

### **Figure 9: Madison, Wisconsin**

*The City of Madison, Wisconsin, lies in south central Wisconsin on Lakes Mendota, Monona, Wingra and Waubesa. The downtown area developed on a narrow Isthmus between Lakes Monona and Mendota. As the city has grown, the Isthmus has become a transportation bottleneck and a constant headache for transportation planners. For bicyclists, the narrow Isthmus means there are a limited number of possible route choices for traveling through this corridor.*

MADISON, WISCONSIN

- = INSIDE MADISON CITY LIMITS
- ▨ = OUTSIDE MADISON CITY LIMITS
- = CAPITAL BUILDING
- 1 = WEST SIDE
- 2 = ISTHMUS
- 3 = EAST SIDE



representative of all trips. The National Personal Transportation Study (USDOT, 1990) reported that only 25 percent of all trips are work-related (See Table 2 on p. 22 for supporting data). It should also be noted that the census data may reflect the current pattern of bicycling in Madison, but not necessarily people's preferences. With these caveats in mind, according to the 1990 census, 3.4 percent of all work trips in Madison are made by bicycle. Although well below the 61 percent of people who drive alone to work, the percentage of people who bicycle to work is well above the national average of 0.5 percent (USDOT, 1990). By census tract, the percentages in Madison vary from 0.0 to 12.5 percent (Figure 10).

Children who are 10-14 years old are too young to drive, but are old enough to be active and want to travel. Because they cannot drive, they have to rely on other means of getting around: parental chauffeurs, bus, walking, bicycling. Therefore understanding the distribution of 10-14 year olds can provide insight into the bicycle transportation planning context. Most children in this age range probably ride a bike and, given safe places to ride, they can meet many of their travel needs by bicycle. In Madison, 4.5 percent of the population is 10-14 years old, representing a large potential bicycling population.

It is difficult to know how many people in Madison do not have a car. One possible measure of this is the 1990 census figure indicating the number of households without cars. This figure gives a rough idea, but it does not include carless people who live with other people who themselves have cars. Therefore, like the bicycling figure, although it is not a perfect measure, it at least provides a rough estimate. In Madison, the 1990 census indicates 13.8 percent of households do not have cars.

Madison's bicycle facilities are another element of the context in which bicycle transportation planning takes place. Accommodations for bicycles range from no special treatment to wide curb lanes to stripes bicycle lanes to separate path facilities. Madison has had a designated bicycle route system since the early 1970s which now includes over 100 miles of designated on-road and off-road routes (there are roughly 600 miles of roads in Madison). The intent of the bicycle route network is not to identify all the acceptable streets for bicycling in the community, but rather its intent is to designate at least one acceptable route through each major travel corridor in the city.

**Figure 10: Journey to Work Distribution of Bicyclists by Census Tract**

*The 1990 US census data show that in Madison, 3.4 percent of all work trips are made by bicycle. Although well below the 61 percent of people who drive alone to work, the percentage of people who bicycle to work is well above the national average of 0.5 percent (USDOT, 1990). By census tract, the number of people who bicycle to work varies from 0.0 to 12.5 percent.*



0-2 PERCENT NON-WORK TRIPS IN CENSUS TRACT MADE BY BICYCLE (1990 US CENSUS)

- 0-2
- 3-4
- 5-6
- 7-8
- > 8

Madison's collective attitude toward bicycling is another important element of the city's bicycle transportation planning context. Bicycling is a popular activity in Madison, both for transportation and for recreation. The city is home to about 15 touring and racing clubs aimed at bicyclists with all possible backgrounds and interests. In addition, the Bicycle Transportation Alliance of Dane County and the Bicycle Federation of Wisconsin actively advocate for bicycling in Madison.

#### **4.2.2 Summary of the Roadway Compatibility Module of the Proposed Framework for Thinking About Bicycle Compatibility**

The methodological approach for the case study directly follows the process outlined in the roadway compatibility module description in section 3.4.4:

1. Identify study area boundaries;
2. Identify all collector and arterial streets within the study boundaries;
3. Divide the collector and arterial streets into segments with uniform characteristics;
4. Collect data about curb lane width, traffic volume and traffic speed;
5. Calculate bicycle compatibility ratings using Sorton and Walsh's (1994) BCE model; and
6. Create a bicycle compatibility rating map to visually represent the bicycle compatibility ratings.

#### **4.2.3 Sampling and Data Collection**

My bicycle compatibility analysis of Madison's roadway network focuses on collector and arterial streets under the jurisdiction of the Madison Department of Transportation. Local streets are assumed to have acceptable compatibility ratings because of low traffic volumes and slow speeds, and therefore are excluded from the study. Also, streets outside MadDOT's jurisdiction are excluded from the study due to difficulties in obtaining data about the traffic and physical characteristics of the roadway in these areas.

MadDOT's 1994 Highway and Street Functional Classification Map is used to identify the arterial and collector street segments to be included in the bicycle compatibility analysis (Appendix B.1).

Once I identified the collector and arterial streets, I divided them into segments for analysis based on changes in the bicycle compatibility variables: curb lane width, traffic volume in the curb lane and traffic speed in the curb lane. The goal was to create road segments for which these three variables were constant for the analysis segment. Madison's Local Roads Inventory Listing was used as a starting point for dividing the arterial and collector streets into appropriate segments for bicycle compatibility analysis (Appendix B.2). The Local Roads Inventory includes data about many roadway characteristics for every road in Madison. The inventory divides the roads into segments according to when any of the variables changes values.

Madison's Local Roads Inventory Listing and Intersection Condition Diagrams (Appendix B.3) were used to identify the curb lane widths for the street segments. MadDOT's 1989 Speed Zone Map was used to determine posted speed limits (Appendix B.4). These speed limits were translated into traffic speeds by assuming that 85 percent of traffic travels no more than 5 mph over the posted speed limit. The Local Roads Inventory and MadDOT's 1993 Traffic Flow Map were used to identify traffic volumes for the roadway (Appendix B.5). Information about the number of traffic lanes in the Local Roads Inventory and the Intersection Condition Diagrams were used to convert these figures from total traffic volume to traffic volume in the curb lane. It was assumed that the traffic was evenly divided among the lanes and calculations were made for peak conditions assuming that 10 percent of the total traffic volume for a 24 hour period occurs during the peak.

The boundaries for changes in curb lane width and traffic speed were definite and therefore straightforward to define. Traffic volumes, on the other hand, were not as clear cut. In many cases, if absolutely any change in the estimated traffic volume would have triggered a subdivision of a road segment into two smaller segments, the number of segments to analyze would have rapidly become unrealistic to manage. Because the traffic flows changes gradually and data are collected for only specific points, the traffic volumes for points between the count sites can only be estimated. For this study, a road segment was subdivided if the change in vehicles per hour per lane was 50 or greater.

The above identified sources for dividing the streets into analysis segments were also the primary data sources for each variable. In addition to data about curb lane width, traffic volume and speed limit, data were collected about the street's classification, the number of travel lanes, parking conditions, roadway width, and bike lane or shoulder width. In cases where the data from these sources was unclear or questionable, the data were field checked. These data were entered into a Lotus 5.0 spreadsheet where each row contained data about a uniform road segment and each column represented one of the variables for which data were collected (Appendix C).

#### **4.2.4 Calculation of Bicycle Compatibility Ratings and Creation of Planning Tools**

I calculated bicycle compatibility ratings for each individual variable as well as for the combined impact of the three variables for each arterial and collector road segment using Sorton and Walsh's model (Sorton and Walsh, 1994). The formulas used to make the calculations, as entered in the spreadsheet, are included in Appendix D. The overall bicycle compatibility rating for each segment is provided both as a number index (1.00-5.00) as well as a verbal summary (very good to very poor compatibility).

I color coded each of the five bicycle compatibility rating levels. Then I accordingly mapped the overall bicycle compatibility ratings for each arterial and collector street segment from the compatibility rating spreadsheet onto a base map showing Madison's arterial and collector street network (Figure 11).

In addition to the bicycle compatibility map of existing conditions, I also created a bicycle compatibility warning map (Figure 12). This map indicates arterial and collector street segments which, although they currently have acceptable bicycle compatibility ratings, are at risk of changing to poor compatibility in the next five to ten years through increases in traffic volume alone. Two categories of roads are included in this warning map: 1) road segments which will have a poor bicycle compatibility rating if the traffic in the curb lane increases 50 vehicles per hour during peak conditions, and 2) road segments which will have a poor bicycle compatibility rating if the traffic in the curb lane increases 100 vehicles per hour during peak conditions.

#### **4.2.5 Evaluation of the Bicycle Compatibility Ratings and Planning Tools**

I evaluated the bicycle compatibility spreadsheet, rating map and warning map to determine the usefulness of the roadway compatibility module of the proposed bicycle transportation planning framework as a planning tool. I met with the Bicycle Transportation Alliance of Dane County (BTA) steering committee to get feedback about the validity of the bicycle compatibility module of the proposed bicycle transportation planning framework. BTA, the local bicycle advocacy organization in Madison, Wisconsin, is actively working to have bicycles be an equal partner in Dane County's transportation system and to institutionalize getting bicycle issues addressed in all transportation planning, construction and maintenance processes in the county. They are strong advocates in the belief that "if it's bikable, it's livable." BTA steering committee members participating in the informal evaluation included Mike Barrett, east side resident and board member of the Bicycle Federation of Wisconsin; Dieter Bingeman, east side resident and talented artist who adds inspiring creative flare to local and statewide bicycle advocacy effort; Mark Shahan, west side resident and dedicated spokesperson at governmental meetings; and Tim Wong, east side resident and vice chair of Madison's Pedestrian-Bicycle Subcommittee. All are active year-round bicycle commuters with a vested vocal interest in the bicycle compatibility of Madison's transportation system.

### **4.3 Results**

#### **4.3.1 General Observations About the Bicycle Compatibility Evaluation Results**

Results from the roadway compatibility evaluation suggest Madison's street network is moderately bicycle compatible (Figures 11 and 12). To arrive at this conclusion, I estimate how well the street network provides bicyclists with the mobility and access they desire. To do this, I consider the proportion of arterial and collector streets that rate as having acceptable bicycle compatibility, how well the compatible streets connect in a network, and how well bicyclists can access some major commercial areas.

There two possible ways to evaluate the proportion of arterial and collector streets that have acceptable bicycle compatibility ratings (very good, good, or moderate compatibility). Counting the number of street segments with acceptable bicycle compatibility and dividing by the total number of street segments is one possible

approach. However, this method does not provide a good estimate of the proportion of street segments with acceptable bicycle compatibility because some segments are a block long and others a half mile long, so some segments would receive too much weight and others not enough weight to accurately reflect the overall level of bicycle compatibility for the arterial and collector street network.

To be able to report more accurately the proportion of bicycle compatible streets, data about the length of each segment is required. For many of the road segments in this analysis, data about the segment length is available from the local road inventory. For segments in this analysis that are subdivisions of the segments in the local road inventory, I estimate their length by measuring them on a standard city street map. This analysis reveals that in all, 64.4 percent of the total arterial and collector street mileage has acceptable bicycle compatibility (very good, good or moderate compatibility rating) and conversely that 35.6 percent has unacceptable ratings (poor or very poor compatibility rating). Of the 733 segments analyzed, the shortest segment is 0.02 miles long and the longest segment is 2.1 miles long; each segment has a wide possible range of impact on the overall weighted average bicycle compatibility for the network. The average bicycle compatibility of the arterial and collector street network, weighted for street segment length, is 3.34, or moderate compatibility.

The absolute proportion of streets that are bicycle compatible is only a small piece of the bigger picture. If the bicycle compatible segments are surrounded by less compatible segments, they will do little to facilitate bicycle mobility. In short, connectivity of bicycle compatible street segments is important because it is this connectivity that provides bicyclists mobility across neighborhoods. A mathematical measure of connectivity would perhaps provide the most consistent and objective measurement; however, I base the present analysis on a less rigorous visual assessment of the bicycle compatibility rating map. The best connectivity of bicycle compatible streets is found downtown near the capital square. The street network to the west of the capital is better connected than the network on the east side of the capital. The connectivity of the roads with poor compatibility to the west of the capital at least somewhat offsets the connectivity of the compatible roads. In addition, the Isthmus bike path (just to the east of the capital square) and the east rail corridor bike path help to improve the connectivity of Madison's bicycle compatible streets east of the capital. Therefore, the overall connectivity of

Madison's bicycle compatible street network is fair, the downtown is best, and it is difficult to say whether the east side or west side is better connected.

Accessibility to major commercial areas is another criterion to consider in evaluating how bicycle compatible the results from the roadway compatibility evaluation module suggest Madison's street network is. The data suggest Madison's three major shopping malls (West Towne, East Towne and South Towne) have very limited accessibility by bicycle because the streets leading to these facilities have poor bicycle compatibility ratings. In addition, accessibility to Hilldale and Westgate Malls is variable depending on from which direction a bicyclist is approaching. Results show regional/neighborhood shopping areas such as Monroe St. and Williamson St. are fairly bicycle accessible.

#### 4.3.2 Bicycle Compatibility Spreadsheet

I collected bicycle compatibility data for 733 roadway segments in Madison, representing about 220 miles of roads (approximately 36.8% of the city's total street mileage) (Appendix C). The segment mileage falling in each bicycle compatibility category for both arterial and collector streets is summarized in Table 3.

In characterizing the bicycle compatibility ratings of the arterial and collector streets in Madison's roadway network, streets which have 'poor' and 'very poor' ratings are of particular interest because it is these streets that the bicycle compatibility planning methodology assumes most bicyclists will find to be unacceptable riding environments and therefore should be targeted for improvements. One rating combination of interest, therefore, is streets which have a posted speed limit of 35 mph, a curb lane of less than 12 feet, and >400 vphpl. Roads with this combination of characteristics will have a bicycle compatibility rating of 4.67, or 'very poor compatibility'. In Madison, there are 22 road segments with this bicycle compatibility rating including:

##### EAST OF CAPITAL:

East Washington Ave.

International Lane (Packers-Anderson)

Northport Dr. (Troy-Packers)

Pennsylvania Ave. (Johnson-Packers)

Packers Ave. (Darwin-Pennsylvania)

**WEST OF CAPITAL:**

Gammon Rd. (Odana-Seybold)

University Ave. (Whitney Way-Old Middleton)

**SOUTH:**

Park St. (Wingra-RR/Coop Dr. - north bound)

**Table 3: Summary of Road Lengths Falling in Each  
Bicycle Compatibility Category**

<b>Bicycle Compatibility Rating</b>	<b>Collector Streets (in miles)</b>	<b>Arterial Streets (in miles)</b>	<b>Arterial, Collector Street Totals (in miles)</b>
<b>Very Good</b>	0.81	0.00	0.81
<b>Good</b>	32.24	1.46	33.70
<b>Moderate</b>	71.78	35.48	107.26
<b>Poor</b>	16.01	49.99	66.00
<b>Very Poor</b>	0.20	12.46	12.66

*Results from the bicycle compatibility analysis indicate about 35.6% of Madison's arterial and collector street mileage has unacceptable bicycle compatibility ratings. Of this unacceptable mileage, 80% represents arterial streets. Conversely, 74% of the street mileage with acceptable ratings in collector streets. These results suggest that the approximately three times out of four one would be correct in guessing collector street has an acceptable bicycle compatibility rating and that an arterial street has an unacceptable bicycle compatibility rating.*

These high ratings are particularly important to address for the east side because these streets network together and therefore present a particularly significant access barrier to bicyclists. These roads all have 4 lanes of traffic with the exceptions of Packers Ave. (Darwin to Northport) [2 lanes] and East Washington Ave. [6 lanes]. Also, all streets falling into this category are classified as arterial streets except International Lane from

Packers to Anderson. In addition, only East Washington (except Franklin - Blair) and Packers (Darwin-Aberg) have traffic volumes well above 400 vphpl. Further, all of these streets have either a 12 or 13 foot curb lane and only East Washington has parking. Finally, most of these streets have a total roadway width between 74 and 84 feet. The exceptions to this trend include Packers (Darwin-Northport) [26 ft.], International Lane (Packers-Anderson) [48 ft.], Park (Wingra-RR) [64 ft.], University Ave. (Whitney-Old Middleton).

Very few traffic and road configuration combinations produce a bicycle compatibility rating at either extreme of the spectrum—either very good compatibility or very poor compatibility. In Madison, 0.81 miles of road (0.4%) are classified as very good compatibility and 12.66 miles of road (5.7%) are rated as very poor compatibility. The very good compatibility rating is possible only on streets with a posted speed limit of 25 mph, a wide curb lane ( $\geq 17$  feet), and very little traffic ( $< 100$  vphpl). This combination will rarely happen because the only streets which will likely have this combination of traffic and road characteristics are streets which were constructed to be collector streets, but actually function as residential streets. Streets constructed and utilized as residential streets will meet the criteria for speed limit and traffic volume. However, their curb lanes will generally be less than 17 feet and therefore their usual rating will be 'good compatibility' rather than 'very good compatibility'. At the other end of the spectrum, the very poor compatibility rating is possible only on streets with a posted speed limit  $\geq 35$  mph, a curb lane width  $< 13$  feet and a traffic volume  $> 300$  vphpl. Another aspect of the bicycle compatibility ratings is that ratings for which the speed limit component is '1' will only happen in parking lots because this is the only locations where speed limits will likely be less than 25 mph. Because 85th percentile speeds (assumed to be 5 mph over posted speed limit) were used to calculate the compatibility ratings, even on residential streets where the statutory speed limit is 25 mph, traffic is assumed to travel at 30 mph and therefore the compatibility index used for calculating the overall compatibility rating will be '2'.

Also, given the assumption that streets with a bicycle compatibility rating of 'moderate' or better are acceptable and 'poor' or worse are unacceptable, street segments which fall on the border directly between 'moderate' and 'poor' are of particular interest. These streets are prime targets for modifications to improve their compatibility rating or

measures to ensure that no changes are allowed which make the road slip into an unacceptable bicycle compatibility rating.

#### 4.3.3 Bicycle Compatibility Rating Map

The bicycle compatibility rating map graphically represents the data in the bicycle compatibility spreadsheet, allowing me to examine the spatial relationships between the bicycle compatibility ratings and to determine the lengths of the individual segments (Figure 11). My analysis shows the longest continuous stretch of poor and/or very poor compatible road is 6.37 miles long (Mineral Point Rd. — Speedway — Highland Ave. — University Ave.) and the longest stretch of very good and/or good and/or moderate compatible road is 5.28 miles long (Old Sauk Rd. — Old Middleton Rd. — Eau Claire Ave. — Regent St. — Bluff Street — Franklin St. — Regent St.).

To guide my observations related to the bicycle compatibility rating map, I focused on:

1. Identifying streets with poor compatibility; and
2. Deciding how much of a problem this poor compatibility is based on whether the street is:
  - a. On a route that does not link major residential and employment centers;
  - b. On a major commuting route, but alternative routes exist; or
  - c. On a major commuting route and no convenient route alternatives exist.

Within this framework, the streets that are of the greatest concern and highest priority for improvements are those streets with poor compatibility ratings that are on a major commuting route where no convenient route alternatives exist.

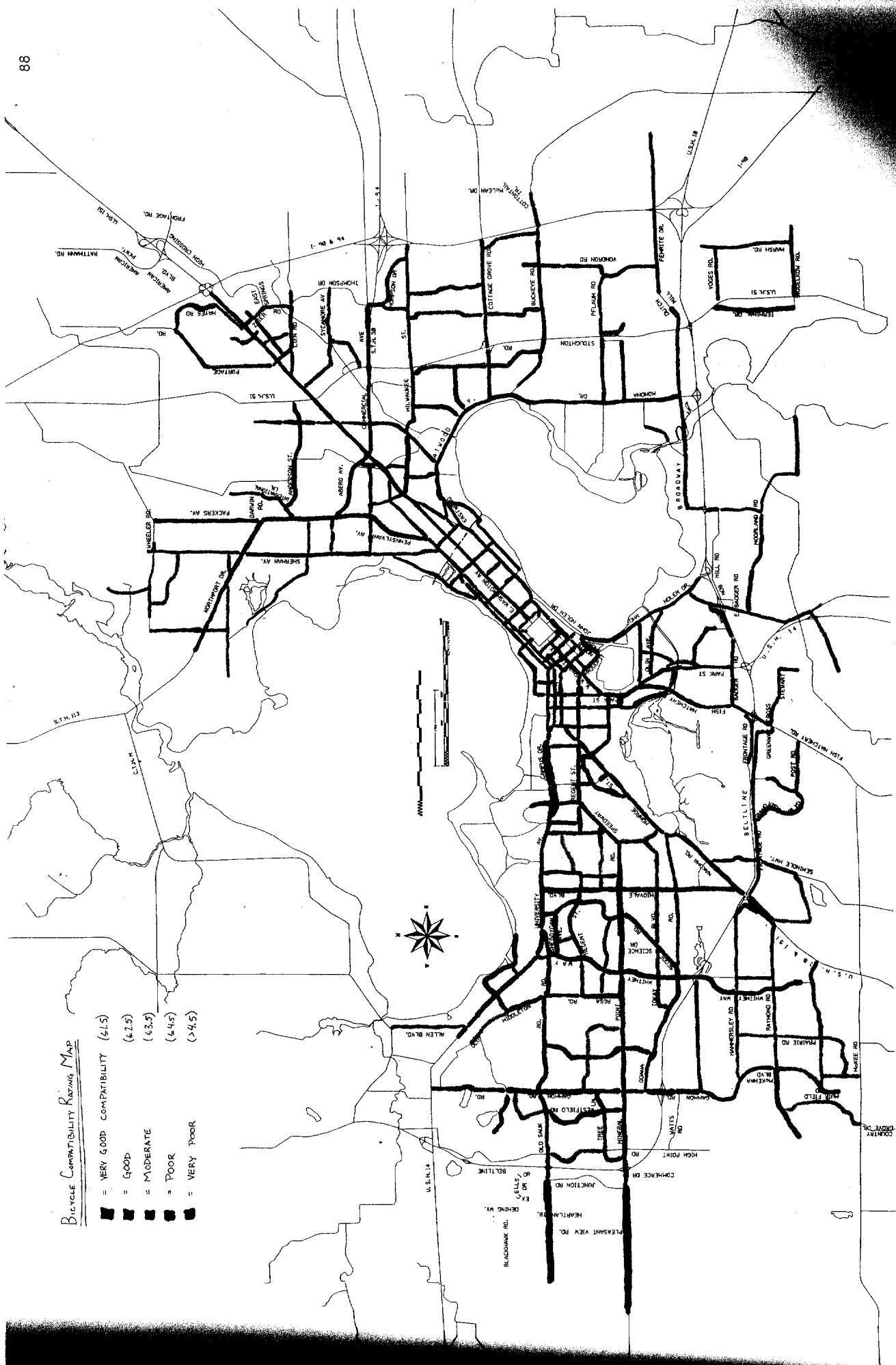
The bicycle compatibility rating map makes it readily possible to evaluate the bicycle compatibility of the arterial streets providing mobility through Madison's seven major commuting corridors that extend outward from the downtown. Three corridors extend from the east end of the Isthmus — one straight out (E. Washington/ Johnson/

### **Figure 11: Bicycle Compatibility Rating Map for Madison, Wisconsin**



*The bicycle compatibility rating map graphically represents the data in the bicycle compatibility spreadsheet. This graphical representation allowed me to examine the spatial relationships between the bicycle compatibility ratings and to determine the lengths of the individual segments.*

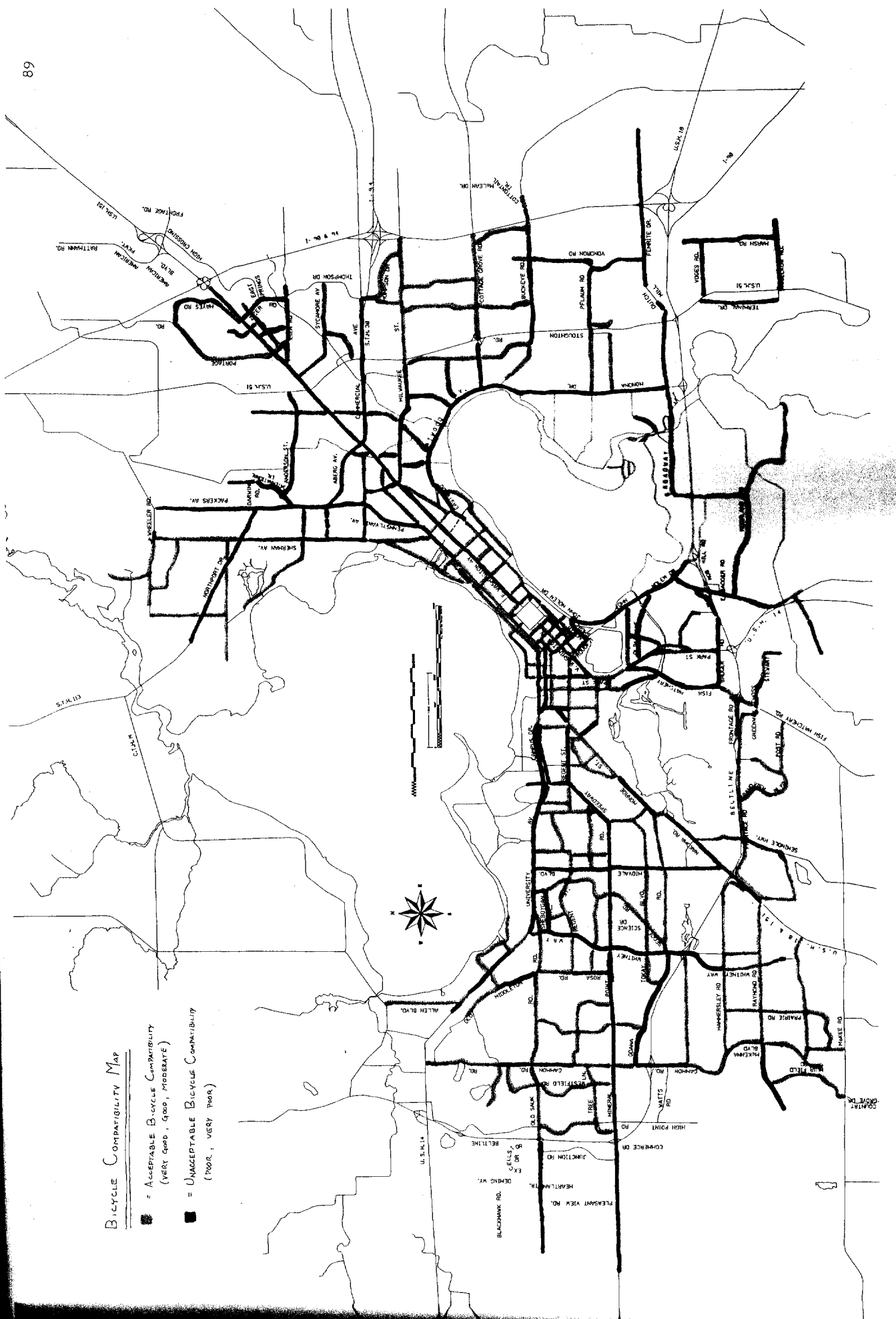
Bicycle Compatibility Rating Map

- = VERY GOOD COMPATIBILITY (4.15)
- = GOOD (4.25)
- = MODERATE (4.35)
- = POOR (4.45)
- = VERY POOR (>4.5)



# BICYCLE COMPATIBILITY MAP

-  = ACCEPTABLE BICYCLE COMPATIBILITY (VERY GOOD, GOOD, MODERATE)
-  = UNACCEPTABLE BICYCLE COMPATIBILITY (POOR, VERY POOR)



Gorham), one veering around Lake Mendota to the north (N. Sherman/ Packers/ Northport), and one veering around Lake Monona to the south (Atwood/ Monona Dr.). Four corridors extend from the west end of the Isthmus — one straight west (Mineral Point Rd.), one veering north around Lake Mendota (University Ave.), and two veering south around either end of Lake Wingra (Monroe/ Nakoma, Park/ Fish Hatchery). The bicycle compatibility rating map shows the two south veering corridors west of the Isthmus on Monroe St. and Park St. alternate between stretches of poor and good compatibility. The map shows that all the remaining corridors have either poor or very poor bicycle compatibility ratings.

Given these bicycling barriers, another important group of observations relates to possible alternate routes. Bicycle commuters, like commuters traveling by any other mode, are interested in the fastest, most direct route possible. Because bicycles are human-powered and travel more slowly than motor vehicles, route choices are often a particularly important criterion in evaluating the bicycle compatibility of the roadway network. If convenient parallel routes exist which are more bicycle compatible, the barrier represented by the poorly compatible roads presents less of a problem than if no alternatives exist. However, the existence of alternative routes does not mean efforts should be made to improve the bicycle compatibility of these corridors. Bicyclists need access to destinations on these streets as well as mobility through the corridor.

It is particularly important to assess route alternatives in Madison because the city's topography, lakes, golf courses, parks, and cemeteries have led to a street network which largely does not operate on a simple grid even in the older parts of town. At the neighborhood scale, grids certainly exist, but for commuters traveling across several neighborhoods and desiring bicycle compatible alternatives parallel to the major arterials, the effectiveness of the grid rapidly breaks down. In applying the alternative route criterion to the problem streets mentioned above, there are a number of these roads which have reasonable alternatives available. In each case, the alternates lie in the major commuting corridors identified above and are residential streets that are assumed to have good bicycle compatibility. For example, there is a road through the cemetery along Speedway which provides a desirable alternative to Speedway itself, although connectivity with the street network is a bit of a problem at the east end of the cemetery. Kendall Ave. provides a reasonable alternative to old University Ave. Keyes and Gregory

are acceptable alternatives to Monroe Street, for mobility through the corridor, but not for access to the businesses on Monroe Street. And Rowley provides a less traveled route parallel to Regent St. Although these route alternatives may make bicycle travel more feasible and pleasant along these corridors, they often represent definite compromises. Traveling these alternate routes often means giving up two desirable commuting characteristics of the collector and arterials. First, these alternate routes often have more stop signs. Also, these routes often go through residential neighborhoods, so kids running into the street without watching can sometimes be an issue. These are factors that could be addressed respectively by the intersection and network compatibility modules of the proposed bicycle transportation planning framework.

Although some major commuting roads with poor bicycle compatibility have acceptable alternative routes available, others do not. Because I am most familiar with the route options to the west of the capital, I focused my analysis of this issue on this part of the city. University Avenue, Midvale Blvd., Nakoma Road, Whitney Way, Mineral Point Road and Odana Road are major commuting corridors with no readily available alternative routes. Because no convenient bicycle compatible alternatives exist for these roads, as seen on the bicycle compatibility map by a lack of a parallel street in close proximity to the problem street, and because they represent major commuting corridors, these roads should be priority targets for bicycle compatibility improvements. In some cases, the improvement options are limited. For example, Mineral Point Road has a designated bicycles/buses/right turn only lane, but in this case the bicycle compatibility methodology indicates the traffic volumes and traffic speed are simply too great for the bike lane to overcome. In this case, since a speed limit reduction through speed limit postings is unrealistic, efforts to improve this corridor's bicycle compatibility may be limited to broader transportation demand management efforts to reduce single occupancy vehicles on the roads. It should be noted that the Mineral Point example above represents a case where the bicycle compatibility methodology seems to break down. Experience suggests that the 13 foot bike/bus/right turn lane on this road provides for a better level of bicycle compatibility than the rating methodology indicates.

For others of these roads, there are better opportunities to improve bicycle compatibility through the corridor. Along University Ave., for example, a bicycle path has been proposed in the rail corridor parallel to the road. Separated paths are not always a good solution because often crossings with roads and pedestrian-bicycle conflicts on

paths are significant safety problems. However, in this case road crossings would be limited and the road lanes are already very narrow and the traffic volume so high that there are no realistic options for reconfiguring the roadway. A path in the rail corridor will provide bicyclists convenient mobility through this corridor where presently they have to take indirect routes through the neighborhoods, but access to destinations on University Ave. are still needed. Odana Road between Whitney Way and Gammon Road is an interesting case because it is an example of a road that used to have bike lanes, but currently does not because they were removed to accommodate additional motor vehicle traffic. As a result, the corridor has a poor bicycle compatibility rating and there are essentially no parallel roads available to provide a reasonable alternative. Schroeder Rd. and Mineral Point Rd. are the only remote possibilities. However, they both represent a significant route deviation and neither option provides reasonable access to the businesses in the Odana Rd. corridor. In addition, as discussed above Mineral Point Rd. itself represents a road with poor bicycle compatibility, according to the bicycle compatibility methodology, and in order to get to Schroeder Rd. from Odana Rd. at the Whitney Way end of the segment requires bicyclists to negotiate a traffic clogged maze of turning lanes at the beltline. The CUNA Mutual Insurance Society lands on the north side of Odana Road are currently being developed as an office park. A path or road connection in conjunction with this development could greatly improve bicycle accessibility and mobility through this corridor.

#### **4.3.4 Bicycle Compatibility Warning Map**

The bicycle compatibility warning map shows that 7.69 miles of collector streets (6.4%) and 4.1 miles of arterial streets (4.1%) are at risk of changing to poor compatibility if traffic volumes on these roads increase 50 vphpl during peak conditions (Figure 12). In addition, the map shows that 5.82 miles of collector streets (4.8%) and 0.25 miles of arterial streets (0.25%) are at risk of changing to poor compatibility if traffic volumes on these roads increase 100 vphpl during peak conditions. The shortest at-risk stretch is 0.02 miles long and the longest stretch is 1.75 miles long.

**Figure 12: Bicycle Compatibility Warning Map for Madison, Wisconsin**

*The bicycle compatibility warning map shows that 7.69 miles of collector streets (6.4%) and 4.1 miles of arterial streets (4.1%) are at risk of changing to poor compatibility if traffic volumes on these roads increase 50 vphpl during peak conditions. In addition, the map shows that 5.82 miles of collector streets (4.8%) and 0.25 miles of arterial streets (0.25%) are at risk of changing to poor compatibility if traffic volumes on these roads increase 100 vphpl during peak conditions.*



The bicycle compatibility warning map suggests a number of implications for bicycle transportation planning. First, many of the at-risk segments are at the outskirts of the present urban area. This condition is particularly striking for the east side where six streets leading out of the city are at risk of becoming an unacceptable route for many bicyclists. Given the strong recreational bicycling community in Madison, as evidenced by at least 15 active touring and racing clubs, and the rapid development occurring at the urban fringe (Madison is the fastest growing urban area in Dane County which is in turn the fastest growing county in Wisconsin (Dane 2020 Task Force, 1992)), this map highlights some critical streets which should be addressed now so they do not become serious bottlenecks for bicyclists in the near future.

In the established part of the city, the at risk segments are concentrated around the capital square and are generally shorter than 0.05 miles long. It should be noted, however, that just because a segment is short does not mean it is insignificant. Short segments with poor bicycle compatibility ratings have the potential to discourage people from bicycling in the area although it is in general a very desirable place to ride because they do not want to contend with the bottleneck. This is particularly critical if no convenient parallel route alternatives exist. Since it can be difficult to change roadway configurations in well established urban areas, it is comforting that relatively few streets in this area are at risk of getting an unacceptable compatibility rating simply through an increase in traffic volume.

It is also significant that only 8.0 percent of the city's arterial and collector street miles fall into one of the at-risk categories. If most streets were at risk, the future of bicycle transportation would look gloomy indeed and it would be difficult to get the planners and engineers to take concerns about any single road segment seriously because it would be only one of many. If this were the case, it would likely be much more difficult to convince transportation planners and engineers to accommodate bicyclists because it would be a challenge to convince them that changing any particular segment would have a significant impact on the overall system and be a good financial investment. Also, since there are relatively few at risk segments, it makes it much more feasible to be proactive in planning to accommodate bicyclists on these road segments. If the list of at risk segments were too unwieldy, it would be much more likely that a road would have to reach the

point of being unacceptable before any changes would be considered to increase its bicycle compatibility.

It should also be noted that the road segments mapped on the bicycle compatibility warning map do not represent all of the road segments for which it is possible to have a poor bicycle compatibility rating through an increase in traffic volume alone. There are many more streets which have the potential to become unacceptable, however, the traffic volume increases which would be required (>100 vphpl) would likely not happen for more than 10 years and therefore they were not mapped at this time. It is therefore recommended that the bicycle compatibility warning map be updated every five years based on current traffic counts.

Madison planners can try to increase the curb lane width, decrease the traffic volume or decrease the traffic speed in efforts to proactively prevent these segments from changing to poor compatibility due to increases in traffic volumes. Curb lane width is probably the easiest of the three variables to impact. It may be possible in the short term to re-stripe a roadway, narrowing inside lanes and widening the curb lane, to provide a wide curb lane to accommodate both motorists and bicyclists, or to provide for a bike lane. As roads are scheduled for reconstruction, it may be possible to widen the entire roadway by a few feet, with the extra space allocated to wide curb lanes, bike lanes, or paved shoulders.

#### **4.4 Discussion**

##### **4.4.1 Bicycle Compatibility Spreadsheet**

In considering the usefulness of bicycle compatibility ratings for bicycle planning, it is interesting to note the specific variables the methodology uses to assess compatibility because measuring compatibility changes by using this methodology suggests these are the variables a planner will try to impact. As discussed earlier, attempts can be made to impact curb lane width, traffic volume and traffic speed with varying degrees of success.

The prevailing speed of traffic, taken as the 85th percentile speed, is more difficult to impact. The posted speed limit could be changed, but this does not necessarily mean the behaviors of individual motorists will change. A successful speeding education and enforcement program can improve the bicycle compatibility of roads in a community by lowering the 85th percentile speeds.

Traffic volume is perhaps the most difficult variable to impact due to its complexity. Land use patterns that emphasize mixed use development and connectivity of the local street network, at least for pedestrian and bicycle access, can have an impact on traffic volumes. Transportation demand management programs and transit services can also help. It should be noted that curb lane width, traffic speed and traffic volume are not the only three variables which impact a roadway's bicycle compatibility. Bicycle safe drain grates, attention to railroad crossings, traffic signal detection loop sensitivity to bicycles, patching potholes and sweeping curb lanes are other variables which will also impact a roadway network's bicycle compatibility.

To evaluate the usefulness of the bicycle compatibility ratings, it would be valuable to have a good idea how 'fuzzy' the boundaries are between the rating levels. Of particular interest are streets with bicycle compatibility ratings which fall directly on the border between acceptable and unacceptable. For example, Glenway St. (Paunack-St. Clair) is configured as follows: 12 ft curb lane, 282.5 vphpl, 25 mph posted speed limit. These characteristics translate to bicycle compatibility indices of 5, 3.5, 2 for the individual components and an overall bicycle compatibility rating of 3.50, or 'moderate' compatibility. Depending on how 'fuzzy' the boundary really is between compatibility rating levels, Glenway St. may really be acceptable, or it might not be. [In this case, experience suggests that it really is acceptable, but one of the goals of this methodology is to predict the bicycle compatibility of a roadway without having to rely completely on personal experience.] If the perceived compatibility due to any one of these three variables is any less than the methodology predicts, the bicycle compatibility evaluation procedure may be inaccurately identifying Glenway St. as acceptable. It is also possible that an error in assumptions may lean in the opposite direction, suggesting that the street may actually be more acceptable and therefore less at risk of becoming unacceptable than the methodology predicts. A possible solution to this 'fuzzy' boundary issue is to collect volume and speed data in the field for road segments falling in this 'fuzzy' category.

Another aspect of the bicycle compatibility ratings to evaluate is the assumptions which the methodology makes. These assumptions include:

1. The primary variables which influence people's perception of bicycle compatibility are curb lane width, traffic volume and traffic speed;

2. The bicycle compatibility scales for each variable accurately reflect people's perceptions of these conditions;
3. People weight curb lane width, traffic volume and traffic speed equally in their perceptions of bicycle compatibility;
4. With all three variables, there is a linear relationship between change in perceived bicycle compatibility and change in the attribute;
5. Traffic flow is evenly divided between all the lanes of traffic;
6. Ten percent of the average daily traffic occurs during peak conditions;
7. Eighty-five percent of traffic travels 5 mph or less over the posted speed limit;
8. The grain of people's perception of bicycle compatibility is 5 mph for speed, six inches for curb lane width, and 50 vphpl for traffic volume; and
9. It is reasonable to rate all three variables on a scale of 1-5 using 0.5 increments. This assumption implies that within the range that each variable varies, people perceive nine different levels of bicycle compatibility.

To evaluate the significance of these assumptions and their impact on the bicycle compatibility ratings, several questions were considered: 1) what if traffic doesn't travel at 5 mph over the posted speed limit?; and 2) should peak hour conditions be used for calculating the bicycle compatibility ratings?

Given the above assumptions, it is appropriate to question how accurate and therefore how useful the bicycle compatibility ratings are. For example, what if traffic really travels at 8 mph over the posted speed limit rather than 5 mph? In the case of the Glenway St. example above, changing this assumption changes the bicycle compatibility index for speed from 2 to 3. As a result the overall bicycle compatibility rating changes from 3.50 (moderate compatibility/acceptable) to 3.83 (poor compatibility/unacceptable).

To evaluate this situation, it should be noted that the posted speed limit is at the upper limit of each compatibility index category and each category covers a range of 5 mph. Given the scale used for estimating bicycle compatibility related to speed, if traffic travels at the posted speed limit, the compatibility rating translates directly. If traffic

travels 1-5 mph over the posted limit, the compatibility index is bumped up one level. If it travels 6-10 mph over the posted limit, it is bumped up two levels. And if it travels 11-15 mph over the posted limit, it is bumped up three levels. Therefore, in assuming the 85th percentile for traffic speed to be 5 mph over the posted speed limit, the corresponding speed is always at the upper limit of the risk perception category and that if the traffic actually travels even 1 mph faster, the compatibility index attributed to speed will be inaccurate.

The planning implication of this situation is that with respect to traffic speed, the boundary between acceptable and unacceptable is quite fuzzy; therefore, in cases where the compatibility rating is directly on the border between acceptable and unacceptable, it may be desirable to collect actual speed measurements to refine the compatibility rating more accurately. With respect to traffic speed, the compatibility indices are unlikely to be too high given that traffic most likely travels at least 1 mph above the speed limit. However, for road segments within two categories of the border between acceptable and unacceptable (Table 4), it is fairly likely that their compatibility is predicted to be better than it really is. Although this method for speed measurement is seemingly crude, for segments which end up falling well within the boundaries of acceptable or unacceptable, this level of accuracy is sufficient and is much less time consuming than other possible methods for measuring traffic speed. For roads rated 'moderate compatibility' which fall within two squares of the unacceptable boundary, the compatibility ratings predicted by the methodology may or may not be accurate. For these segments, field checking traffic speed using a speed gun would be a possible way to overcome this imprecision.

The peak hour conditions assumption is another aspect of the methodology to evaluate. The proposed methodology calculates bicycle compatibility for traffic volume using peak hour conditions. Further it is assumed that 10 percent of the daily traffic flow occurs during this time. If peak traffic is assumed to occur during one hour in the morning and one hour in the evening, the remaining 90 percent of the traffic flow occurs during the remaining 22 hours of the day. During the off peak hours, depending on the distribution of traffic volumes, the potential bicycle compatibility of a roadway may increase significantly. This is a reason to encourage flextime.

#### **Table 4: Bicycle Compatibility Index Rating Chart**

*The bicycle compatibility index rating chart depicts how the possible combinations of traffic speed, curb lane width and curb lane volume result in the various bicycle compatibility ratings. Each bicycle compatibility rating (very good, good, moderate, etc.) is shaded a different shade of grey, progressing from white representing very good to the darkest grey representing very poor. This graphic depiction is useful for assessing how close a road segment is to the boundary between moderate and poor bicycle compatibility.*

Bicycle Street Compatibility Rating Index									
Speed	Width	>=15	14.5 to <15	14 to <14.5	13.5 to <14	13 to <13.5	12.5 to <13	12 to <12.5	<12
<= 25 (1)	Volume	1	2	2.5	3	3.5	4	4.5	5
< 50	1	1.00	1.33	1.50	1.67	1.83	2.00	2.17	2.33
50 - 100	1.5	1.17	1.50	1.67	1.83	2.00	2.17	2.33	2.50
101 - 150	2	1.33	1.67	1.83	2.00	2.17	2.33	2.50	
151 - 200	2.5	1.50	1.83	2.00	2.17	2.33	2.50		
201 - 250	3	1.67	2.00	2.17	2.33	2.50			
251 - 300	3.5	1.83	2.17	2.33	2.50				
301 - 350	4	2.00	2.33	2.50	2.67				
351 - 400	4.5	2.17	2.50	2.67	2.83				
> 400	5	2.33	2.67	2.83	3.00				
Speed	Width	>=15	14.5 to <15	14 to <14.5	13.5 to <14	13 to <13.5	12.5 to <13	12 to <12.5	<12
26 - 30 (2)	Volume	1	2	2.5	3	3.5	4	4.5	5
< 50	1	1.33	1.67	1.83	2.00	2.17	2.33	2.50	
50 - 100	1.5	1.50	1.83	2.00	2.17	2.33	2.50		
101 - 150	2	1.67	2.00	2.17	2.33	2.50			
151 - 200	2.5	1.83	2.17	2.33	2.50				
201 - 250	3	2.00	2.33	2.50	2.67				
251 - 300	3.5	2.17	2.50	2.67	2.83				
301 - 350	4	2.33	2.67	2.83	3.00				
351 - 400	4.5	2.50	2.83	3.00	3.17				
> 400	5	2.67	3.00	3.17	3.33				
Speed	Width	>=15	14.5 to <15	14 to <14.5	13.5 to <14	13 to <13.5	12.5 to <13	12 to <12.5	<12
31 - 35 (3)	Volume	1	2	2.5	3	3.5	4	4.5	5
< 50	1	1.67	2.00	2.17	2.33	2.50			
50 - 100	1.5	1.83	2.17	2.33	2.50	2.67			
101 - 150	2	2.00	2.33	2.50	2.67	2.83			
151 - 200	2.5	2.17	2.50	2.67	2.83	3.00			
201 - 250	3	2.33	2.67	2.83	3.00	3.17			
251 - 300	3.5	2.50	2.83	3.00	3.17	3.33			
301 - 350	4	2.67	3.00	3.17	3.33	3.50			
351 - 400	4.5	2.83	3.17	3.33	3.50				
> 400	5	3.00	3.33	3.50					
Speed	Width	>=15	14.5 to <15	14 to <14.5	13.5 to <14	13 to <13.5	12.5 to <13	12 to <12.5	<12
36 - 40 (4)	Volume	1	2	2.5	3	3.5	4	4.5	5
< 50	1	2.00	2.33	2.50	2.67	2.83			
50 - 100	1.5	2.17	2.50	2.67	2.83	3.00			
101 - 150	2	2.33	2.67	2.83	3.00	3.17			
151 - 200	2.5	2.50	2.83	3.00	3.17	3.33			
201 - 250	3	2.67	3.00	3.17	3.33	3.50			
251 - 300	3.5	2.83	3.17	3.33	3.50				
301 - 350	4	3.00	3.33	3.50					
351 - 400	4.5	3.17	3.50						
> 400	5	3.33							
Speed	Width	>=15	14.5 to <15	14 to <14.5	13.5 to <14	13 to <13.5	12.5 to <13	12 to <12.5	<12
> 40 (5)	Volume	1	2	2.5	3	3.5	4	4.5	5
< 50	1	2.33	2.67	2.83	3.00	3.17			
50 - 100	1.5	2.50	2.83	3.00	3.17	3.33			
101 - 150	2	2.67	3.00	3.17	3.33	3.50			
151 - 200	2.5	2.83	3.17	3.33	3.50				
201 - 250	3	3.00	3.33	3.50					
251 - 300	3.5								
301 - 350	4								
351 - 400	4.5								
> 400	5								
		Volume*	Width**	Speed***	Bicycle Compatibility				
		< 50	>= 15	<= 25	Rating				
		1	1	1	1	Very Good			
		50 - 100	1.5	1.5	1.5	Very Good			
		101 - 150	2	14.5 to <15	2	26 - 30	2	Good	
		151 - 200	2.5	14 to <14.5	2.5	31 - 35	2.5	Good	
		201 - 250	3	13.5 to <14	3	36 - 40	3	Moderate	
		251 - 300	3.5	13 to <13.5	3.5		3.5	Moderate	
		301 - 350	4	12.5 to <13	4		4		
		351 - 400	4.5	12 to <12.5	4.5		4.5		
		> 400	5	<12	5		5		
* Vehicles per hour in the curb lane.									
** Curb lane width, excluding gutter section									
*** 85th %ile speed									

Bicycle Street Compatibility Rating Index									
Speed	Width	>=15	14.5 to <15	14 to <14.5	13.5 to <14	13 to <13.5	12.5 to <13	12 to <12.5	<12
<= 25 (1)	Volume	1	2	2.5	3	3.5	4	4.5	5
< 50	1	1.00	1.33	1.50	1.67	1.83	2.00	2.17	2.33
50 - 100	1.5	1.17	1.50	1.67	1.83	2.00	2.17	2.33	2.50
101 - 150	2	1.33	1.67	1.83	2.00	2.17	2.33	2.50	2.67
151 - 200	2.5	1.50	1.83	2.00	2.17	2.33	2.50	2.67	2.83
201 - 250	3	1.67	2.00	2.17	2.33	2.50	2.67	2.83	3.00
251 - 300	3.5	1.83	2.17	2.33	2.50	2.67	2.83	3.00	3.17
301 - 350	4	2.00	2.33	2.50	2.67	2.83	3.00	3.17	3.33
351 - 400	4.5	2.17	2.50	2.67	2.83	3.00	3.17	3.33	3.50
> 400	5	2.33	2.67	2.83	3.00	3.17	3.33	3.50	3.67
Speed	Width	>=15	14.5 to <15	14 to <14.5	13.5 to <14	13 to <13.5	12.5 to <13	12 to <12.5	<12
26 - 30 (2)	Volume	1	2	2.5	3	3.5	4	4.5	5
< 50	1	1.33	1.67	1.83	2.00	2.17	2.33	2.50	2.67
50 - 100	1.5	1.50	1.83	2.00	2.17	2.33	2.50	2.67	2.83
101 - 150	2	1.67	2.00	2.17	2.33	2.50	2.67	2.83	3.00
151 - 200	2.5	1.83	2.17	2.33	2.50	2.67	2.83	3.00	3.17
201 - 250	3	2.00	2.33	2.50	2.67	2.83	3.00	3.17	3.33
251 - 300	3.5	2.17	2.50	2.67	2.83	3.00	3.17	3.33	3.50
301 - 350	4	2.33	2.67	2.83	3.00	3.17	3.33	3.50	3.67
351 - 400	4.5	2.50	2.83	3.00	3.17	3.33	3.50	3.67	3.83
> 400	5	2.67	3.00	3.17	3.33	3.50	3.67	3.83	4.00
Speed	Width	>=15	14.5 to <15	14 to <14.5	13.5 to <14	13 to <13.5	12.5 to <13	12 to <12.5	<12
31 - 35 (3)	Volume	1	2	2.5	3	3.5	4	4.5	5
< 50	1	1.67	2.00	2.17	2.33	2.50	2.67	2.83	3.00
50 - 100	1.5	1.83	2.17	2.33	2.50	2.67	2.83	3.00	3.17
101 - 150	2	2.00	2.33	2.50	2.67	2.83	3.00	3.17	3.33
151 - 200	2.5	2.17	2.50	2.67	2.83	3.00	3.17	3.33	3.50
201 - 250	3	2.33	2.67	2.83	3.00	3.17	3.33	3.50	3.67
251 - 300	3.5	2.50	2.83	3.00	3.17	3.33	3.50	3.67	3.83
301 - 350	4	2.67	3.00	3.17	3.33	3.50	3.67	3.83	4.00
351 - 400	4.5	2.83	3.17	3.33	3.50	3.67	3.83	4.00	4.17
> 400	5	3.00	3.33	3.50	3.67	3.83	4.00	4.17	4.33
Speed	Width	>=15	14.5 to <15	14 to <14.5	13.5 to <14	13 to <13.5	12.5 to <13	12 to <12.5	<12
36 - 40 (4)	Volume	1	2	2.5	3	3.5	4	4.5	5
< 50	1	2.00	2.33	2.50	2.67	2.83	3.00	3.17	3.33
50 - 100	1.5	2.17	2.50	2.67	2.83	3.00	3.17	3.33	3.50
101 - 150	2	2.33	2.67	2.83	3.00	3.17	3.33	3.50	3.67
151 - 200	2.5	2.50	2.83	3.00	3.17	3.33	3.50	3.67	3.83
201 - 250	3	2.67	3.00	3.17	3.33	3.50	3.67	3.83	4.00
251 - 300	3.5	2.83	3.17	3.33	3.50	3.67	3.83	4.00	4.17
301 - 350	4	3.00	3.33	3.50	3.67	3.83	4.00	4.17	4.33
351 - 400	4.5	3.17	3.50	3.67	3.83	4.00	4.17	4.33	4.50
> 400	5	3.33	3.67	3.83	4.00	4.17	4.33	4.50	4.67
Speed	Width	>=15	14.5 to <15	14 to <14.5	13.5 to <14	13 to <13.5	12.5 to <13	12 to <12.5	<12
> 40 (5)	Volume	1	2	2.5	3	3.5	4	4.5	5
< 50	1	2.33	2.67	2.83	3.00	3.17	3.33	3.50	3.67
50 - 100	1.5	2.50	2.83	3.00	3.17	3.33	3.50	3.67	3.83
101 - 150	2	2.67	3.00	3.17	3.33	3.50	3.67	3.83	4.00
151 - 200	2.5	2.83	3.17	3.33	3.50	3.67	3.83	4.00	4.17
201 - 250	3	3.00	3.33	3.50	3.67	3.83	4.00	4.17	4.33
251 - 300	3.5	3.17	3.50	3.67	3.83	4.00	4.17	4.33	4.50
301 - 350	4	3.33	3.67	3.83	4.00	4.17	4.33	4.50	4.67
351 - 400	4.5	3.50	3.83	4.00	4.17	4.33	4.50	4.67	4.83
> 400	5	3.67	4.00	4.17	4.33	4.50	4.67	4.83	5.00
		Volume*	Width**			Speed***	Bicycle Compatibility		
	< 50	1	>= 15	1	<= 25	1	Very Good		
	50 - 100	1.5		1.5		1.5	Very Good		
	101 - 150	2	14.5 to <15	2	26 - 30	2	Good		
	151 - 200	2.5	14 to <14.5	2.5		2.5	Good		
	201 - 250	3	13.5 to <14	3	31 - 35	3	Moderate		
	251 - 300	3.5	13 to <13.5	3.5		3.5	Moderate		
	301 - 350	4	12.5 to <13	4	36 - 40	4	Moderate		
	351 - 400	4.5	12 to <12.5	4.5		4.5	Moderate		
	> 400	5	<12	5	>40	5	Moderate		

\* Vehicles per hour in the curb lane.  
 \*\* Curb lane width, excluding gutter section  
 \*\*\* 85th %ile speed

The traffic flow during off peak hours likely ranges between four and seven percent of the daily traffic flow each hour. If each of the remaining 22 hours is assumed to have an equal proportion of the traffic, each hour will account for 4 percent of the total daily traffic. If, on the other hand, it is assumed that traffic between 9p.m. and 7a.m. is lower and all together accounts for 10 percent of the total daily traffic volume, then each of the remaining off-peak hours accounts of 6.7 percent of the total daily traffic.

Since percentages of the total daily traffic flow are used to calculate bicycle compatibility ratings, streets with higher daily traffic volumes will be impacted more by the difference between peak and off-peak traffic flows. To better understand the bicycle compatibility implications of the variability of traffic flows, consider the scenario of a two lane road which has a daily traffic flow ranging between 3000 and 8000 vehicles. Depending on the total daily traffic flow and whether peak or off-peak conditions are considered, the bicycle compatibility index for traffic volume will range the entire spectrum from very poor compatibility to very good compatibility (Table 5).

**Table 5: Variability of Traffic Volume Compatibility Index for  
Peak vs. Off-Peak Conditions**

ADT	VPHPL (10% ADT)	VOLUME COMPAT. INDEX	VPHPL (6.7% ADT)	VOLUME COMPAT. INDEX	VPHPL (4% ADT)	VOLUME COMPAT. INDEX
8001	401	very poor [5]	270	moderate [3.5]	160	good [2]
7001	351	poor [4.5]	235	moderate [3]	140	good [2]
6001	301	poor [4]	200	good [2.5]	120	good [2]
5001	251	moderate [3.5]	168	good [2.5]	100	very good [1.5]
4001	201	moderate [3]	134	good [2]	80	very good [1.5]
3001	151	good [2.5]	101	good [2]	60	very good [1.5]

*Depending on the total daily traffic flow and whether peak or off-peak conditions are considered, the bicycle compatibility index for traffic volume will range the entire spectrum from very poor compatibility to very good compatibility.*

Another perspective from which to evaluate the impact of developing bicycle compatibility ratings using peak vs. off-peak traffic flow conditions is to consider a couple of street segments in Madison's roadway network. First, consider Glenway St. [ADT=5650; curb lane width=12 ft; posted speed limit=25 mph]. The compatibility index for curb lane width is '5' and for speed is '2'. The compatibility index for traffic volume depends on the percentage of total daily traffic which is used. If peak hour conditions as defined by the proposed methodology are used, then the compatibility index for speed is '3.5' and the overall bicycle compatibility rating is moderate [3.50]. Significantly, although this rating is considered acceptable, it lies directly on the border between acceptable and unacceptable, so that if there is any inaccuracy in the measurements or the predictive abilities of the model, the road may actually be unacceptable. If on the other hand off-peak conditions [4%] are used, the compatibility index for traffic volume is good [2] and the overall rating is moderate [3.0]. Notice that although the compatibility rating in both cases is moderate, only in the second case the rating is well within the boundaries of acceptable.

Another example to demonstrate the impacts of peak vs. off-peak conditions is Whitney Way (Tokay-Odana), which fluctuates between poor and moderate compatibility under different traffic flow conditions. Its compatibility index for curb lane width is '5' [13 ft.] and its compatibility index for speed is '3' [30 mph posted limit]. The ADT is 22,950, so the compatibility index for volume during peak hour conditions (10% ADT) is '4.5', making the overall compatibility rating poor [4.14]. During off peak conditions (4% ADT), on the other hand, the compatibility index for volume is '2.5', making the overall compatibility rating moderate [3.50].

This change in the overall bicycle compatibility rating depending on the assumed percentage of total daily traffic volume used in the calculations has several planning implications. First, it shows the dramatic effect time of day can have on perceived risk levels and therefore is a strong argument for encouraging flex-time for bicyclists so they can avoid rush hour traffic. Also, these results suggest that for road segments which are borderline acceptable, it might be useful to take hourly traffic counts to see what the real peak and off-peak traffic volume splits are. Since high ADT's are more affected than smaller ADT's by the volume splits, this type of counting would be particularly useful for high volume streets.

#### **4.4.2 Bicycle Compatibility Rating Map**

The goal of the bicycle compatibility rating map is to provide a visual representation of the pattern of bicycle compatibility to facilitate 1) evaluating mobility and accessibility; 2) identifying problem areas for bicyclists; and 3) making planning recommendations to improve the road network's bicycle compatibility. The results described for the bicycle compatibility map in Section 4.3.2 confirm that the bicycle compatibility map successfully facilitates addressing the first two of these issues. In particular, the map is useful for evaluating the spatial patterning of problem areas and evaluating whether route alternatives exist to avoid problem areas as these conditions are difficult to evaluate by simply looking at the compatibility rating spreadsheet. The bicycle compatibility rating map is not a stand alone tool for making planning decisions about recommendations to improve the road network's bicycle compatibility. However, when used in conjunction with the bicycle compatibility rating index chart (refer back to Table 3) and data from the compatibility rating spreadsheet, the bicycle compatibility rating map can prove a powerful planning tool because it allows planners to evaluate system-wide impacts of proposed changes.

Analysis of the bicycle compatibility rating map suggests it is a valuable planning tool. Potential planning applications of this map include 1) rapidly assessing present bicycle compatibility of Madison's arterial and collector streets; 2) assessing impacts of proposed changes within the context of the broader transportation system; 3) evaluating the connectivity of the roadway network from a bicycle compatibility perspective; 4) designating bicycle routes, and identifying problem areas for bicyclists which should be targeted for bicycle accommodation improvements.

#### **4.4.3 Bicycle Compatibility Warning Map**

One improvement which could be made to this map is that it could be created as an overlay. If the map were an overlay, it would be possible to impose it over the bicycle compatibility rating map of present conditions, so that the at risk segments could be more easily interpreted in the context of the entire transportation system. Analysis within this broader context would allow for better evaluation of priority ranking of the segments for planning action.

In conclusion, application of the bicycle compatibility warning map in Madison, Wisconsin confirms this map is a useful bicycle transportation planning tool. The map successfully highlights street segments which although the bicycle compatibility map of present conditions shows to be acceptable, they are at risk of becoming unacceptable in the next five to ten years as traffic volumes increase. Therefore, this map provides planners with the power to play a proactive role in accommodating bicycles in the transportation system by dealing with problem areas before they are problems.

#### **4.4.4 Validation of the Bicycle Compatibility Rating Results by the Bicycle Transportation Alliance of Dane County Steering Committee**

I discussed with the BTA steering committee the reason for carrying out the project and the philosophy guiding it, the model used to calculate the bicycle compatibility ratings, the bicycle compatibility rating map, and the bicycle compatibility warning map. The overall reaction to the project was one of strong agreement and support.

The committee strongly supported the guiding philosophy of the project that bicycle transportation planning should aim to maximize bicycle compatibility of all streets in the transportation network to maximize bicyclists' mobility and accessibility. They encouraged the boundaries of the evaluation area to be expanded beyond Madison's political boundaries to include the surrounding suburbs. Also, they were excited to see an objective approach to evaluating bicycle compatibility that has the potential to add credibility to their complaints about problem areas for bicyclists.

With respect to reactions to the BCE model, they agreed with the variables included in the model. They suggested perhaps the traffic volume ratings should include categories above 400 vphpl. In addition, they expressed some concern about the assumption that 85 percent of the traffic flows at five miles per hour or less over the posted speed limit and suggested that on many streets traffic likely travels faster. They noted a possible connection between the width of a roadway and speed, noting that traffic is more likely to travel faster on wider roads. As a disclaimer to their questions about the model's assumptions, the committee acknowledged the need for making assumptions in models and realized the important thing is not necessarily the specific assumptions made, but rather how well the model represents reality.

The committee concluded the bicycle compatibility map provided a good representation of their perceptions of the bicycle compatibility of Madison's street network. They found no glaring errors in the compatibility ratings the model assigned to the road segments. They noted the accuracy of identifying roads like Packers Ave. and Sherman Ave. as bad places to ride and how well the map showed problem areas creating barriers for bicyclists like the stretches of Whitney Way and Gammon Rd. where they pass under the beltline. In addition, they agreed with the designation of streets such as Tokay Blvd., Segoe Rd. and Spaight St. as good places for bicycling. Further, they like how the map revealed points where streets like Odana Rd. and Old Sauk Rd. make major transitions from acceptable to unacceptable bicycle compatibility.

The committee did have comments about several streets where their perceptions of bicycle compatibility differ slightly from the model's predictions. They suggested that Segoe Rd. from Mineral Point Rd. to Regent St., and Regent St. from Midvale Blvd. to Whitney Way may even be more compatible than the model's prediction [this may be accounted for by lane width provided for parking although relatively few cars park there]. For E. Johnson St., they mentioned the bike lane ends at Brearly St. and that the compatibility rating should change from moderate to poor at this point rather than one block east at Few St. as indicated on the map. The committee also discussed the conditions on Williamson St. They felt the side of the street with restricted parking during rush hour should be rated as poor rather than moderate compatibility. They noted that despite the 13 foot curb lane, cars on this road more so than on other roads seem to adamant about using the entire lane rather than sharing it with bicyclists.

A general observation the committee made is that when presented with the five rating levels, they could fairly readily distinguish between the different levels of compatibility. However, they thought that in reality they tend to think more generally in terms of compatible and not compatible. They suggested from a bicyclist perspective, especially for streets with many short segments of subtle differences of levels of acceptable or unacceptable compatibility, it might be more useful to just distinguish between acceptable and unacceptable compatibility. But they did acknowledge that bicyclist and planning needs may be different in this regard.

The committee also reviewed the bicycle compatibility warning map favorably. They liked its proactive philosophy and how it confirmed their concerns about the

decreasing compatibility of the "escape routes" at the city's edge going out of town for recreational bicyclists. Their interest was peaked by the appearance of Segoe Rd. on the compatibility warning map because he has observed increasing traffic volumes on Segoe and is concerned it has the potential to be an undesirable place to bicycle.

## **CHAPTER 5**

### **FUTURE BICYCLE TRANSPORTATION PLANNING**

#### **5.1 Further Applications of the Proposed Framework for Thinking About Bicycle Compatibility**

Creating the bicycle compatibility spreadsheet, bicycle compatibility rating map and bicycle compatibility warning map will not in and of themselves do anything to maximize the bicycle compatibility of the roadway network in Madison, Wisconsin, or any other community. However, these products are valuable tools to facilitate comprehensive transportation planning as encouraged by the bicycle compatibility planning methodology proposed in Chapter 3. The purpose of this section is to suggest some ways these tools might be used in a broader planning context.

An obvious application of the bicycle compatibility evaluation products is to facilitate bicycle route designation and mapping efforts. It is this application which attracted the Madison Department of Transportation to the BCE model. Many issues enter into decisions about designating bicycle routes: what is the purpose of having bicycle routes; how many routes should there be; where should the routes go to and from; what level bicyclist should they be aimed at; should they target daily commuters or casual cyclists; how should they be marked? In addition to these broad questions, more specific design issues should be addressed, including how direct or indirect a route is; in what way should topography be considered; how should the desirability of one possible route designation versus another be evaluated? The BCE products can help address this last issue in particular. For the most part the route with more compatible roads will be considered the better option for bicycle route designation. Information about bicycle compatibility can also be valuable information to incorporate into bicycle maps. This information can help bicyclists to make informed route choice decisions when they are riding on undesignated routes.

Evaluation of a proposed development project's impact on bicycle compatibility of a roadway network is another possible application of the bicycle compatibility evaluation products. Projects which would be relevant for this type of application include proposed

subdivisions and public buildings that will attract a lot of people. In Madison, recent high profile projects which could have been subjected to this type of analysis include the Middleton Hills subdivision, the Frank Lloyd Wright Convention Center, and the Kohl Sports Facility.

Generally part of the approval process for large proposed construction projects such as these includes a traffic impact analysis. Bicycle compatibility evaluation makes it possible to predict how the projected traffic increases will impact bicycle compatibility of the roadway network. For proposed subdivision developments, this type of analysis should be done both for the roads within the development as well as the surrounding neighborhoods and the arterial and collector streets feeding into the proposed subdivision. If this type of analysis were conducted as an integral part of the approval process, then negotiations to mitigate bicycle compatibility impacts could be considered, planned and paid for before problems develop.

Another useful application of the bicycle compatibility evaluation products is guiding designs for roads that are slated for reconstruction. Such evaluation could involve recommendations to alleviate problems identified in the bicycle compatibility rating and warning maps or it might involve evaluating the bicycle compatibility of plans that have already been proposed for the reconstruction.

Sherman Ave. on Madison's northeast side is a road which was recently reconstructed where the bicycle compatibility evaluation methodology would have been a useful tool for strengthening the bicyclists' arguments. The debate focused on if the road should be striped as a four lane road like it had been before, or if an alternative three lane configuration with a center turn lane should be considered. Several useful observations are evident when the bicycle compatibility evaluation products are used to evaluate this situation. The four lane configuration would have meant the curb lane would be only 11 feet wide and, given the traffic volume and speed, the road would remain a barrier to many bicyclists due to its poor bicycle compatibility rating [4.33]. The three lane configuration would have allowed for wide curb lanes ( 16 ft. wide) and a moderate bicycle compatibility rating [3.00] so that bicyclists and motor vehicles could co-exist more readily. From a bicyclist's perspective, therefore, the three lane option would be far superior. Adding to the significance of the three lane option for the bicycle compatibility of Madison's roadway network is that Sherman Ave. is an important commuting corridor

to the northeast side of town from the downtown and near east side. Unfortunately for bicyclists, the four lane option was implemented and therefore the street remains poor compatibility and the corridor remains a problem for bicycle access and mobility. In addition, it is also clear there are no obvious desirable route alternatives so that improving the bicycle compatibility of N. Sherman Ave. itself is particularly important for bicycle accessibility and mobility. The evidence provided by the bicycle compatibility evaluation products would have helped to advance bicyclists arguments beyond anecdotal evidence.

## 5.2 Research Needs to Refine the Proposed Framework for Thinking About Bicycle Compatibility

As shown through the case study in Madison, Wisconsin, the roadway compatibility module of the proposed bicycle compatibility planning framework has the potential to greatly enhance transportation planning efforts to develop a truly multimodal transportation system. However, as with any planning methodology, a better understanding of the transportation system elements would make it possible to make even better informed decisions. This section suggests future research that would make it possible to refine the bicycle compatibility planning methodology. The research suggestions can be broken down into five categories: rating the bicycle compatibility of road segments, intersections, street patterns, route choice and traffic calming.

The present methodology for the bicycle compatibility rating evaluation makes many assumptions about bicyclist and motor vehicle operator behavior. The following research efforts would make it possible either to validate the assumptions made or to modify the methodology to make more reasonable assumptions based on the enhanced knowledge base.

- To what extent do bicyclists' perception of compatibility correspond to their behaviors? What street segments do bicyclists use? Which street segments do they prefer to use? What streets do they avoid? Why? Do bicyclists behaviors correspond to the behaviors which the bicycle compatibility evaluation model predicts? Do the patterns of use/avoidance vary with riding experience, age gender, time of day?

- How do special facilities such as bike lanes and wide curb lanes fit into the model? The model does not distinguish between these two facilities, but do bicyclists perceive them the same or differently?
- Is the assumption that 85 percent of the traffic travels at no more than 5 mph over the speed limit reasonable?
- Is it reasonable to assume that traffic is evenly divided between the lanes? Does the division vary as the number of travel lanes varies? Is there a pattern to how the traffic is divided between direction of travel?
- How accurately does 10% ADT reflect the peak hour traffic volume? Are there identifiable patterns for how the ADT varies during the day, suggesting patterns for how bicycle compatibility varies with time of day?

Intersections were proposed in Chapter 3 as an important transportation system element to consider in planning for bicycle compatibility. However, little research has been done to understand how different intersections impact bicyclists differently. As a result, it is difficult to establish criteria that would make it possible to evaluate the acceptability of an intersection for bicyclists. The following research would enhance planners', engineers' and designers' abilities to accommodate bicyclists in their intersection designs and evaluations:

- What behavioral patterns do bicyclists and motorists tend to exhibit as they negotiate intersections with different configurations? What types of conflicts are most common? How might these conflicts be minimized through alternative intersection design?
- Are there intersection designs which are worse than others for bicycle-pedestrian conflicts?
- How can intersections be striped to minimize confusion and maximize safety for how bicycles and motor vehicles proceed through intersections? Particular problem areas to address include bicyclists wanting to turn left and motor vehicles wanting to turn right.

- How might a rating system for intersections analogous to Sorton and Walsh's bicycle compatibility model be developed to facilitate intersection evaluation and design?

In addition to intersections, street patterns are another element of the proposed bicycle compatibility planning framework for which it would be useful to have a much better understanding. As described in Chapter 3, street patterns can have a significant influence on the bicycle compatibility of a community's roadway network. Even if all the roads themselves are bicycle compatible, if the roads either don't go where bicyclists want to go or take a very indirect route to get there, the overall bicycle compatibility of the roadway network will be low. Because bicyclists want to access the same destinations that motorists do, it is unlikely that the roads will not go to a destination at all. What is much more likely is that the possible route(s) is very circuitous. Since motor vehicles more easily overcome greater distances, where streets are designed to maximize motor vehicle mobility while at the same time minimizing neighborhood traffic for quietness and safety, cul-de-sacs are often the resulting proposed pattern. However, cul-de-sac patterns often lead to longer trip distances and often funnel all traffic onto major arterial and collector streets which bicyclists may or may not consider acceptable places to ride. To be able to better address the street pattern issue in the bicycle compatibility planning methodology it would be useful to research the following questions:

- How might a typology of street patterns be developed which could serve as a basis for evaluating the bicycle compatibility of these patterns?
- How do the various street patterns impact the concentration or dispersion of traffic in the transportation system?

Finally, it is clear that if bicyclists route choice decisions were better understood, the ability of transportation planners to appropriately plan for bicycle transportation would be greatly enhanced. The following are among the route choice questions which it would be helpful to better understand:

- What criteria do bicyclists use in selecting their routes?
- How do these criteria differ with trip purpose, time available and bicyclist experience?

- How do bicyclist criteria differ from those of motorists?
- What implications might these differences have on designing a transportation system that adequately accommodates both bicycles and motor vehicles?
- How might knowledge of bicyclist route choice criteria be utilized to prioritize projects to improve bicycle compatibility?

## EPILOGUE

### E.1 Thesis Summary

Because bicyclists need and want to access the same houses, businesses, offices, work sites, parks, etc. that motorists do, the existing street network will naturally be the backbone of any bikeway system. In order to successfully plan for bicycle accommodations, it is important to be able to evaluate roadways with respect to their desirability as places to bicycle.

The **purpose** of this project is to provide information to facilitate Madison, Wisconsin's efforts "to develop and maintain an all-mode transportation system that offers convenient alternatives to private motor-vehicle travel" (DCRPC, 1991).

The **objectives** are to:

- 1) Propose a conceptual framework for bicycle transportation planning;
- 2) Apply the roadway compatibility module of this framework to the street network in Madison, Wisconsin; and
- 3) Evaluate the usefulness of the roadway compatibility module in planning for bicycle transportation.

I have produced several **products** in order to achieve these objectives:

- 1) A proposed conceptual framework for bicycle transportation planning;
- 2) A roadway and traffic characteristics spreadsheet for Madison, Wisconsin;
- 3) A bicycle compatibility rating map for Madison, Wisconsin;
- 4) A bicycle compatibility warning map for Madison, Wisconsin;
- 5) A discussion of further applications of bicycle compatibility evaluation results;  
and

- 6) Identification of research needs to refine the proposed bicycle planning methodology.

## **E.2 Conclusions about the Roadway Compatibility Evaluation Methodology**

This thesis demonstrates the value of the roadway compatibility evaluation methodology as a tool to facilitate efforts to evaluate the desirability of roadways as places to bicycle. In summary, the methodology is realistic to implement given the easy availability of data; pilot studies have confirmed the validity of the bicycle compatibility ratings; the bicycle compatibility rating map provides a useful graphic summary of a roadway network's bicycle compatibility; and the bicycle compatibility warning map has the potential to facilitate a proactive approach to maintaining bicycle compatible roadways.

Analysis suggests four possible problems with the roadway compatibility evaluation methodology as a tool to facilitate efforts to evaluate the desirability of roadways as places to bicycle. First, the methodology does not distinguish between bike lanes and wide curb lanes. Bike lanes explicitly reserve space for bicyclists on the roadway and therefore, in theory at least, add an additional level of comfort beyond wide curb lanes to roadways. Opinions about the value of bike lanes vs. wide curb lanes differ, but there does seem to be agreement at least that the two situations do represent different levels of compatibility. It seems, therefore, that the bicycle compatibility evaluation methodology should distinguish between these two situations.

Second, the methodology seems to break down in situations where there is high-volume, high-speed traffic and an extra-wide, separately striped curb lane. The formula in the roadway compatibility evaluation methodology, as specified, has no way to overcome the traffic volume and speed, no matter how wide the curb lane. However, in some situations, such as Mineral Point Road and University Ave. in the campus area, where these conditions exist, separate lanes are provided for bicycles and experience suggests these roads are more compatible than the roadway compatibility evaluation methodology predicts.

In addition, the potential fuzziness of the boundaries between acceptable and unacceptable bicycle compatibility ratings is at least a small concern. It is easy to calculate

the ratings and take them as truth. However, depending on the boundary fuzziness, inappropriate conclusions may be drawn about a roadway's bicycle compatibility.

The final possible problem with the roadway compatibility evaluation methodology is that intersections are excluded from the analysis. As with the fuzzy boundary issue, exclusion of intersections has the potential to lead to a false picture of a roadway network's bicycle compatibility. It is quite possible that all the mid-block segments of road are bicycle compatible, but that the intersections have been designed poorly so that the area actually presents a real access and mobility problem for bicyclists. Therefore, efforts should be made to develop a companion compatibility methodology that evaluates intersection bicycle compatibility.

### **E.3 Conclusions about the Madison, Wisconsin Case Study Application of the Roadway Compatibility Evaluation Methodology**

Review of Madison's policies related to bicycles reveals that the city should have an outstanding bicycle network. However, the bicycle compatibility analysis indicates that only 65 percent of the arterial and collector streets are considered bicycle compatible. (To put the city's roadway network in a more positive light, if all the streets including local streets are considered, then the percentage of compatible streets rises to 87.) Further most of the arterial streets in the major commuting corridors have poor or very poor compatibility ratings. This situation suggests a significant mobility and access problem for bicyclists. On the other hand, it is also significant that the city has provided wide curb lanes or bike lanes on many streets (for example, Dayton St., Williamson St., Johnson St. and Gorham St.) and that these accommodations have resulted in acceptable bicycle compatibility ratings.

In conclusion, Madison has made significant strides in providing a bicycle compatible transportation network; however, comparison of the city's policies against the street network's bicycle compatibility performance, begs the question 'why aren't we doing better?' For example, one of Madison's policies in its Policies and Objectives statement is "to include provision for *all* needed bicycle facilities when authorizing the construction or reconstruction of *any* street in the City" (MDPD, 1985). This policy suggests that all streets in the city either constructed or reconstructed in the city since 1985

should not have a problem with bicycle compatibility. Yet, streets such as N. Sherman Ave. have a poor bicycle compatibility rating.

Are decision-makers unaware of the policies mandating bicycle compatibility? Do the decision-makers disagree with the policies and choose to ignore them? Are the consequences of not following the policies insignificant? Has there been a lack of an adequate process to monitor progress toward the ideals identified in the policies? Has there been a lack of adequate design guidelines to guide bicycle-compatible facility development? Has there been a lack of political or financial feasibility for making better progress toward a completely bicycle compatible roadway network?

None of these questions are easy to answer. However, it is the answers to these questions that are necessary to truly evaluate the meaning of Madison's present state of bicycle compatibility. The bicycle compatibility evaluation methodology has made it possible to evaluate Madison's street network using a set of consistent criteria. The methodology is very useful for identifying problem areas in the street network, as well as areas that work well. The questions that remain unanswered relate to how to make sense out of the evaluation and what recommendations for the future to make based on the findings. On paper, the city's bicycle-related policies look like they should lead to an outstanding bicycle compatible roadway network. Without a better understanding of why the city has not made better progress toward implementing these policies, it is difficult to make useful suggestions about what to do differently in order to make better progress in maximizing the bicycle compatibility of Madison, Wisconsin's roadway network.

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APPENDIX A

NATIONAL BICYCLING AND WALKING STUDY MATERIALS

### National Bicycling and Walking Study Case Study Reports

Case Study No. 1, Reasons Why Bicycling and Walking are Not Being Used More Extensively as Travel Modes, Goldsmith, Stuart, FHWA-PD-93-041.

Case Study No. 2, The Training Needs of Transportation Professionals Regards the Pedestrian Bicyclists, Carter, Everett, FHWA-PD-93-038.

Case Study No. 3, What Needs to be Done to Promote Bicycling and Walking, Garber, Sorbin, FHWA-PD-93-039.

Case Study No. 4, Measures to Overcome Impediments to bicycling and Walking, Zehnphennig, Gary, FHWA-PD-93-031.

Case Study No. 5, An Analysis of Current Funding Mechanisms for Bicycle and Pedestrian Programs at the Federal, State and Local Levels, Clarke, Andy, FHWA-PD-93-008.

Case Study No. 6, Analysis of Successful Grass-roots Movements Relating to Pedestrians and Bicyclists and a Guide on how to Initiate a Successful Program, Lusk, Anne, FHWA-PD-93-024.

Case Study No. 7, Transportation Potential and Other Benefits of Off-Road Bicycle and Pedestrian Facilities, Flink, Charles, FHWA-PD-92-040.

Case Study No. 8, Organizing Citizen Support and Acquiring Funding for Bicycle and Pedestrian Trails, Burwell, David, FHWA-PD-93-007.

Case Study No. 9, Linking Bicycle/Pedestrian Facilities with Transit, Replogle, Michael, FHWA-PD-93-012.

Case Study No. 10, Trading Off Among the Needs of Motor Vehicle Users, Pedestrians, and Bicyclists, Wilkinson, Bill, FHWA-PD-94-012.

Case Study No. 11, Balancing Engineering, Education, Law Enforcement, and Encouragement, Williams, John, FHWA-PD-93-009.

Case Study No. 12, Incorporating Consideration of Bicyclists and Pedestrians into Education Programs, Blomberg, Richard, FHWA-PD-92-036.

Case Study No. 13, A Synthesis of Existing Bicyclist and Pedestrian Related Laws and Enforcement Programs, Bowman, Brian, FHWA-PD-93-009.

Case Study No. 14, Benefits of Bicycling and Walking to Health, Burke, Edmund, FHWA-PD-93-025.

Case Study No. 15, The Environmental Benefits of Bicycling and Walking, Komanoff, Charles, FHWA-PD-93-015.

Case Study No. 16, A Study of Bicycle and Pedestrian Programs in European Countries, Wynne, George, FHWA-PD-92-037.

Case Study No. 17, Bicycle and Pedestrian Policies and Programs in Asia, Australia, and New Zealand, Replogle, Michael, FHWA-PD-93-016.

Case Study No. 18, Analyses of Successful Provincial, State and Local Bicycle and Pedestrian Programs in Canada and the United States, Wilkinson, Bill, FHWA-PD-93-010.

Case Study No. 19, Traffic Claming, Auto Restricted Zones and Other Traffic Management Techniques: Their Effect on Bicyclists and Pedestrians, Clarke, Andy & Michael Dornfeld, FHWA-PD-03-028.

Case Study No. 20, The Effects of Environmental Design on the Amount and Type of Bicycling and Walking, Kent, Fred, FHWA-PD-93-037.

Case Study No. 21, Incorporating Bicycle and Pedestrian Considerations Into State and Local Transportation Planning, Design and Operations, Wilkinson, Bill FHWA-PD-93-017.

Case Study No. 22, The Role of State Bicycle/Pedestrian Coordinators, Williams, John, FHWA-PD-PD-93-019.

Case Study No. 23, The Role of Local Bicycle/Pedestrian Coordinators, Wilkinson, Bill & Peter Lagerwey, FHWA-PD-93-014.

Case Study No. 24, Current Planning Guidelines and Design Standards Being Used by State and Local Agencies in the Design of Pedestrian/Bicycle Facilities, Flink, Charles, FHWA-PD-93-006.

### **Federal, State and Local Action Plan Recommendations Presented in the National Bicycling and Walking Study**

At the federal level, the NBWS concluded that "to help meet the goals of doubling the percentage of bicycling and walking trips and reducing by ten percent the number of bicyclist and pedestrian injuries and fatalities, the federal government must undertake new roles not previously performed" (US DOT, 1994). One of the new roles which the federal government should fill according the NBWS is to promote intermodal initiatives. Another aspect of the NBWS recommendations is that bicycling and walking issues should be institutionalized so that they become "part of day-to-day planning, design and operational activities throughout the DOT" (US DOT, 1994).

In summary, the NBWS recommended the US DOT take on new roles in order to promote intermodal projects and to integrate bicycling and walking concerns into its

everyday operations. In order to achieve these goals, NBWS suggested the following action items:

1. Provide technical guidance in the interpretation of national transportation legislation and distribute other technical information.
2. Fully integrate consideration of bicyclist and pedestrian needs into planning; design; operational policies and procedures; and suggested usage, accident rate, and evaluation methodologies.
3. Provide funding for a bicycle and pedestrian friendly infrastructure that includes new facilities and infrastructure retrofitting and education for all road users, and enforcement programs for all road users.
4. Provide initial and continuing education and training for planning and engineering professionals which encourages routine consideration of the needs of bicyclists and pedestrians.
5. Conduct promotion and awareness activities both to increase the level of bicycling and walking for all trip purposes and to legitimize these travel modes within the transportation system.
6. Carry out activities that increase the safety of bicycling and walking.
7. Provide outreach to other governmental agencies and develop new public/private partnerships to safely increase bicycling and walking usage levels.
8. Conduct research and develop effective methods of technology transfer.
9. Serve as a positive national presence and role model.

At the state level, the NBWS recommended the following actions:

1. *Organize a bicyclist/pedestrian program*

This action item encompasses establishing a full-time coordinator in the State DOT, obtaining sufficient staff to support this person, and to generating supportive

professionals within state government agencies. Establishing a full-time coordinator is already required by the ISTEA legislation:

Each state receiving an apportionment under the Congestion Mitigation and Air Quality Improvement, and the Surface Transportation Programs shall use such amount of the apportionment as may be necessary to fund in the state department of transportation a position of bicycle and pedestrian coordinator for promoting and facilitating the increased use of non-motorized modes of transportation, including developing facilities for the use of pedestrians and bicyclists and public education, promotional and safety programs for using such facilities. (ISTEA, 1991)

*2. Plan and construct needed facilities*

As with the first action item, planning and constructing needed facilities are described in terms of ISTEA requirements. Facilities, as defined by ISTEA, encompass new or improved lanes, paths, or shoulders for use by bicyclists, traffic control devices, shelters, and bicycle parking facilities. With respect to planning, ISTEA required that each state develop a statewide transportation plan to be signed by the governor by January 1, 1995. The plan should include "elements for all modes of travel and policies for implementing projects. The plan must be developed in cooperation with MPOs for metropolitan areas of the State. The opportunity for public comment must also be provided" (US DOT, 1994).

*3. Promote bicycling and walking*

The NBWS recommended that the bicycling and walking be promoted at the state level in several ways. First, the statewide coordinator should assist with and facilitate private sector and local organization activities such as bike-to-work days, festival days, moonlight rides, bike tours, bike-a-thons, rallies and races. Also, the state should produce promotional materials which local groups can use in their promotional activities.

*4. Educate bicyclists, pedestrians and the public*

According to the NBWS, state level involvement in education should focus on providing brochures, pamphlets and other resources, and on initiating educational school curricula.

*5. Enforce laws and regulations*

The NBWS states "enforcement is important to the concept of having roadways that can be shared by pedestrians, bicyclists, and drivers of motor vehicles. Effective enforcement means the citing of pedestrians and bicyclists that are dangerous to themselves and others, as well as motor vehicle operators" (US DOT, 1994). The study suggests state level law enforcement should include examining the state vehicle code, considering new laws which would encourage bicycling and walking, and promoting local law enforcement.

One of the goals for the proposed local action plan is that rather than being treated as an afterthought, bicycling and walking should be integral parts of the transportation planning process. The NBWS has identified a number of goals which it suggests will help to more fully meet bicyclist and pedestrian needs:

*1. Organize a bicycle/pedestrian program*

The NBWS outlines several elements of their proposed program including people who should be involved as well as some of the activities in which they should be engaged. At the very least, the NBWS recommends each metropolitan area should have a full-time bicycle/pedestrian coordinator. The study notes that current coordinators are typically classified as 'engineer' or 'planner', with a definite shift toward the 'planner' classification. Typical responsibilities include program planning, policy development, facility design, accident analysis, coordination among agencies and within government, public relations, educational support and development of local legislation.

The NBWS proposes that another potentially helpful aspect of a successful bicycle/pedestrian program is a bicycle advisory committee. This group can help to provide continuity through turnover in staff, leverage to implement projects proposed by the coordinator and longevity of the coordinator program through grass roots support.

According to the NBWS, the local bicycle/pedestrian coordinator and bicycle advisory council should:

- review, modify, expand existing policies;
- promote adoption of efficient non-motorized compatible land use patterns and zoning requirements;

- develop/adapt bicyclist and pedestrian compatible urban design guidelines.

## *2. Plan and construct needed facilities*

One of the NBWS recommendations to achieve this goal is to integrate bicycling and walking into transportation planning by encouraging mixed-use zones, affordable housing near places of employment, and limiting motor-vehicle parking facilities. The NBWS also recommended that a network of greenways be established, that facilities be evaluated and improved, and that user surveys be conducted.

## *3. Promote bicycling and walking*

NBWS recommendations for promoting bicycling and walking describe projects that a number of cities have undertaken. Conferences, posters, paycheck stuffers, bike-to-work days, television and radio PSA's, route maps and employee reimbursements for business travel on bicycles as is done for cars are some of the promotional projects cited in the NBWS.

## *4. Educate bicyclists, pedestrians and the public*

The major education focus proposed in the NBWS is safety education programs based in the community, school and driver education programs.

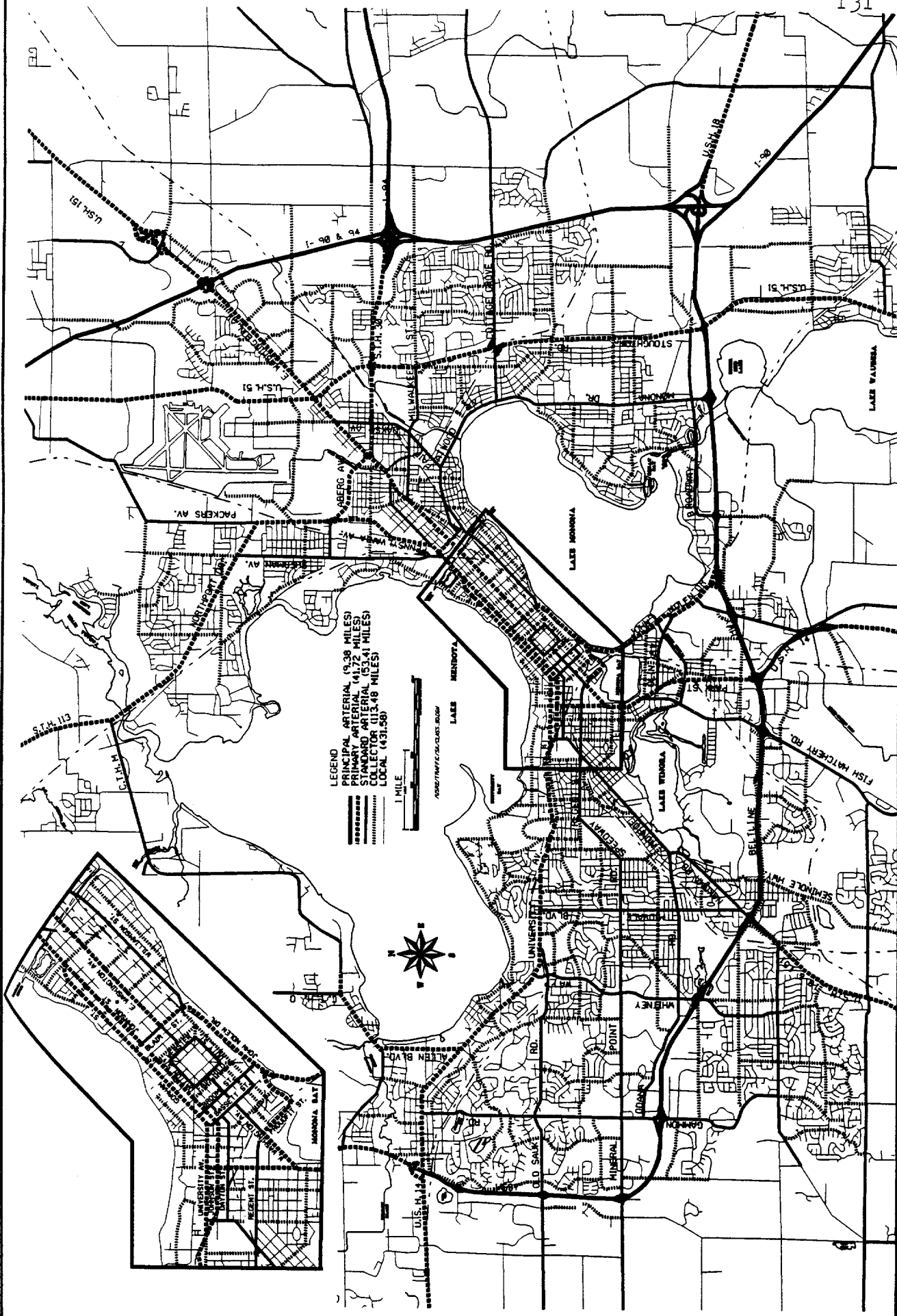
## *5. Enforce laws and regulations*

The NBWS recommendations related to enforcing laws and regulations are two-fold. The study suggests that law and regulation enforcement will promote both bicycle and pedestrian awareness of the law as well as driver awareness of bicycles and pedestrians. The other aspect of this action plan goal is to establish a police on bicycles program. The NBWS proposes that such a program is especially effective in congested urban areas, that it further legitimizes the bicycle as a valuable transportation mode, and that it offers new possibilities for enforcement and for improved community relations.

## APPENDIX B

### DATA SOURCES

1. MADISON DEPARTMENT OF TRANSPORTATION'S 1994 HIGHWAY AND STREET FUNCTIONAL CLASSIFICATION MAP
2. SAMPLE PAGE FROM MADISON DEPARTMENT OF TRANSPORTATION'S 1994 LOCAL ROADS INVENTORY
3. SAMPLE INTERSECTION CONDITION DIAGRAM
4. MADISON DEPARTMENT OF TRANSPORTATION'S 1989 SPEED ZONE MAP
5. MADISON DEPARTMENT OF TRANSPORTATION'S 1993 TRAFFIC FLOW MAP



LEGEND  
 PRINCIPAL ARTERIAL (19.98 MILES)  
 PRIMARY ARTERIAL (41.73 MILES)  
 STANDARD ARTERIAL (63.41 MILES)  
 COLLECTOR (113.48 MILES)  
 LOCAL (431.58)



**TransMadison**  
 The Word is Getting Around



**CITY OF MADISON  
 DEPARTMENT OF TRANSPORTATION  
 TRAFFIC ENGINEERING DIVISION**

**HIGHWAY & STREET FUNCTIONAL  
 CLASSIFICATION MAP**

JAN 1994

DANCE COUNTY  
CITY - MADISON  
13-2

LOCAL ROADS INVENTORY LISTING

DATE: 06/28/94  
PAGE: 288

FROM	ROAD NAME	TO	RD NO.	YR	ROAD	LNTH	IN-RG-SC	P	SECTION	SURFACE	L	RSH	LSH	C	P	R/W	MED	W	ADT	RC	SC	U/R	FA	SF	D	H
GRID																										
===>	SEGOE RD		1267	90		2.23																				
	UNIVERSITY	KELAB	M-15	001	.33	6203	89	64	4	000	000	3	1	A120	026	N	A09650	05	00	047	NDN	80	4		N	
	KELAB	REGENT	M-15	003	.15	6203	89	64	4	000	000	3	1	A120	026	N	A09400	05	00	047	NDN	80	4		N	
	REGENT	MINERAL POINT RD	M-16	002	.70	6203	89	64	4	000	000	3	3	A120	026	N	A05850	05	00	047	NDN	80	4		N	
	MINERAL PT RD	HILLVIEW	M-17	005	.34	6203	89	64	4	000	000	3	3	A100	015	N	A06000	05	00	047	NDN	80	4		N	
	HILLVIEW	ODANA	( L-18	004	.71	6203	72	64	4	000	000	3	3	A100	016	N	A05750	05	00	047	NDN	80	4		Y	
===>	SEIFERTH RD		1268	90		.25																				
	TOMPKINS	PFLAUM	BB-17	002	.25	6203	93	32	2	000	000	3	3	A050	000	N	E00100	05	00	047	NDN	90	4		N	
===>	SEMINOLE HWY		1269	90		.97																				
	NAKOMA	MANITOU WAY	0-19	003	.26	6706	81	36	2	000	000	3	1	A066	000	N	A05200	05	00	047	NDN	80	4		N	
	MANITOU WAY	WEST BELTLINE	0-20	004	.35	6203	89	36	2	000	000	3	0	A066	000	N	A05500	05	00	047	NDN	80	4		N	
	BELTLINE	LUMLEY	0-20	002	.06	6201	92	36	2	000	000	3	1	A066	000	N	A03300	05	00	047	NDN	80	4		N	
	LUMLEY	MILFORD	N-20	005	.15	6201	92	36	2	000	000	3	1	A066	000	N	A03550	05	00	047	NDN	80	4		N	
	MILFORD	CITY LIMITS	N-21	001	.15	6201	92	36	2	000	000	3	1	A066	000	N	A03000	05	00	047	NDN	80	4		N	

H: HPMS (Highway Performance Monitoring System)  
This is a Federal Administration mandated program.

Y = Yes, it is a sample section.  
N = No, it is not a sample section.

FF: FEDERAL FUNCTION CLASS:

FEDERAL FUNCTIONAL CLASS: Indicates the classification of the road section by the character of service the road section provides or is expected to provide.

(Inside Federal Urban Area)

CODES: 50 = Freeway or Expressway - Connecting link of rural prin. art.  
51 = Freeway or Expressway - Connecting link of rural minor art.  
52 = Freeway or Expressway - Non-connecting link  
60 = Other Principal Arterials - Connecting link of rural prin. art.  
61 = Other Principal Arterials - Connecting link of rural minor art.  
62 = Other Principal Arterials - Non-connecting link  
70 = Minor Arterial  
80 = Collector  
90 = Local Street

Rural (Outside Federal Urban Area)

10 = Principal  
20 = Minor Arterial  
30 = Major Collector  
40 = Minor Collector  
45 = Local Road  
46 = Private Entrance Type of Field Entrance Type

FA

FEDERAL AID CLASS: Identifies the federal aid classification assigned to the road section.

CODES: FAP = Federal Aid Primary  
 FAS = Federal Aid Secondary  
 FAU = Federal Aid Urban  
 NON = Non-Federal Aid

SF

STATE FUNCTIONAL CLASS: Indicates the classification of the road section by the character of service the road section provides or is expected to provide.

CODES: 50 = Freeway or Expressway - connecting link of a rural principal arterial  
 51 = Freeway or Expressway - connecting link of a rural minor arterial  
 52 = Freeway or Expressway - non-connecting link  
 60 = Other Principal Arterials - Connecting link of rural principal arterial  
 61 = Other Principal Arterials - Connecting link of rural minor arterial  
 62 = Other Principal Arterials - Non-connecting link  
 70 = Minor Arterial  
 80 = Collector  
 90 = Local Street

Rural

10 = Principal  
 20 = Minor Arterial  
 30 = Major Collector  
 40 = Minor Collector  
 45 = Local Road, Street  
 46 = Private Entrance or Field Entrance

O

OWNER AGENCY TYPE: Indicates the general governmental level of the civil body or public agency which is legally and financially responsible for the road section.

CODES: 1 = Federal  
 2 = State  
 3 = County  
 4 = Municipality

ADT INDICATOR: Indicates whether the ADT Count is an estimated or actual count value.

CODES: A = Actual  
E = Estimated

RC

ROAD CATEGORY: Indicates the general road category to which the road section is assigned.

CODES: 4 = County Trunk Highway  
5 = Municipal Road  
6 = Rustic Road  
7 = County Forest Road  
8 = County Park Road  
99 = Statistical Road  
09 = County Road

SC

SUB ROAD CATEGORY: Indicates the specific sub category, if any, to which the road section is assigned.

CODES: 5 = Frontage Road  
7 = Park Road  
9 = Parkway  
10 = Service Road  
11 = Fire Lane  
12 = State Park Road  
13 = State Forest Road  
14 = Federal Forest Highway  
15 = National Forest Development Road  
16 = BIA Roads

U/R

FEDERAL U/R AREA: Indicates whether the road section lies within an Urban or Rural Area.  
Urban areas are defined as having a population of 5000 or greater.

FEDERAL URBAN CODES IN DISTRICT #1

14 = Baraboo	66 = Platteville
15 = Beaver Dam	68 = Portage
16 = Beloit *	72 = Reedsburg
32 = Fort Atkinson	83 = Stoughton
39 = Janesville *	85 = Sun Prairie
40 = Jefferson	91 = Watertown
47 = Madison *	93 = Waupun
58 = Monroe	96 = Whitewater
62 = Oconomowoc	

\* Federally-defined "Urbanized" areas.

## RSH

RIGHT SHOULDER TYPE: Indicates the type of shoulder, if any, the right side of the road section has.

CODES: 0 = None  
 1 = Grass  
 2 = Gravel  
 3 = Paved

RIGHT SHOULDER WIDTH: Indicates the right shoulder width of the road section to the nearest foot.

## LSH

LEFT SHOULDER TYPE: Coded same as for the Right Shoulder.

## C

CURBS: Indicates if there are curbs on the road section, and the side they are located on.

CODES: 0 = None  
 1 = Right Side  
 2 = Left Side  
 3 = Both Sides

## P

PARKING: Indicates the type of parking, if any, that is permitted along the road section.

CODES: 0 = None  
 1 = Right Side  
 2 = Left Side  
 3 = Both Sides  
 4 = Rural

R/W INDICATOR: Indicates whether the Right-of-Way Width is an estimated value or an actual value measured to the nearest foot.

CODES: A = Actual  
 E = Estimated

R/W WIDTH: Indicates the footage, to the nearest foot, or the right-of-way for the road section.

## MED

MEDIAN WIDTH: Indicates the width, to the nearest foot, of the median on a divided roadway.

## OW

ONE-WAY: Indicates whether or not a road section is a one-way road.

CODES: Y = Yes  
 N = No

Planning: IMS

Heading Explanations for the "LOCAL ROAD INVENTORY LISTING"  
On 8" x 14" Computer Print Out:

From Left to Right.

County Name

Village, City or Town Name

County Number and Municipality

Road or Street Name      Self Explanatory

SECTION FROM: Describes or identifies the beginning location of the road section.

SECTION TO: Describes or identifies the ending location of the road section.

RD NO. Road or Street number assigned, all urban areas begin with 0100 and township match with road number on Official Town Plat Record.

YR The year that the record was changed or validated on the computer file.

SECTION LENGTH: Length of the road section to the nearest hundredth of a mile.

SURFACE TYPE: Identifies the roadway surface as described by a four digit federal code. Basic examples are:

2010 = Gravel

3210 = Gravel with Seal Coat

4231 = Low Type Bituminous, Road Mix

6201 = Bituminous Concrete on Gravel Base

6203 = Bituminous Concrete over Hot or Cold Bituminous

6706 = Bituminous Concrete over PCC

7201 = PCC Non Reinforced

7221 = PCC Full Reinforced

YR

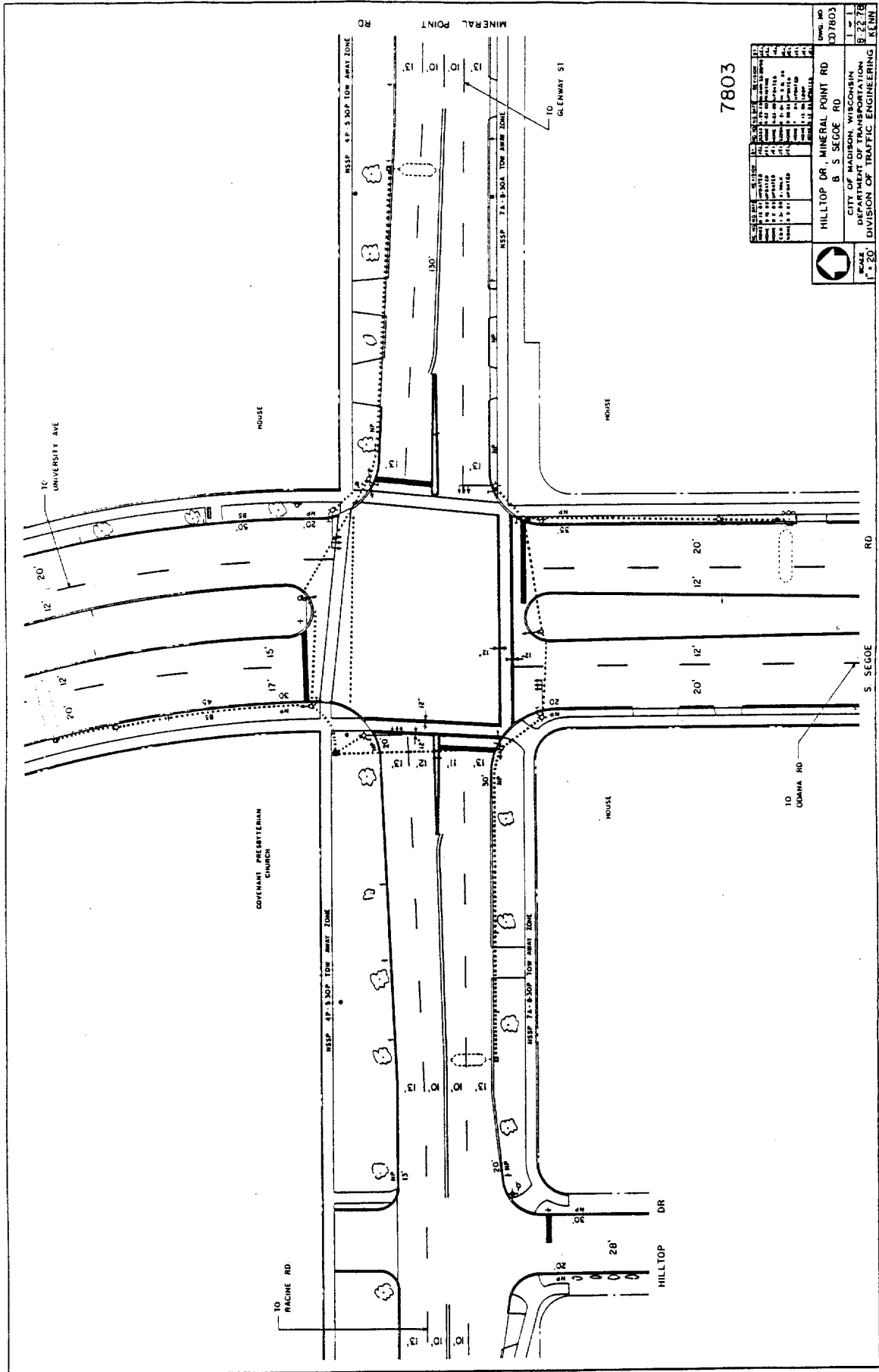
SURFACE YEAR: Identifies the calendar year in which the road section was last surfaced.

W

SURFACE WIDTH: Indicates the width, to the nearest foot, of the surfaced portion of the roadway including the travelled way and auxiliary lanes, but excluding the shoulders. In the case of a divided roadway, the surface width is the sum of both roadway surface widths.

L

TRAFFIC LANES: Indicates the total number of through traffic lanes. In the case of divided highways, the figure represents the total number of through traffic lanes provided for both roadways.

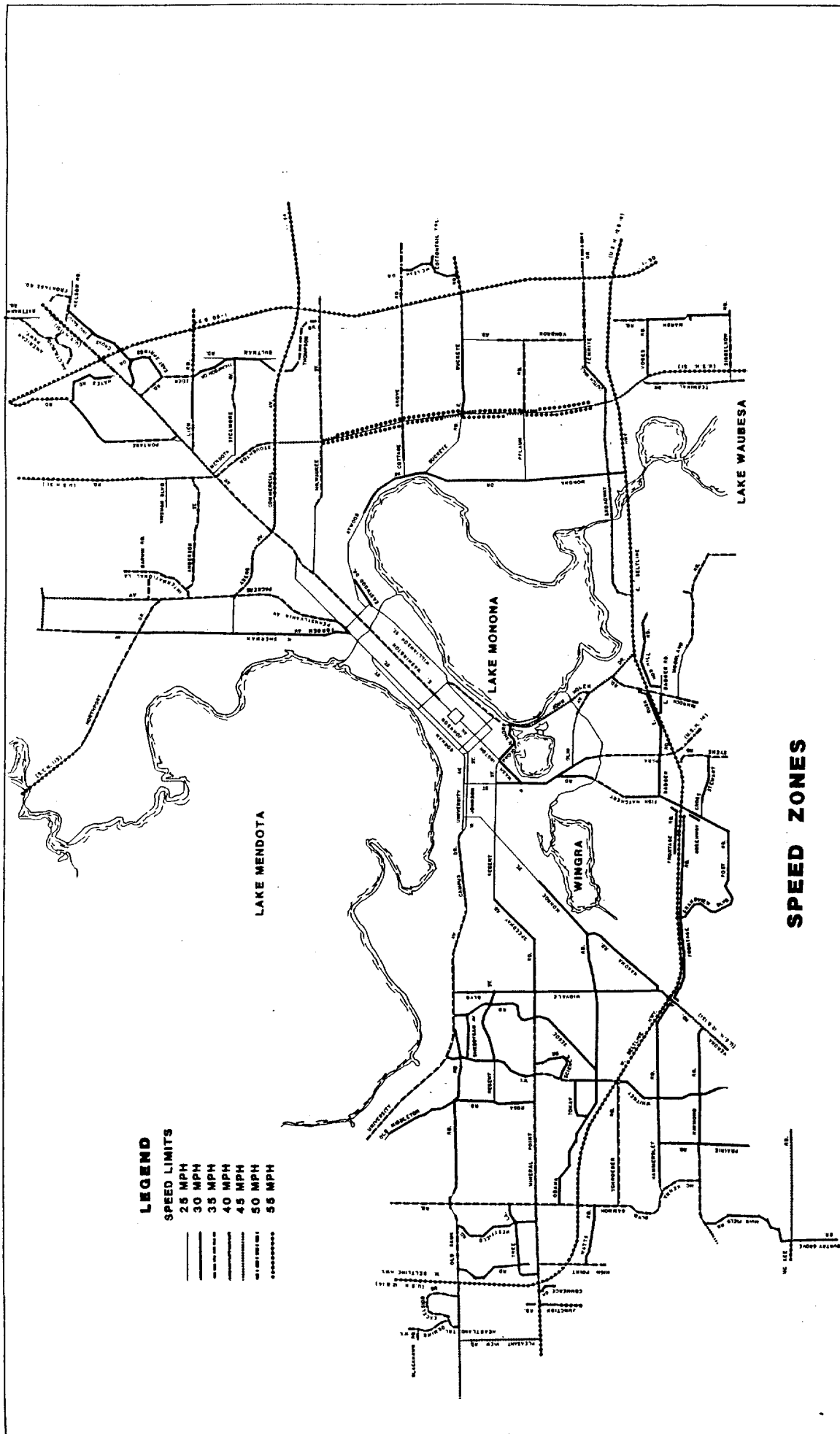


7803

DATE	11/15/11	BY	W. J. KENNEDY
REVISION	11/15/11	BY	W. J. KENNEDY
NO.	1	DATE	11/15/11
BY	W. J. KENNEDY	DATE	11/15/11
PROJECT	HILLTOP DR., MINERAL POINT RD B. S. SEGOE RD		
CITY	CITY OF MADISON, WISCONSIN		
DEPARTMENT	DEPARTMENT OF TRANSPORTATION		
DIVISION	DIVISION OF TRAFFIC ENGINEERING		
ENGINEER	W. J. KENNEDY		
PROJECT NO.	337803		
DATE	8/22/78		
BY	K. J. KENNEDY		



11/15/11 W. J. KENNEDY



	<b>SPEED ZONES</b> CITY OF MADISON, WISCONSIN DEPARTMENT OF TRANSPORTATION DIVISION OF TRAFFIC ENGINEERING	DATE: 10-1-83
		DRAWN BY: J.E.L.

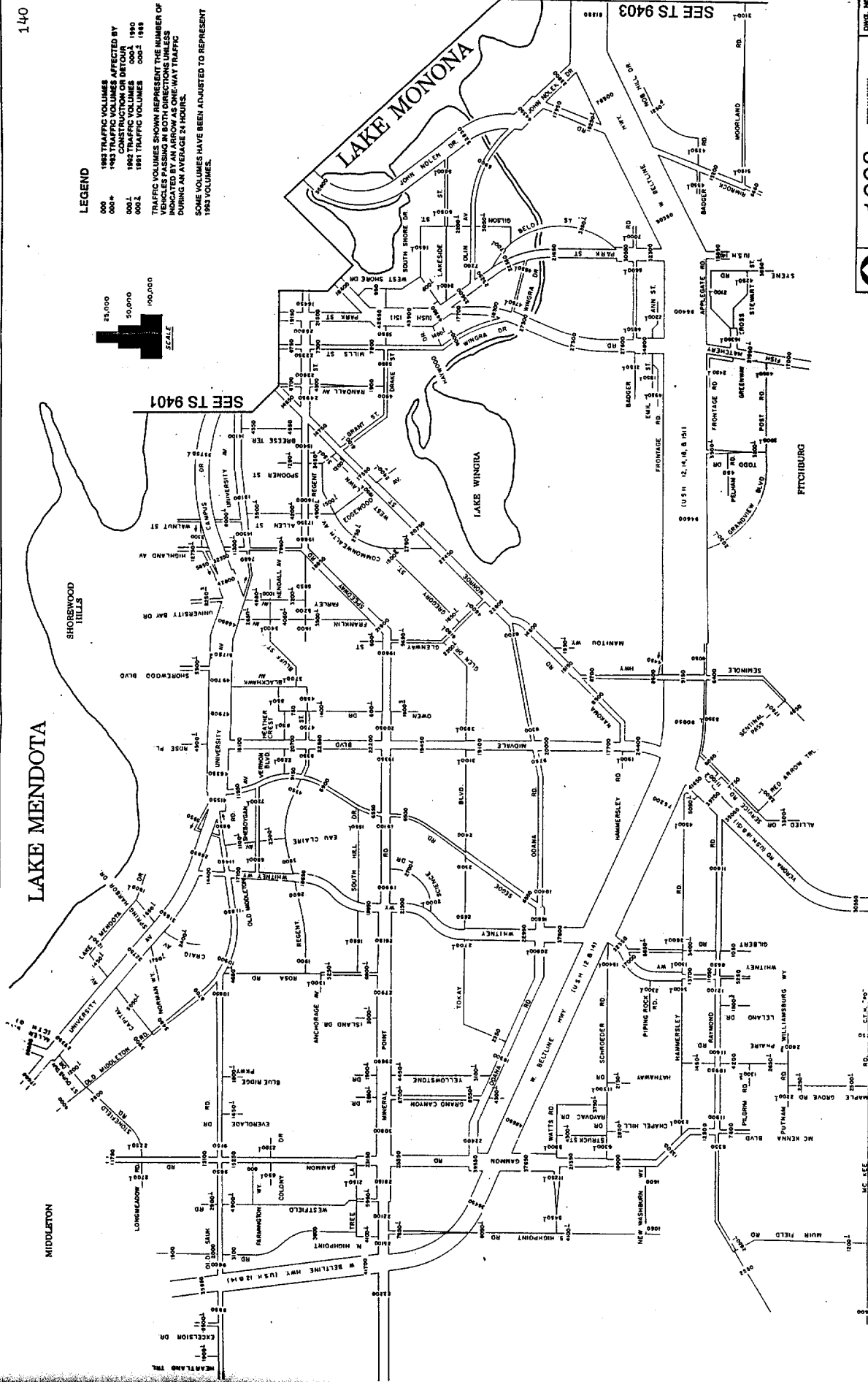
# LAKE MENDOTA

**LEGEND**

1983 TRAFFIC VOLUMES  
 1984 TRAFFIC VOLUMES  
 1985 TRAFFIC VOLUMES  
 1986 TRAFFIC VOLUMES  
 1987 TRAFFIC VOLUMES  
 1988 TRAFFIC VOLUMES  
 1989 TRAFFIC VOLUMES  
 1990 TRAFFIC VOLUMES

TRAFFIC VOLUMES SHOWN REPRESENT THE NUMBER OF VEHICLES PASSING IN BOTH DIRECTIONS UNLESS INDICATED BY AN ARROW AS ONE-WAY TRAFFIC DURING AN AVERAGE 24 HOUR PERIOD.

SOME VOLUMES HAVE BEEN ADJUSTED TO REPRESENT 1983 VOLUMES.



**1993**

WEST MADISON  
 TRAFFIC STUDY MAP  
 TR 9403  
 11/83

CITY OF MADISON, WISCONSIN  
 DEPARTMENT OF TRANSPORTATION  
 DIVISION OF TRAFFIC ENGINEERING

SCALE  
 NOTED

**LEGEND**

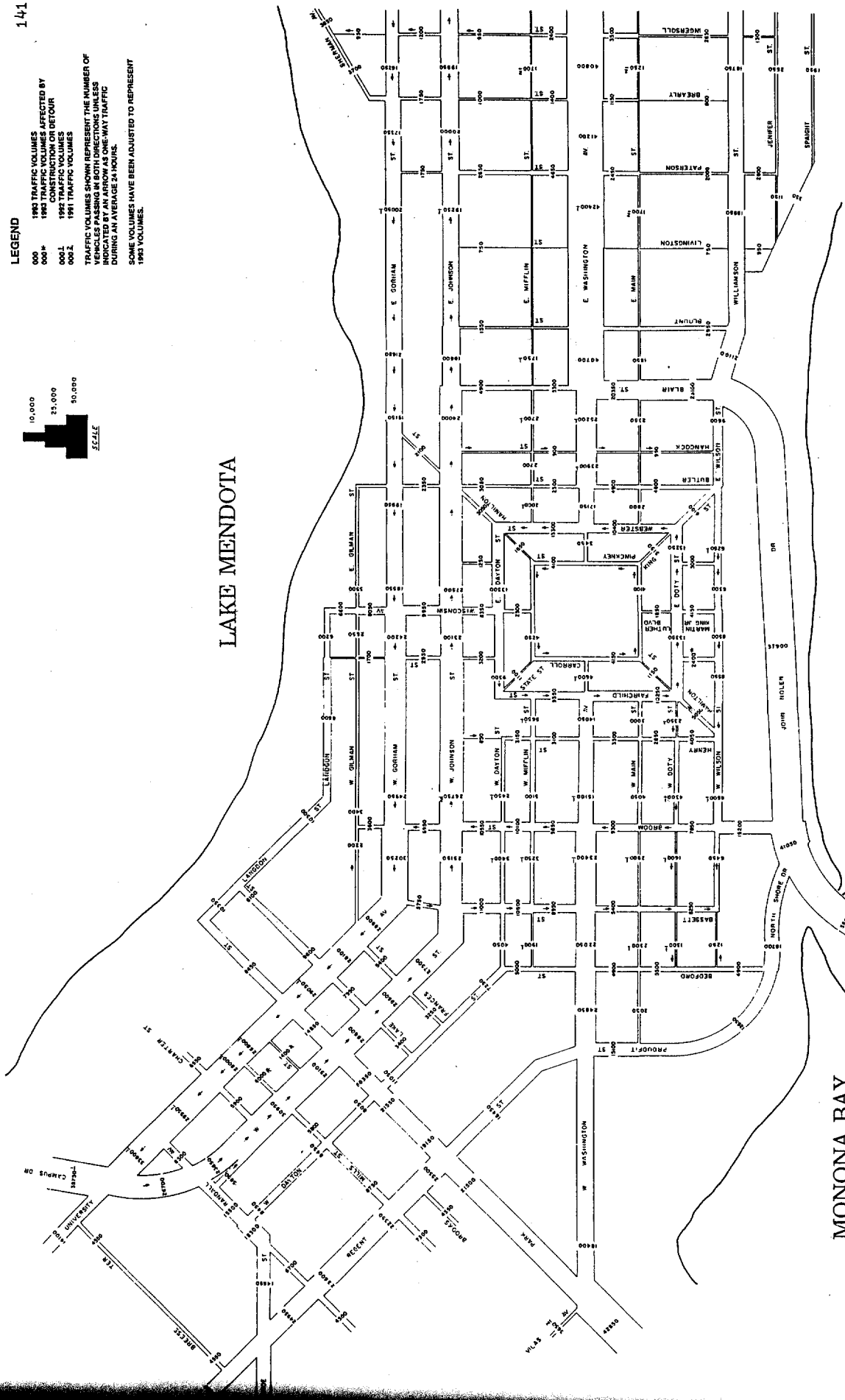
- 000 1983 TRAFFIC VOLUMES
  - 000\* 1983 TRAFFIC VOLUMES AFFECTED BY CONSTRUCTION OR DETOUR
  - 0001 1992 TRAFFIC VOLUMES
  - 0002 1991 TRAFFIC VOLUMES
- TRAFFIC VOLUMES SHOWN REPRESENT THE NUMBER OF VEHICLES PASSING IN BOTH DIRECTIONS UNLESS OTHERWISE NOTED. VOLUMES SHOWN AT INTERSECTIONS DURING AN AVERAGE 24 HOURS.
- SOME VOLUMES HAVE BEEN ADJUSTED TO REPRESENT 1985 VOLUMES.



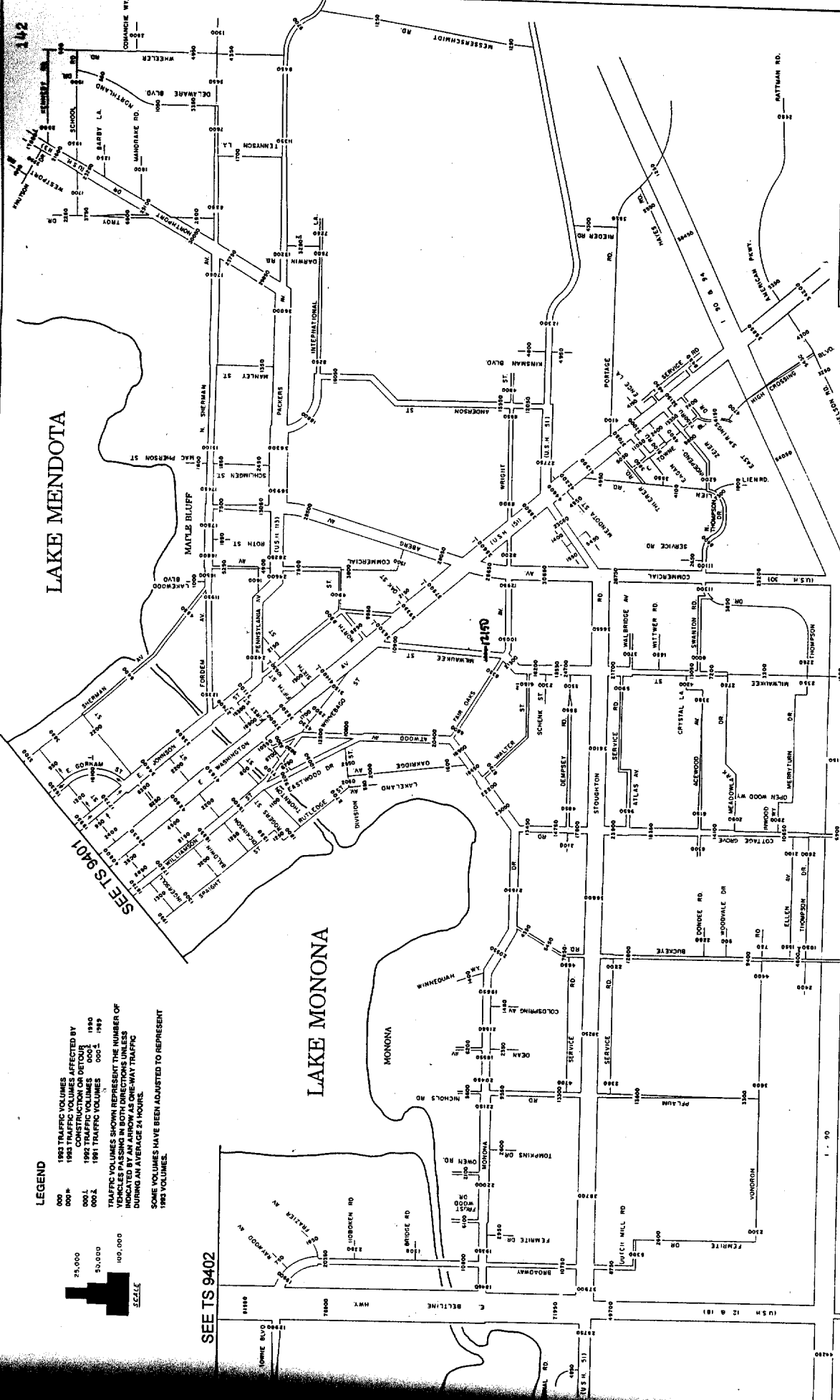
LAKE MENDOTA

LAKE MONONA

MONONA BAY



	<b>1993</b>	DNIC NO.
	CITY OF MADISON, WISCONSIN	TS 9401
DEPARTMENT OF TRANSPORTATION	SCALE	1" = 1
DIVISION OF TRAFFIC ENGINEERING	NOTED	3.26.94
		M.F.S.



**LEGEND**

000 1993 TRAFFIC VOLUMES  
 000+ 1993 TRAFFIC VOLUMES AFFECTED BY CONSTRUCTION OR DETOUR  
 000L 1990 TRAFFIC VOLUMES  
 000R 1991 TRAFFIC VOLUMES  
 000-1989 TRAFFIC VOLUMES

TRAFFIC VOLUMES SHOWN REPRESENT THE NUMBER OF VEHICLES PER HOUR IN EACH DIRECTION UNLESS INDICATED BY AN ARROW IN OPPOSITE TRAFFIC DURING AN AVERAGE 24 HOURS.

SOME VOLUMES HAVE BEEN ADJUSTED TO REPRESENT 1993 VOLUMES.



SEE TS 9402

SEE TS 9401

**1993**  
 SAFETY MAP  
 TRAFFIC FLOW MAP

CITY OF MADISON, WISCONSIN  
 DEPARTMENT OF TRANSPORTATION  
 DIVISION OF TRAFFIC ENGINEERING

DWG. NO. TS 9403  
 1 OF 1  
 3-24-94  
 M.P.S.

NOTED

APPENDIX C

**BICYCLE COMPATIBILITY EVALUATION DATA SPREADSHEET  
FOR MADISON, WISCONSIN**

A	B	C	D	E	F	G	H	I	J	K	M	N	O	Q	R	S	T	U
Street Name	Section	Street Class.	Segment Length	# of Lanes	Parking	Roadway Width	Curb Lane Width	Bike Lane or Shoulder	AWT	Posted Speed Limit	VPH/L	85th %ile Speed	Effective Curb Lane Width	Volume Index	Width Index	Speed Index	Index Average	Primary Compatibility Rating
Aberg Ave	N Sherman - Crowley	a	0.10	2	0	40	20		7500	25	375	30	18	4.5	1	2	2.50	good
	Crowley - RR (East Bound)	a	0.23	2	1	40	20		7500	25	375	30	18	4.5	1	2	2.50	good
	Crowley - RR (West Bound)	a	0.23	2	1	40	20		7500	25	375	30	12	4.5	4.5	2	3.67	poor
	RR - Everett	a	0.04	2	0	40	20		7500	25	375	30	18	4.5	1	2	2.50	good
	Everett - Packers	a	0.12	2	0	40	20		13050	25	652.5	30	18	5	1	2	2.67	moderate
	Packers - McCormick	a	0.80	4	0	48	12	10	28500	45	712.5	50	20	5	1	5	3.67	poor
	McCormick - E Washington	a	0.13	4	0	48	12		28050	45	701.3	50	10	5	5	5	5.00	very-poor
Acewood Blvd	Crystal La - Onyx	c	0.38	2	2	48	16		3350	25	167.5	30	16	2.5	1	2	1.83	good
	Onyx - Cottage Grove	c	0.54	2	2	48	16		6150	25	307.5	30	16	4	1	2	2.33	good
	Cottage Grove - Starter	c	0.50	2	2	48	16		6300	25	315	30	16	4	1	2	2.33	good
Allen Blvd (oth Q)	University - Century	a	1.00	4	0	62	15	5	20800	35	520	40	18	5	1	4	3.33	moderate
Allen St	University - Chadbourne	c	0.25	2	1	30	11		3500	25	175	30	11	2.5	5	2	3.17	moderate
	Chadbourne - Regent	c	0.07	2	1	30	11		4200	25	210	30	11	3	5	2	3.33	moderate
	Regent - Commonwealth	c	0.18	2	1	30	11		4900	25	245	30	11	3	5	2	3.33	moderate
Allied Dr	Verona Rd Front - Crescent	c	0.49	2	1	40	16		3300	25	165	30	16	2.5	1	2	1.83	good
Anderson St	International - Grim	c	0.24	4	0	54	14		16050	35	401.3	40	12	5	4.5	4	4.50	poor
	Grim - Hoffman	c	0.79	2	0	34	12	3	16050	35	802.5	40	13	5	3.5	4	4.17	poor
	Hoffman - Wright (East Bound)	c	0.16	4	0	52	13		15550	35	388.8	40	11	4.5	5	4	4.50	poor
	Hoffman - Wright (West Bound)	c	0.16	4	0	52	14		15550	35	388.8	40	12	4.5	4.5	4	4.33	poor
	Wright - Iush 51	c	0.31	4	0	48	13		12050	35	301.3	40	11	4	5	4	4.33	poor
Atwood Ave	First - Winnebago	a	0.15	2	2	38	11		5300	25	265	30	11	3.5	5	2	3.50	moderate
	Winnebago - Corscott	a	0.17	2	2	44	14		12500	25	625	30	14	5	2.5	2	3.17	moderate
	Corscott - Dunning	a	0.10	2	0	26	13		10800	25	540	30	11	5	5	2	4.00	poor
	Dunning - Hudson	a	0.23	2	2	44	12		20400	25	1020	30	12	5	4.5	2	3.83	poor
	Hudson - Fair Oaks	a	0.15	4	0	44	12		20400	25	510	30	10	5	5	2	4.00	poor
	Fair Oaks - Oakridge	a	0.20	3	0	37	12		16900	25	563.3	35	10	5	5	3	4.33	poor
	Oakridge - Walter	a	0.42	4	0	48	13		18450	30	461.3	35	11	5	5	3	4.33	poor
	Walter - Cottage Grove	a	0.33	4	0	48	13		23050	30	576.3	35	11	5	5	3	4.33	poor
Badger Rd (W)	Fish Hatchery - Catalpa	c	0.10	2	0	40	16		6850	30	342.5	35	14	4	2.5	3	3.17	moderate
	Catalpa-Cypress (West Bound)	c	0.20	2	1	40	12		6850	30	342.5	35	12	4	4.5	3	3.83	poor
	Catalpa-Cypress (East Bound)	c	0.20	2	0	40	20		6850	30	342.5	35	18	4	1	3	2.67	moderate
	Cypress-Park	c	0.15	2	0	40	20		6850	30	342.5	35	18	4	1	3	2.67	moderate
	Park - Rusk	c	0.45	2	0	36	18		7000	30	350	35	16	4.5	1	3	2.83	moderate
Baldwin St	Sherman - Johnson	c	0.26	2	2	34	9		2200	25	110	30	9	2	5	2	3.00	moderate
	Johnson - E Wash	c	0.21	2	2	42	13		8250	25	412.5	30	13	5	3.5	2	3.50	moderate
	E Wash - 08 East	c	0.08	3	0	42	12		4500	25	150	30	10	2	5	2	3.00	moderate
	08 East - Williamson	c	0.19	2	2	42	13		5150	25	257.5	30	13	3.5	3.5	2	3.00	moderate
	Williamson - Spaight	c	0.13	2	2	40	12		3200	25	160	30	12	2.5	4.5	2	3.00	moderate
Bassett St	University - Johnson	a	0.07	2	1	32	12		5750	25	287.5	30	12	3.5	4.5	2	3.33	moderate
	Johnson - Dayton	a	0.06	3	0	38	12		11000	25	367.5	30	10	4.5	5	2	3.83	poor
	Dayton - W Wash	a	0.15	2	1	38	11	5	10600	25	530	30	16	5	1	2	2.67	moderate
	W Wash - Main	a	0.15	2	1	38	11	4	6250	25	312.5	30	15	4	1	2	2.33	good
	Main - Wilson	a	0.07	2	1	38	11		6250	25	312.5	30	15	4.5	1	2	2.50	good
Bedford St	Dayton - W Wash	c	0.17	2	2	38	11		5000	25	250	30	11	3.5	5	2	3.50	moderate
	W Wash - Main	c	0.08	2	2	44	14		4900	25	245	30	14	3	2.5	2	2.50	good
	W Wash - Wilson	c	0.11	2	2	38	11		5500	25	275	30	11	3.5	5	2	3.50	moderate
	Wilson - N Shore	c	0.10	2	2	43	13.5		4900	25	245	30	13.5	3	3	2	2.67	moderate
Beid St	Park - Wingra Cr	c	0.25	2	2	40	12		1700	25	85	30	12	1.5	4.5	2	2.67	moderate
	Wingra Cr - Burr Oak	c	0.34	2	2	44	14		3350	25	167.5	30	14	2.5	2.5	2	2.33	good

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Beltline Frntg (north)	Burr Oak - Park	C	0.05	1	1	22	14		3350	25	335	30	14	4	2.5	2	2.83	moderate
Beltline Frntg (south)	Todd - Emil	C	0.90	2	0	32	16		5050	30	252.5	35	14	3.5	2.5	3	3.00	moderate
	Hammersly - Verona	C	0.33	2	0	34	17		6050	30	302.5	35	15	3.5	1	3	2.50	good
	Verona - Seminole	C	0.59	2	0	32	16		6050	30	302.5	35	14	4	2.5	3	3.17	moderate
	Seminole - Todd (east bound)	C	1.05	2	0	32	12	5	6050	30	302.5	35	15	4	1	3	2.67	moderate
	Seminole - Todd (west bound)	C	1.05	2	0	32	12	3	6050	30	302.5	35	13	4	3.5	3	3.50	moderate
	Todd - Greenway Cross	C	0.85	2	0	32	16		6050	30	302.5	35	14	4	2.5	3	3.17	moderate
Blackhawk Ave	University - Regent	C	0.50	2	2	36	10		4550	25	227.5	30	10	3	5	2	3.33	moderate
Blair St	Gorham - Johnson	C	0.06	2	2	36	10		1150	25	57.5	30	10	1.5	5	2	2.83	moderate
	Johnson - E Wash	A	0.21	2	2	38	10		5300	25	265	30	10	3.5	5	2	3.50	moderate
	E Wash - John Nolen	A	0.23	4	0	48	13		23100	25	577.5	30	11	5	5	2	4.00	poor
Blue Ridge Pkwy	Old Sauk - N Yellowstone	C	0.37	2	2	32	8		1800	25	90	30	8	1.5	5	2	2.83	moderate
Bluff St	Blackhawk - Ridge	C	0.42	2	1	36	14		3700	25	185	30	14	2.5	2.5	2	2.33	good
Bram St	Beld - Koster	C	0.20	2	2	38	11		75	25	3.75	30	11	1	5	2	2.67	moderate
Brearily	Sherman - Gorham	C	0.03	2	2	36	11	6	3700	25	185	30	17	2.5	1	2	1.83	good
Breese Terr	University - Regent	C	0.39	2	2	48	16		4550	25	227.5	30	16	3	1	2	2.00	good
Bridge Rd	Regent - Monroe	C	0.06	2	2	40	12		1800	25	65	30	12	1.5	4.5	2	2.67	moderate
	Frost Woods - Winnequah	C	0.37	2	2	40	12		1300	25	90	30	12	1.5	4.5	2	2.67	moderate
	Winnequah - Broadway	C	0.27	2	0	44	22		1300	25	65	30	20	1.5	1	2	1.50	very-good
Broadway (CTH BW)	South Towne - Bridge Rd	A	0.71	4	0	58	11	5	20350	40	508.8	45	14	5	2.5	5	4.17	poor
	Bridge Rd - Falcon	A	0.40	4	0	56	11	4	10800	40	270	45	13	3.5	3.5	5	4.00	poor
	Falcon - Taylor	A	0.75	4	0	62	12	6	10800	40	270	45	16	3.5	1	5	3.17	moderate
	Taylor - USH 51	A	0.25	4	0	58	12	4	10800	40	270	45	14	3.5	2.5	5	3.67	poor
Broom St	Gorham - Johnson	A	0.06	2	1	36	15		6950	25	347.5	30	15	4	1	2	2.33	good
	Johnson - Dayton	A	0.06	3	0	36	12		10550	25	351.7	30	10	4.5	5	2	3.83	poor
	Dayton - Mifflin	A	0.05	2	1	36	14		10100	25	505	30	14	5	2.5	2	3.17	moderate
	Mifflin - Doty	A	0.25	2	1	40	16		9850	25	492.5	30	16	5	1	2	2.67	moderate
	Doty - Wilson	A	0.05	3	0	40	14		7850	25	261.7	30	12	3.5	4.5	2	3.33	moderate
	Wilson - RR	A	0.10	4	0	48	13		15200	25	380	30	11	4.5	5	2	3.83	poor
Buckeye Rd	Monona Dr - 08 E Monona Dr	C	0.08	2	2	44	14		4350	25	217.5	30	14	3	2.5	2	2.50	good
	08 E Monona - Camden	C	0.70	2	2	44	14		5480	25	274	30	14	3.5	2.5	2	2.67	moderate
	Camden - USH 51 Serv.	C	0.08	2	2	37	10		7850	25	392.5	30	10	4.5	5	2	3.83	poor
	USH 51 Serv. - Blossom	C	0.03	4	0	58	16		12800	30	320	35	14	4	2.5	3	3.17	moderate
	Blossom - Droster	C	1.20	2	2	41	12.5		12800	30	640	35	12.5	5	4	3	4.00	poor
	Droster - Thompson	C	0.21	2	2	44	14		9400	30	470	35	14	5	2.5	3	3.50	moderate
	Thompson - East I-90 R/W	C	0.06	2	0	22	11		4800	35	240	40	9	3	5	4	4.00	poor
	E I-90 R/W - Cottontail Tr (east bound)	C	0.21	3	0	50	11		4800	55	160	60	26	2.5	5	5	4.17	poor
	E I-90 R/W - Cottontail Tr (west bound)	C	0.21	3	0	50	11	17	4800	55	160	60	26	2.5	1	5	2.83	moderate
	Cottontail Tr - Sprecher	C	0.30	2	2	28	11	3	4800	55	240	60	14	3	2.5	5	3.50	moderate
Bultman Rd	Thompson - CTH T	C	0.57	2	2	22	11		11100	30	555	35	11	5	5	3	4.33	poor
Butler St	Johnson - Mifflin	C	0.15	2	1	28	10		3050	25	152.5	30	10	2.5	5	2	3.17	moderate
	Mifflin - E Wash (north bound)	C	0.10	2	0	32	14		2300	25	115	30	12	2	4.5	2	2.83	moderate
	Mifflin - E Wash (south bound)	C	0.10	2	1	32	10		2300	25	115	30	10	2	5	2	3.00	moderate
	E Wash - Wilson	C	0.20	2	2	40	12		4900	25	245	30	12	3	4.5	2	3.17	moderate
Campus Dr	Farley - 87 E Farley	A	0.87	4	0	48	14		42800	40	1070	45	12	5	4.5	5	4.83	moderate
	87 E Farley - University	A	0.23	4	0	48	12		35750	40	893.8	45	10	5	5	5	5.00	very-poor
	University - Johnson	A	0.29	3	0	48	13		26700	25	890	30	11	5	5	2	4.00	poor
Capital Ave	Lake Mendota - University	C	0.28	2	2	36	10		1450	25	72.5	30	10	1.5	5	2	2.83	moderate
	University - Old Middleton	C	0.28	2	2	36	10		3050	25	152.5	30	10	2.5	5	2	3.17	moderate

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Charter St	Observatory - Linden	C	0.08	2	0	32	10	6	6550	25	327.5	30	14	4	2.5	2	2.83	moderate	
	Linden - University	C	0.08	2	0	36	11.5	6.5	6550	25	327.5	30	16	4	1	2	2.33	good	
	University - Johnson	C	0.07	4	0	44	11		5900	25	147.5	30	9	2	5	2	3.00	moderate	
Colony Dr	Gammon - Everglade	C	0.18	2	2	32	8		2300	25	115	30	8	2	5	2	3.00	moderate	
Comanche Way	Manitowish - Menominee	C	0.33	2	2	32	8		2500	25	125	30	8	2	5	2	3.00	moderate	
	Menominee - Wheeler	C	0.31	2	2	40	12		2500	25	125	30	12	2	4.5	2	2.83	moderate	
Commercial Ave	N Sherman - C&NW RR (east bound)	C	0.07	2	0	40	22		5250	25	262.5	30	20	3.5	1	2	2.17	good	
	N Sherman - C&NW RR (west bound)	C	0.15	2	0	40	18		5250	25	262.5	30	16	3.5	1	2	2.17	good	
	C&NW - SOO RR	C	0.15	2	2	44	14		5250	25	262.5	30	14	3.5	2.5	2	2.67	moderate	
	SOO RR - North	C	0.38	4	0	44	13		7500	25	187.5	30	11	2.5	5	2	3.17	moderate	
	North - Algoma	C	0.37	2	2	44	14		3800	25	190	30	14	2.5	2.5	2	2.33	good	
	Algoma - McCormick	C	0.15	2	2	40	12		3800	25	190	30	12	2.5	4.5	2	3.00	moderate	
	E Wash - Fairroaks	a	0.33	4	0	52	13		28650	45	716.3	50	11	5	5	5	5.00	very-poor	
	Fairoaks - End STH 30	a	1.25	4	0	52	13		30650	55	766.3	60	11	5	5	5	5.00	very-poor	
Commonwealth Ave	Rowley - Allen	C	0.25	2	1	30	11		1500	25	75	30	11	1.5	5	2	2.83	moderate	
	Allen - Monroe	C	0.55	2	1	30	11		2750	25	137.5	30	11	2	5	2	3.00	moderate	
Cottage Grove Rd	Monona - Claire	a	0.52	4	0	48	13		14750	25	368.8	30	11	4.5	5	2	3.83	poor	
	Ramp North	a	0.23	4	0	48	14		17800	30	445	35	12	5	4.5	3	4.17	poor	
	Ramp North - Atlas	a	0.10	4	2	72	16		23900	35	597.5	40	16	5	1	4	3.33	moderate	
	Atlas - Acewood	a	0.23	4	2	72	16		18350	35	458.8	40	16	5	1	4	3.33	moderate	
	Acewood - Inwood	a	0.48	4	2	72	16		14100	35	352.5	40	16	4.5	1	4	3.17	moderate	
	Inwood - Thompson	a	0.39	4	1	64	16		10650	35	266.3	40	16	3.5	1	4	2.83	moderate	
	Thompson - I-90	a	0.19	2	2	40	13		6900	35	345	40	15	4	1	4	3.00	moderate	
Crescent Rd	Allied - 450 E of Allied	C	0.08	2	2	40	12		25	25	15	30	12	1	4.5	2	2.50	good	
Crystal Ln	Milwaukee - Acewood	C	0.11	2	2	32	8		400	25	210	30	8	3	5	2	3.33	moderate	
CTH MM	Rimrock - McCoy	a	0.28	2	2	30	11		2130	50	106.5	55	15	2	1	5	2.67	moderate	
	McCoy - Clayton (north bound)	a	0.06	3	2	43.5	12		2130	50	71	55	15.5	1.5	1	5	2.50	good	
	McCoy - Clayton (south bound)	a	0.06	3	2	43.5	11		2130	50	71	55	17	1.5	1	5	2.50	good	
Dayton St	Randall - Orchard	a	0.08	3	0	36	13		8450	25	281.7	30	11	3.5	5	2	3.50	moderate	
	Orchard - Park	a	0.34	2	0	36	12		8450	25	422.5	30	16	5	1	2	2.67	moderate	
	Park - Lake	a	0.17	2	0	36	12		11050	25	552.5	30	16	5	1	2	2.67	moderate	
	Lake - Bedford	a	0.17	2	0	36	12		7250	25	362.5	30	16	4.5	1	2	2.50	good	
	Bedford - Bassett (west bound)	a	0.10	3	0	40	12		4050	25	135	30	19	2	2	1	1.67	good	
	Bedford - Bassett (east bound)	a	0.10	3	0	40	12		4050	25	135	30	19	2	2	5	2	3.00	moderate
	Bassett - Broom	a	0.13	4	0	40	11		3400	25	85	30	9	1.5	5	2	2.83	moderate	
	State - Wisconsin	a	0.14	2	2	44	14		9300	25	465	30	14	2.5	2.5	2	3.17	moderate	
	Wisconsin - Hamilton	a	0.14	2	2	44	14		13300	25	665	30	14	5	2.5	2	3.17	moderate	
Delaware Blvd	Wheeler - Sherman	C	0.85	2	2	48	16		3350	25	167.5	30	16	2.5	1	2	1.83	good	
Dempsey Rd	Milwaukee - Calvert	C	0.28	2	0	36	18		3300	25	165	30	16	2.5	1	2	1.83	good	
	Calvert - Cottage Grove	C	0.75	2	2	36	10		5550	25	277.5	30	10	3.5	5	2	3.50	moderate	
	Cottage Grove - Park Ct	C	0.10	2	2	36	10		2100	25	105	30	10	2	5	2	3.00	moderate	
	Park Ct - Maher	C	0.20	2	1	32	12		2100	25	105	30	12	2	4.5	2	2.83	moderate	
Dennett Dr	Atwood - Dempsey	C	0.63	2	2	36	10		1050	25	52.5	30	10	1.5	5	2	2.83	moderate	
Division St	Eastwood - Oakridge	C	0.18	2	1	28	10		2550	25	127.5	30	10	2	5	2	3.00	moderate	
	Oakridge - Lakeland/Rutledge	C	0.06	2	1	28	10		2550	25	127.5	30	10	2	5	2	3.00	moderate	
Dondee Rd	Starker - Buckeye	C	0.25	2	2	32	8		2250	25	112.5	30	8	2	5	2	3.00	moderate	
Doty St	Bedford - Broom	C	0.25	2	2	40	12		1600	25	80	30	12	1.5	4.5	2	2.67	moderate	
	Broom - Henry	C	0.12	2	2	40	12		4300	25	215	30	12	3	4.5	2	3.17	moderate	
	Henry - Fairchild	C	0.06	2	2	44	14		2350	25	117.5	30	14	2	2.5	2	2.17	good	

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Drake St	Fairchild - Webster	a	0.29	2	2	44	11	5	13350	25	667.5	30	16	5	1	2	2.67	moderate
Dutch Mill Rd	Grant - Mills	c	0.42	2	2	44	14		5850	25	292.5	30	14	3.5	2.5	2	2.67	moderate
	Mills - Park	c	0.16	2	2	44	14		3550	25	177.5	30	14	2.5	2.5	2	2.33	good
	Broadway - Bwy Service (east bound)	c	0.12	4	0	62	12	5	8750	40	218.8	45	15	3	1	5	3.00	moderate
	Broadway - Bwy Service (west bound)	c	0.12	4	0	62	15	2	8750	40	218.8	45	15	3	1	5	3.00	moderate
Eagan Rd	Broadway Service - Femrite	c	0.32	2	2	22	11		5300	40	265	45	11	3.5	5	5	4.50	poor
	E Wash - East Towne Blvd	c	0.10	4	0	51	13		11050	25	276.3	30	11	3.5	5	2	3.50	moderate
	East Towne - Lein Rd	c	0.31	4	0	50	13		3550	25	88.75	30	11	1.5	5	2	2.83	moderate
	Thierer Rd - Eagan Rd	c	0.26	2	2	48	16		5550	25	277.5	30	16	3.5	1	2	2.17	good
	Eagan Rd - Zeiler Rd	c	0.35	4	0	48	13		5100	25	127.5	30	11	2	5	2	3.00	moderate
	Zeiler Rd - East Spring Dr	c	0.20	4	0	64	12		7350	25	183.8	30	10	2.5	5	2	3.17	moderate
Eastwood Dr	Winnabago - First	a	0.05	2	0	28	14		9200	30	460	35	12	5	4.5	3	4.17	poor
	First - Atwood	a	0.46	2	0	26	13		10050	30	502.5	35	11	5	5	3	4.33	poor
Eau Claire Ave	Old Middleton - Sheboygan	c	0.11	2	2	44	14		1100	25	55	30	14	1.5	2.5	2	2.00	good
Edgewood Ave	Sheboygan - Regent	c	0.08	2	0	30	15		1950	25	97.5	30	13	1.5	3.5	2	2.33	good
	Allen/Commonwealth - Fox	c	0.18	2	1	30	11		1950	25	97.5	30	11	1.5	5	2	2.83	moderate
Erin St	Fox - Monroe	c	0.16	2	1	32	12		300	25	15	30	12	1	4.5	2	2.50	good
Fairchild St	Mills - Park	c	0.14	2	2	44	14		9350	25	467.5	30	14	5	2.5	2	3.17	moderate
	State - W Wash	a	0.14	2	2	44	14		10250	25	512.5	30	16	5	1	2	2.67	moderate
	W Wash - Main St	a	0.07	3	1	44	13		10250	25	341.7	30	13	4	3.5	2	3.17	moderate
Fair Oaks Ave	Main St - Hamilton	a	0.05	3	1	44	14		6800	25	226.7	30	14	3	2.5	2	2.50	good
	Atwood - Dixon (north bound)	a	0.05	3	0	44	12		6800	25	226.7	30	10	3	5	2	3.33	moderate
	Atwood - Dixon (south bound)	a	0.05	3	0	44	12		8000	25	417.5	30	14	5	2.5	2	3.17	moderate
	Dixon - Milwaukee	a	0.56	2	2	44	14		8350	25	417.5	30	14	5	2.5	2	3.17	moderate
	Milwaukee - Commercial	a	0.52	2	2	44	14		12950	25	647.5	30	14	5	2.5	2	3.17	moderate
Farley Ave	Commercial - E Wash	a	0.45	2	2	44	14		8200	25	410	30	10	4	5	2	3.33	moderate
	University - Kendall	c	0.14	2	2	36	10		4550	25	227.5	30	10	3	5	2	3.33	moderate
	Kendall - Regent	c	0.26	2	2	36	10		3200	25	160	30	10	2.5	5	2	3.17	moderate
Femrite Dr	Dutch Mill - I-90	c	0.23	2	2	20	10		2600	40	130	45	10	2	5	5	4.00	poor
First St	I-90 - Ohmedia	c	0.20	4	0	52	14		18500	25	462.5	30	12	5	4.5	2	3.83	poor
	E Wash - Winnebago	a	0.12	3	0	36	13		10350	25	345	30	11	4	5	2	3.67	poor
	Winnabago - Eastwood	a	0.07	3	0	37	12		6750	25	225	30	10	3	5	2	3.33	moderate
Fish Hatchery	Winnabago - Eastwood	a	0.45	3	2	54	12		18300	30	610	35	12	5	4.5	3	4.17	poor
	Park - Wingra (north bound)	a	0.45	3	2	54	14		18300	30	610	35	14	5	2.5	3	3.50	moderate
	Park - Wingra (south bound)	a	0.45	3	2	54	14		18300	30	610	35	14	5	2.5	3	3.50	moderate
	Wingra - Carver	a	0.45	4	0	53	11	4.5	27300	35	682.5	40	13.5	5	3	4	4.00	poor
	Carver - Catalpa	a	0.20	4	0	53	11	4.5	27300	30	682.5	35	13.5	5	3	3	3.67	poor
	Catalpa - Badger (north bound)	a	0.19	4	1	64	11	5	27600	35	690	40	16	5	1	4	3.33	moderate
	Catalpa - Badger (south bound)	a	0.19	4	0	64	11	5	27600	35	690	40	14	5	2.5	4	3.83	poor
	Badger - Beltline	a	0.26	6	0	80	12	16	34800	30	580	35	26	5	1	3	3.00	moderate
Fordem Ave	Beltline - Greenway	a	0.22	6	0	80	12	16	34800	30	580	35	26	5	1	3	3.00	moderate
Franklin Ave	Johnson - Sherman	a	0.70	2	2	44	14		12350	30	617.5	35	14	5	2.5	3	3.50	moderate
	University - Kendall	c	0.18	2	2	40	12		2650	25	132.5	30	12	2	4.5	2	2.83	moderate
	Kendall - Regent	c	0.25	2	2	40	12		4050	25	202.5	30	12	3	4.5	2	3.17	moderate
	Regent - Hillcrest	c	0.26	2	0	22	11		3500	25	175	30	9	2.5	5	2	3.17	moderate
	Hillcrest - Speedway	c	0.12	2	0	22	11		3500	25	175	30	9	2.5	5	2	3.17	moderate
Gammon Rd	Univ Ave - Elmwood (north bound)	a	0.03	3	0	40	13		11750	25	391.7	30	11	4.5	5	2	3.83	poor
	Univ Ave - Elmwood (south bound)	a	0.03	3	0	40	15		11750	25	391.7	30	13	4.5	3.5	2	3.33	moderate
	Elmwood - RR	a	0.25	2	1	36	14		11750	25	587.5	30	14	5	2.5	2	3.17	moderate

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Street Name	Section	Street Class.	Segment Length	# of Lanes	Parking ?	Roadway Width	Curb Lane Width	Bike Lane or Shoulder	AWT	Posted Speed Limit	VP/HL	85th %ile Speed	Effective Curb Lane Width	Volume Index	Width Index	Speed Index	Index Average	Primary Compatibility Rating
	RR - Longmeadow	a	0.70	4	0	48	13		11750	25	293.8	30	11	3.5	5	2	3.50	moderate
	Longmeadow - .05 N Old Sauk	a	0.15	4	0	40	11		15100	35	377.5	40	9	4.5	5	4	4.50	poor
	.05 N Old Sauk - .10 S O Sk	a	0.15	4	0	54	12		15250	35	381.3	40	10	4.5	5	4	4.50	poor
	.10 S Old Sauk - Tree Ln	a	0.65	4	0	40	11		15250	35	381.3	40	9	4.5	5	4	4.50	poor
	Tree Ln - Mineral Pt	a	0.30	6	0	74	11	13	23150	35	385.8	40	22	4.5	1	4	3.17	moderate
	Mineral Pt - Odana	a	0.25	6	0	72	11	13	25550	35	425.8	40	22	5	1	4	3.33	moderate
	Odana - Seybold	a	0.30	6	0	72	13		39550	35	659.2	40	11	5	5	4	4.67	very-poor
	Seybold Rd - End Divided	a	0.25	4	0	60	15		37650	35	941.3	40	13	5	3.5	4	4.17	poor
	End Divided - Schroeder	a	0.15	4	0	54	11	5	21350	35	533.8	40	14	5	2.5	4	3.83	poor
	Schroeder - Park Ridge	a	0.12	4	0	54	16	6	18000	35	450	40	14	5	2.5	4	3.83	poor
Gilbert Rd	Whitney - Hammersley	c	0.34	2	0	36	12		6650	25	332.5	30	16	4	1	2	2.33	good
	Hammersley - Raymond Rd	c	0.52	2	2	38	11		3400	25	170	30	11	2.5	5	2	3.17	moderate
Gilson St	Lakeside - Olin	c	0.15	2	1	30	11		2200	25	110	30	11	2	5	2	3.00	moderate
	Olin - Beld	c	0.34	2	2	36	10		3050	25	152.5	30	10	2.5	5	2	3.17	moderate
Glen Dr	Tokay - Glenway	c	0.22	2	2	42	13		2200	25	110	30	13	2	3.5	2	2.50	good
Glenway St	Speedway - Paunack	c	0.06	2	1	40	16		5650	25	282.5	30	16	3.5	1	2	2.17	good
	Paunack - St Clair	c	0.30	2	1	32	12		5650	25	282.5	30	12	3.5	4.5	2	3.33	moderate
	St Clair - RR	c	0.05	2	0	36	18		6150	25	307.5	30	16	4	1	2	2.33	good
	RR - Monroe	c	0.20	2	2	30	15		6150	25	307.5	30	15	4	1	2	2.33	good
Gorham St	Bassett - Broom	a	0.11	3	1	44	10	5	30250	25	1008	30	15	5	1	2	2.67	moderate
	Broom - State	a	0.07	2	2	44	10	4	24950	25	1248	30	14	5	2.5	2	3.17	moderate
	State - Henry	a	0.06	2	1	42	10	11	24950	25	1248	30	21	5	1	2	2.67	moderate
	Henry - Wisconsin	a	0.20	2	1	36	10	5	24200	25	1210	30	15	5	1	2	2.67	moderate
	Wisconsin - Hamilton	a	0.20	2	1	36	10	5	19950	25	997.5	30	15	5	1	2	2.67	moderate
	Hamilton - Paterson	a	0.50	2	1	36	10	5	21650	25	1083	30	15	5	1	2	2.67	moderate
	Paterson - Breahey	a	0.12	2	1	36	10	5	17350	25	867.5	30	15	5	1	2	2.67	moderate
	Breahey - Few	a	0.26	2	1	30	11		16250	25	812.5	30	11	5	5	2	4.00	poor
	Few - Baldwin	a	0.10	2	0	36	14	8	16100	25	805	30	20	5	1	2	2.67	moderate
Grandview Blvd	.03 N of Notingham - Knollwood	c	0.42	2	2	50	17		2050	30	102.5	35	17	2	1	3	2.00	good
Grant St	Monroe - Drake	c	0.26	2	1	30	11		6100	25	305	30	11	4	5	2	3.67	poor
Greenway Cross	Fish Hatchery - Latham	c	0.28	2	0	40	20		16350	25	817.5	30	18	5	1	2	2.67	moderate
Hamilton St, N	Gorham - Johnson	c	0.09	2	2	40	12		2100	25	105	30	12	2	4.5	2	2.83	moderate
	Johnson - Dayton	c	0.09	2	2	44	14		3050	25	152.5	30	14	2.5	2.5	2	2.33	good
Hamilton St, S	Doty - Wilson	c	0.09	2	2	34	9		5050	25	252.5	30	9	3.5	5	2	3.50	moderate
Hammersley Rd	McKenna - Rae	c	0.73	2	2	40	12		2300	30	115	35	12	2	4.5	3	3.17	moderate
	Rae - Whitney Way	c	0.41	2	1	36	14		3400	30	170	35	14	2.5	2.5	3	2.67	moderate
	Whitney Way - Gilbert	c	0.22	2	2	40	12		1300	30	65	35	12	1.5	4.5	3	3.00	moderate
	Gilbert - .04 E of Reetz	c	0.68	2	2	40	12		4500	30	225	35	12	3	4.5	3	3.50	moderate
	.04 E Reetz - W Bailline Frt	c	0.08	4	0	40	10		4500	30	112.5	35	8	2	5	3	3.33	moderate
Hayes Rd	Portage - Anniversary	c	0.76	2	1	40	16		2550	30	127.5	35	16	2	1	3	2.00	good
Henry St	Johnson - Dayton	c	0.06	1	0	22	22		850	25	85	30	20	1.5	1	2	1.50	very-good
	Dayton - Mifflin	c	0.16	2	2	40	12		3150	25	157.5	30	12	2.5	4.5	2	3.00	moderate
	Mifflin - Main	c	0.16	2	2	38	11		3300	25	165	30	11	2.5	5	2	3.17	moderate
	Main - Doty (northbound)	c	0.07	2	1	38	11		2850	25	142.5	30	17	2	5	2	3.00	moderate
	Main - Doty (southbound)	c	0.07	2	0	38	19		2850	25	142.5	30	17	2	1	2	1.67	good
	Doty - Wilson	c	0.07	2	1	38	15		4050	25	202.5	30	15	3	1	2	2.00	good
Highland Ave	Marsh Ter. - Campus	c	0.29	4	0	48	12		12750	25	318.8	30	10	4	5	2	3.67	poor
	Campus Dr - University	c	0.05	2	1	40	13		11300	25	565	30	13	5	3.5	2	3.50	moderate
	University - Regent	c	0.29	2	2	36	10		7950	25	397.5	30	10	4.5	5	2	3.83	poor

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High Point Rd	Old Sauk - Tree La	C	0.85	2	2	54	19		3600	30	180	35	19	2.5	1	3	2.17	good	
Hillcrest Dr	Midvale - Owen Pkwy	C	0.37	2	2	22	11		825	25	41.25	30	11	1	5	2	2.67	moderate	
	Owen Pkwy - Westmorland	C	0.02	2	1	36	14		825	25	41.25	30	14	1	2.5	2	1.83	good	
	Westmorland - Alden	C	0.12	2	2	25	12.5		835	25	41.75	30	12.5	1	4	2	2.33	good	
	Alden - Larkin	C	0.05	2	2	32	8		840	25	42	30	8	1	5	2	2.67	moderate	
	Larkin - Franklin	C	0.21	2	2	30	7		700	25	35	30	7	1	5	2	2.67	moderate	
	Franklin - Speedway	C	0.12	2	2	36	10		850	25	42.5	30	10	1	5	2	2.67	moderate	
Independence Ln	Declaration - Melody	C	0.15	2	2	32	8		2000	25	100	30	8	1.5	5	2	2.83	moderate	
	Melody - Dwight	C	0.10	2	0	32	16		4150	25	207.5	30	14	3	2.5	2	2.50	good	
	Dwight - E Wash Frmtg	C	0.09	2	2	44	14		4150	25	207.5	30	14	3	2.5	2	2.50	good	
	E Wash - East Towne Blvd	C	0.04	4	0	52	13		2400	25	60	30	11	1.5	5	2	2.83	moderate	
Ingersoll St	Sherman - Gorham	C	0.10	2	2	36	10		950	25	47.5	30	10	1	5	2	2.67	moderate	
	Gorham - Johnson	C	0.06	2	1	30	11		1200	25	60	30	11	1.5	5	2	2.83	moderate	
	Johnson - Dayton	I	0.06	2	2	30	8		950	25	47.5	30	8	1	5	2	2.67	moderate	
	Dayton - Mifflin	I	0.06	2	1	32	12		950	25	47.5	30	12	1	4.5	2	3.00	good	
	Mifflin - E Wash	I	0.08	2	1	30	11		2400	25	120	30	11	2	5	2	3.00	moderate	
	E Wash - Main (north bound)	C	0.08	2	0	44	24		3500	25	175	30	22	2.5	1	2	1.83	good	
	E Wash - Main (south bound)	C	0.08	2	0	44	20		3500	25	175	30	18	2.5	1	2	1.83	good	
	Main - Williamson	C	0.19	2	2	40	12		2650	25	132.5	30	12	2	4.5	2	2.83	moderate	
	Colony - Nautilus	C	0.74	2	2	44	14		900	25	45	30	14	1	2.5	2	1.83	good	
Inner Dr	Packers - 05 NE of Packers	C	0.05	4	0	48	12		18800	35	470	40	10	5	5	4	4.67	very-poor	
International Ln	05 NE of Packers - Anderson	C	0.15	4	0	48	12		18800	35	470	40	10	5	5	4	4.67	very-poor	
	Anderson - Darwin	C	0.35	2	0	56	10		8250	35	412.5	40	13	5	3.5	4	4.17	poor	
	Darwin - North End	C	0.35	4	0	56	16		7250	35	181.3	40	14	2.5	2.5	4	3.00	moderate	
Island Dr	Nautilus - Driftwood	C	0.23	2	2	32	8		3000	25	150	30	8	2	2	2	2.17	good	
	Driftwood - Mineral Pt	C	0.20	2	2	44	14		3000	25	150	30	14	2	2.5	2	2.17	good	
John Nolen Dr	North Shore - Williamson	a	0.80	4	0	40	11		37900	35	947.5	40	9	5	5	4	4.67	very-poor	
	North Shore Dr - 7 S N Shr	a	0.70	4	0	48	12		35600	45	890	50	10	5	5	5	5.00	very-poor	
	16 N Lakeside - 19 N Olin	a	0.42	4	0	48	12		32850	45	821.3	50	10	5	5	5	5.00	very-poor	
	19 N of Olin - Olin Ave	a	0.19	4	0	48	12		32850	45	821.3	50	10	5	5	5	5.00	very-poor	
	Olin Ave - 06 S of Olin	a	0.06	5	0	60	12		44350	45	887	50	10	5	5	5	5.00	very-poor	
	06 S of Olin - Rimrock	a	0.29	5	0	58	12		44350	45	887	50	10	5	5	5	5.00	very-poor	
	Rimrock - Begin Ramp	a	0.21	4	0	44	11		23900	45	597.5	50	9	3.5	5	5	5.00	very-poor	
Johnson St	Randall - Orchard	a	0.08	2	1	36	14		5850	25	292.5	30	14	5	2.5	2	2.67	moderate	
	Orchard - Bassett	a	0.72	4	0	48	13		30950	25	773.8	30	11	5	5	2	4.00	poor	
	Bassett - Broom	a	0.12	2	0	40	11		5	25150	25	1258	30	14	5	2.5	3.17	moderate	
	Broom - State	a	0.13	3	0	42	12		6	26750	25	891.7	30	16	5	1	2	2.67	moderate
	State - Wisconsin	a	0.20	3	0	40	11		6	23100	25	770	30	15	5	1	2	2.67	moderate
	Wisconsin - Hamilton	a	0.20	3	0	38	10		6	27500	25	916.7	30	14	5	2.5	3.17	moderate	
	Hamilton - Blair	a	0.26	2	2	44	10		5	24000	25	1200	30	15	5	1	2	2.67	moderate
	Blair - Brearly	a	0.41	2	2	44	15		5	20000	25	1000	30	20	5	1	2	2.67	moderate
	Brearly - 06 N of Few	a	0.32	2	2	42	13		19950	25	997.5	30	13	5	3.5	2	3.50	moderate	
	06 N of Few - Baldwin	a	0.07	2	1	36	11		17750	25	887.5	30	11	5	5	2	4.00	poor	
	Baldwin - Fordem	a	0.40	4	0	52	13		34400	25	860	30	11	5	5	2	4.00	poor	
	Fordem - First	a	0.05	4	0	52	13		27400	30	685	35	11	5	5	3	4.33	poor	
	First - Second	a	0.10	6	0	72	13		31100	30	518.3	35	11	5	5	3	4.33	poor	
	Second - Third	c	0.13	2	0	36	18		10650	25	532.5	30	16	5	1	2	2.67	moderate	
	Third - E Wash	c	0.90	2	1	36	14		10650	25	532.5	30	14	5	2.5	2	3.17	moderate	
Kendall Ave	Ridge/Bluff - Shepherd Ter.	c	0.07	2	0	36	18		3400	25	170	30	16	2.5	1	2	1.83	good	

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King St	Shepherd Ter. - Franklin	C	0.06	2	2	36	10		3400	25	170	30	10	2.5	5	2	3.17	moderate	
	Main - Doty	C	0.08	2	2	41	12.5		3150	25	157.5	30	12.5	2.5	4	2	2.83	moderate	
	Doty - Wilson (outbound)	C	0.09	3	1	40	12		6100	25	203.3	30	12	3	4.5	2	3.17	moderate	
	Doty - Wilson (inbound)	C	0.09	3	1	40	11		6100	25	203.3	30	11	3	5	2	3.33	moderate	
Koster St	Bram - Rusk	C	0.30	2	2	22	11		150	25	7.5	30	11	1	5	2	2.67	moderate	
Lake St	Langdon - State	C	0.07	2	2	44	14		6100	25	305	30	14	4	2.5	1	2	2.83	moderate
	State - University (northbound)	C	0.12	2	0	40	22		9600	25	480	30	20	5	1	2	2.67	moderate	
	State - University (southbound)	C	0.12	2	0	40	18		9600	25	480	30	16	5	1	2	2.67	moderate	
	University - Johnson	C	0.08	4	0	48	13		7950	25	198.8	30	11	2.5	5	2	3.17	moderate	
	Johnson - Dayton	C	0.09	2	2	44	14		3400	25	170	30	14	2.5	2.5	2	2.33	good	
Lake Farm Rd	Moerland - Libby	C	0.32	2	0	20	10		700	35	35	40	8	1	5	4	3.33	moderate	
Lake Mendota Dr	Capital - Norman Way	C	0.32	2	2	32	8		1250	25	62.5	30	30	1.5	5	2	2.83	moderate	
	Norman Way - 18 S Norman Wy	C	0.18	2	2	36	10		1250	25	62.5	30	10	1.5	5	2	2.83	moderate	
	18 S Norman - City Limit	C	0.39	2	0	26	13		1600	25	80	30	11	1.5	5	2	2.83	moderate	
Lakeside St	Park - Gilson	C	0.44	2	2	36	10		2400	25	120	30	10	2	5	2	3.00	moderate	
	Gilson - Lake Ct	C	0.15	2	2	44	14		5050	25	252.5	30	14	3.5	2.5	2	2.67	moderate	
	Lake Ct - John Nolen	C	0.27	2	2	36	10		5500	25	275	30	10	3.5	5	2	3.50	moderate	
Langdon St	Park - Lake	C	0.18	2	2	40	12		10350	25	517.5	30	12	5	4.5	2	3.83	poor	
	Lake - Henry	C	0.25	2	1	32	12		10300	25	515	30	12	5	4.5	2	3.83	poor	
Libby Rd	Henry - Wisconsin	C	0.22	2	1	32	12		6200	25	310	30	12	4	4.5	2	3.50	moderate	
Lien Rd	Lake Farm - End	C	0.12	2	2	23	12.5		170	25	8.5	30	12.5	1	4	2	2.33	good	
	E Wash - Thierer	C	0.38	4	0	54	16		4950	35	123.8	40	14	2	2.5	4	2.83	moderate	
	Thierer - Zeiler	C	0.57	2	2	22	11		4100	30	205	35	11	3	5	3	3.67	poor	
	Zeier - Thompson	C	0.03	2	2	54	16		1800	30	90	35	16	1.5	1	3	1.83	good	
Longmeadow Rd	W.C.P.L - Gammon	C	0.62	2	2	40	12		2700	25	135	30	12	2	4.5	2	2.83	moderate	
MacPherson St	Sheridan - Sherman	C	0.25	2	2	30	7		1800	25	90	30	7	1.5	5	2	2.83	moderate	
Maier Ave	Dempsey - Buckeye	C	0.55	2	2	33	8.5		940	25	47	30	8.5	1	5	2	2.67	moderate	
Main St	Proudfit - Bedford	C	0.19	2	2	40	12		2050	25	102.5	30	12	2	4.5	2	2.83	moderate	
Maple Grove Dr	Putnam - Chester	C	0.42	2	2	44	14		2500	25	125	30	14	2	2.5	2	2.17	good	
	Chester - McKee	C	0.08	2	2	54	19		2500	25	125	30	19	2	1	2	1.67	good	
Marcy Rd	Troy - Woodward	C	0.31	2	2	36	10		155	25	7.75	30	10	1	5	2	2.67	moderate	
Marquette St	E Wash - Milwaukee	C	0.32	2	2	30	7		4400	25	220	30	7	3	5	2	3.33	moderate	
Marsh St	Voges - 26 S of Voges	C	0.26	2	0	20	10		150	30	7.5	35	8	1	5	3	3.00	moderate	
	32 N of Siggelkow - 18 N	C	0.32	2	0	24	12		500	30	25	35	10	1	5	3	3.00	moderate	
McCormick Ave	Aberg - Commercial	C	0.15	2	0	36	18		1500	25	75	30	16	1.5	1	2	1.50	very-good	
	Commercial - E Wash	C	0.11	2	1	36	14		1425	25	71.25	30	14	1.5	2.5	2	2.00	good	
McCoy Rd	Syene - Herman	C	0.53	2	2	24	12		1850	55	92.5	60	12	1.5	4.5	5	3.67	poor	
	Herman - USH 14	C	0.20	4	2	52	13		1850	55	46.25	60	13	1	3.5	5	3.17	moderate	
	USH 14 - CTH MM	C	0.10	4	0	52	14		1850	55	46.25	60	12	1	4.5	5	3.50	moderate	
McKenna Blvd	Gammon - Raymond	A	1.08	4	0	54	16		13300	35	332.5	40	14	4	2.5	4	3.50	moderate	
	Raymond - Lancaster	C	0.70	2	2	48	16		7800	25	390	30	16	4.5	1	2	2.50	good	
	Lancaster - Carmwood	C	0.26	2	2	32	8		1000	25	50	30	8	1.5	5	2	2.83	moderate	
Meadowlark Dr	Milwaukee - Cottage Grove	C	1.02	2	2	44	14		2750	25	137.5	30	14	2	2.5	2	2.17	good	
Mendota St	E Wash - Sycamore	C	0.47	2	2	44	14		4950	25	247.5	30	14	3	2.5	2	2.50	good	
Midvale	University - Heather Crest	A	0.25	4	2	64	12		18100	30	452.5	35	12	5	4.5	3	4.17	poor	
	Heather Crest - Regent	A	0.24	4	2	64	12		20700	30	517.5	35	12	5	4.5	3	4.17	poor	
	Regent - Mineral Pt	A	0.50	4	2	64	12		22550	30	563.8	35	12	5	4.5	3	4.17	poor	
	Mineral Pt - Tokay Blvd	A	0.50	4	2	64	12		19450	30	486.3	35	12	5	4.5	3	4.17	poor	
	Tokay Blvd - Odana	A	0.25	4	2	64	12		19100	30	477.5	35	12	5	4.5	3	4.17	poor	

A	B	C	D	E	F	G	H	I	J	K	M	N	O	Q	R	S	T	U
Street Name	Section	Street Class.	Segment Length	# of Lanes	Parking ?	Roadway Width	Curb Lane Width	Bike Lane or Shoulder	AWT	Posted Speed Limit	VPH/L	85th %ile Speed	Effective Curb Lane Width	Volume Index	Width Index	Speed Index	Index Average	Primary Compatibility Rating
	Odana - Yuma	a	0.30	4	2	64	12		20000	30	500	35	12	5	4.5	3	4.17	poor
	Yuma - Hammersley	a	0.48	4	2	64	12		17700	30	442.5	35	12	5	4.5	3	4.17	poor
	Hammersley - Ramp	a	0.14	6	0	74	13		24400	30	406.7	35	11	5	5	3	4.33	poor
Millis St	University - Johnson	c	0.07	2	0	36	18		4000	25	290	30	16	2.5	1	2	1.83	good
	Johnson - Dayton	c	0.08	2	1	36	14		5800	25	290	30	14	3.5	2.5	2	2.67	moderate
	Dayton - Regent	c	0.24	2	1	36	14		8750	25	437.5	30	14	5	2.5	2	3.17	moderate
	Regent - Milton	c	0.09	2	0	44	22		7300	25	365	30	20	4.5	1	2	2.50	good
	Milton - Mound	c	0.08	2	1	36	14		7800	25	390	30	14	4.5	2.5	2	3.00	moderate
	Mound - Drake	c	0.22	2	1	44	14		7800	25	390	30	14	4.5	2.5	2	3.00	moderate
	Drake - Erin	c	0.16	2	1	36	14		7800	25	390	30	20	4.5	1	2	2.50	good
	Erin - Wingra	c	0.32	2	0	44	22		7800	25	390	30	20	4.5	1	2	2.50	good
Milwaukee St	E Wash - Fair Oaks	a	0.85	2	2	38	11		12150	25	607.5	30	11	5	5	2	4.00	poor
	Fair Oaks - Walter (east bound)	a	0.15	2	1	44	14		21300	35	1065	40	20	5	2.5	4	3.33	poor
	Fair Oaks - Walter (west bound)	a	0.15	2	0	44	22		21300	35	1065	40	20	5	1	4	3.33	poor
	Walter - 23 W Ush 51	a	0.30	4	0	54	16		18200	35	455	40	14	5	2.5	4	3.83	poor
	23 W Ush 51 - 11 W Ush 51	a	0.12	4	0	56	16		18550	35	463.8	40	14	5	2.5	4	3.83	poor
	11 W Ush 51 - Ush 51	a	0.11	4	0	54	16		24700	35	617.5	40	14	5	2.5	4	3.83	poor
	Ush 51 - 07 E Ush 51	c	0.07	4	0	54	16		21700	35	542.5	40	14	5	2.5	4	3.83	poor
	07 E Ush 51 - Swanton	c	0.68	2	2	54	20		13050	35	652.5	40	20	5	1	4	3.33	moderate
	Swanton - Meadowlark	c	0.20	2	2	54	20		7200	35	360	40	20	4.5	1	4	3.17	moderate
	Meadowlark - Thompson	c	0.45	2	2	54	20		3300	35	165	40	20	2.5	1	4	2.50	good
	Thompson - I-90	c	0.18	2	0	21	10.5		1900	35	95	40	8.5	1.5	5	4	3.50	moderate
	I-90 - E CPL	c	0.43	2	2	2	10		1900	35	95	40	10	1.5	5	4	3.50	moderate
Mineral Point Rd	.25 W Pleasant View - Pl View	a	0.25	2	2	32	12		22200	55	1110	60	20	5	1	5	3.67	poor
	Pleasant View - E to CPL	a	0.40	2	2	32	12		22200	55	1110	60	20	5	1	5	3.67	poor
	11 West CPL - Ush 12	a	0.11	4	0	64	16		22200	40	555	45	14	5	2.5	5	4.17	poor
	Ush 12 - 06 E Ush 12	a	0.06	4	0	74	11		25100	40	627.5	45	9	5	5	5	5.00	very-poor
	06 E Ush 12 - Whitney Way	a	2.10	4	0	76	11		30800	40	770	45	22	5	1	5	3.67	poor
	Whitney Way - Racine	a	0.34	4	0	74	24		19900	40	497.5	45	22	5	1	5	3.67	poor
	Racine - Midvale	a	0.73	4	0	46	13		19350	30	483.8	35	11	5	5	3	4.33	poor
	Midvale - Speedway	a	0.63	4	0	46	13		20050	30	501.3	35	11	5	5	3	4.33	poor
Monona Dr	Cottage Grove - Frostwoods	a	2.00	4	0	48	13		22000	30	550	35	11	5	5	3	4.33	poor
	Frostwoods - Broadway	a	0.45	4	0	48	13		19350	30	483.8	35	11	5	5	3	4.33	poor
Monroe St	Odana - Leonard (no park side)	a	0.90	3	1	42	12		22600	30	753.3	35	12	5	4.5	3	4.17	poor
	Odana - Leonard (park side)	a	0.90	3	1	42	9		22600	30	753.3	35	13	5	3.5	3	3.83	poor
	Leonard - Edgewood (no park side)	a	0.18	3	1	42	12		20750	25	691.7	30	12	5	4.5	2	3.83	poor
	Leonard - Edgewood (park side)	a	0.18	3	1	42	9		20750	25	691.7	30	13	5	3.5	2	3.50	moderate
	Edgewood - Grant (no park side)	a	0.26	3	1	44	13		17550	25	585	30	13	5	3.5	2	3.50	moderate
	Edgewood - Grant (park side)	a	0.26	3	1	44	9		17550	25	585	30	14	5	2.5	2	3.17	moderate
	Grant - Regent (no park side)	a	0.24	3	1	44	13		14750	25	491.7	30	13	5	3.5	2	3.50	moderate
	Grant - Regent (park side)	a	0.24	3	1	44	10		14750	25	491.7	30	15	5	1	2	2.67	moderate
	Regent - Randall (no park side)	a	0.25	3	0	42	12		14650	25	488.3	30	10	5	5	2	4.00	poor
	Regent - Randall (park side)	a	0.25	3	1	42	9		14650	25	488.3	30	13	5	3.5	2	3.50	moderate
Moonland Rd	Rimrock - Badger La	c	0.28	2	1	38	15		5150	25	257.5	30	15	3.5	1	2	2.17	good
	Badger La - Foxwood	c	0.38	2	2	40	12		3100	25	155	30	12	2.5	4.5	2	3.00	moderate
	Foxwood - South Towne Dr	c	0.25	2	2	40	12		3100	35	155	40	12	2.5	4.5	4	3.67	poor
	South Towne - Lake Farm Rd	c	0.50	2	0	20	10		1350	30	67.5	40	8	1.5	5	4	3.50	moderate
Muir Field Rd	Raymond - McKe	c	1.25	2	2	44	14		2650	30	132.5	35	14	2	2.5	3	2.50	good
Nakoma Rd	Midvale - 07 E Midvale	a	0.07	2	0	48	24		8500	30	425	35	22	5	1	3	3.00	moderate

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Street Name	Section	Street Class.	Segment Length	# of Lanes	Parking	Roadway Width	Curb Lane Width	Bike Lane or Shoulder	AWT	Posted Speed Limit	VPH/L	85th %ile Speed	Effective Curb Lane Width	Volume Index	Width Index	Speed Index	Index Average	Primary Compatibility Rating
	.07 E Midvale - Seminole	a	0.47	2	2	43	13.5		8500	30	425	35	13.5	5	3	3	3.67	poor
	Seminole - Manitou	a	0.40	2	2	42	13		15150	30	757.5	35	13	5	3.5	3	3.83	poor
	Manitou - Spring Tr (north bound)	a	0.16	2	0	40	20		14600	30	730	35	18	5	1	3	3.00	moderate
	Manitou - Spring Tr (south bound)	a	0.16	2	1	40	12		14600	30	730	35	12	5	4.5	3	4.17	poor
	Spring Tr - Monroe	a	0.09	2	0	40	20		14600	30	730	35	18	5	1	3	3.00	moderate
	USH 51 - Walsh	c	0.37	2	0	40	20		2450	25	122.5	30	18	2	1	2	1.67	good
	Commercial - Johnson	c	0.25	2	2	42	13		4900	25	245	30	13	3	3.5	2	2.83	moderate
	Johnson - E Wash	c	0.23	2	2	42	13		8250	25	412.5	30	13	5	3.5	2	3.50	moderate
	Knutson - Kennedy	a	0.26	4	0	56	14		17850	35	446.3	40	12	5	4.5	4	4.50	poor
	Kennedy - Troy	a	1.00	4	0	56	14		25100	35	827.5	40	12	5	4.5	4	4.50	poor
	Troy - Packers	a	0.85	6	0	74	12		30050	35	500.8	40	10	5	5	4	4.67	very-poor
	Proudfit - John Nolen	a	0.42	4	0	56	14		18700	30	467.5	35	12	5	4.5	3	4.17	poor
	Gammon - Potomac	a	0.70	4	0	48	12		22400	30	560	35	10	5	5	3	4.33	poor
	Potomac - Research Park	a	0.30	4	0	52	14		22400	30	520	35	12	5	4.5	3	4.17	poor
	Research Park - S Whitney Way	a	0.73	4	0	44	12		20800	30	520	35	12	5	5	3	4.33	poor
	S Whitney Way - Segoe	a	0.12	4	0	54	14		18600	30	465	35	12	5	4.5	3	4.17	poor
	Segoe - Midvale	a	1.00	2	2	54	19		10400	30	520	35	19	5	1	3	3.00	moderate
	Midvale - Frederick	a	0.36	2	2	54	19		8300	30	415	35	19	5	1	3	3.00	moderate
	Frederick - Monroe	a	0.36	2	2	44	14		8200	30	410	35	14	5	2.5	3	3.50	moderate
	Mid Pt - Capital	c	0.62	2	0	22	11	6	4000	30	200	35	15	2.5	1	3	2.17	good
	Capital - Old Sauk	c	0.54	2	2	40	12		6700	30	335	35	12	4	4.5	3	3.83	poor
	Old Sauk - Whitney (east bound)	a	0.62	2	1	40	10		11850	30	592.5	35	15	5	1	3	3.00	moderate
	Old Sauk - Whitney (west bound)	a	0.62	2	0	40	12	4	11850	30	592.5	35	14	5	2.5	3	3.50	moderate
	Whitney - Eau Claire (east bound)	a	0.10	2	1	40	15		11450	30	572.5	35	15	5	1	3	3.00	moderate
	Whitney - Eau Claire (west bound)	a	0.10	2	0	40	17		11450	30	572.5	35	15	5	1	3	3.00	moderate
	Eau Claire - University	a	0.18	1	0	16	16		5950	30	595	35	14	5	2.5	3	3.50	moderate
	75 W Pleasant View - Pt View	a	0.75	2	2	22	11		2000	45	100	50	11	1.5	5	5	3.83	poor
	Pleasant View - Excelsior	a	0.62	2	2	24	12		2000	45	100	50	12	1.5	4.5	5	3.67	poor
	Excelsior - Highpoint	a	0.33	4	0	62	13	5	9950	35	248.8	40	16	3	1	4	2.67	moderate
	Highpoint - Westfield	a	0.57	4	0	54	10	6	9600	35	240	40	14	3	2.5	4	3.17	moderate
	Westfield - Old Sauk Ct	a	0.39	2	1	40	11	5	9650	35	482.5	40	16	5	1	4	3.33	moderate
	Old Sauk Ct - Old Middleton	a	1.17	2	1	40	11	5	10650	30	532.5	35	16	5	1	3	3.00	moderate
	Park - Gilson	a	0.30	2	2	44	14		7200	25	360	30	14	4.5	2.5	2	3.00	moderate
	Gilson - Wingra Creek	a	0.35	2	2	40	12		6900	25	345	30	12	4	4.5	2	3.50	moderate
	Wingra Creek - John Nolen	a	0.20	4	0	44	12		6900	35	172.5	40	10	2.5	5	4	3.83	poor
	Regent - Hillcrest	c	0.25	2	2	24	8		1400	25	70	30	8	1.5	5	2	2.83	moderate
	Hillcrest - Mineral Point	c	0.23	2	2	24	8		600	25	30	30	8	1	5	2	2.67	moderate
	Messerschmidt - City Limits	a	0.23	2	2	22	11	5	9700	45	485	50	16	5	1	5	3.67	poor
	City Limits - Darwin	a	0.53	2	0	22	11		11350	35	567.5	40	14	5	2.5	4	3.83	poor
	Darwin - Northport	a	0.07	2	0	26	13		13200	35	660	40	11	5	5	4	4.67	very-poor
	Northport - Aberg	a	1.00	6	0	74	13		36950	35	615.8	40	11	5	5	4	4.67	very-poor
	Aberg - Commercial	a	0.45	6	0	74	13		28250	35	470.8	40	11	5	5	4	4.67	very-poor
	Commercial - Pennsylvania	a	0.35	6	0	74	13		24600	35	410	40	11	5	5	4	4.67	very-poor
	Langdon - State St Mail	c	0.05	2	0	34	17		8450	25	422.5	30	15	5	1	2	2.67	moderate
	State Mail - University (northbound)	c	0.12	3	0	42	15	6	8450	25	281.7	30	19	3.5	1	2	2.17	good
	State Mail - University (southbound)	c	0.12	3	0	42	11		8450	25	281.7	30	9	3.5	5	2	3.50	moderate
	University - Johnson	a	0.08	4	0	52	11	6	14850	25	371.3	30	15	4.5	1	2	2.50	good
	Johnson - Dayton (northbound)	a	0.08	4	0	40	14		20350	25	508.8	30	12	5	4.5	2	3.83	poor
	Johnson - Dayton (southbound)	a	0.08	4	0	40	10		20350	25	508.8	30	8	5	5	2	4.00	poor

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Street Name	Section	Street Class.	Segment Length	# of Lanes	Parking	Roadway Width	Curb Lane Width	Bike Lane or Shoulder	AWT	Posted Speed Limit	VPH/L	85th %ile Speed	Effective Curb Lane Width	Volume Index	Width Index	Speed Index	Index Ave	Primary Compatibility Rating
Dayton - Spring	Spring - Fahrenbrook (northbound)	a	0.11	2	0	24	12		21550	25	1078	30	10	5	5	2	4.00	poor
Spring - Fahrenbrook	Spring - Fahrenbrook (southbound)	a	0.05	2	0	46	22		21550	25	1078	30	20	5	1	2	2.67	moderate
Fahrenbrook - Regent	Fahrenbrook - Regent	a	0.08	4	0	62	13		19150	25	478.8	30	11	5	5	2	4.00	poor
Regent - W Wash	W Wash - Fish Hatchery	a	0.30	6	0	74	13		21500	30	358.3	35	11	4.5	5	3	4.17	poor
Fish Hatchery - Wingra	Fish Hatchery - Wingra	a	0.53	4	2	68	16		44960	30	1124	35	16	5	1	3	3.00	moderate
Wingra - RR/Coop Dr. (north bound)	Wingra - RR/Coop Dr. (south bound)	a	0.13	4	1	64	12		25600	30	640	35	12	5	4.5	3	4.17	poor
RR/Coop Dr. - Badger Rd		a	0.13	4	0	64	12		25600	35	640	40	18	5	4	4	3.33	moderate
Paterson St		a	0.60	4	0	72	12	12	30550	35	763.8	40	22	5	1	4	3.33	moderate
Gorham - Johnson		c	0.15	2	2	38	11		1750	25	87.5	30	11	1.5	5	2	2.83	moderate
Johnson - Mifflin		c	0.15	2	2	38	11		2650	25	132.5	30	11	2	5	2	3.00	moderate
Mifflin - E Wash		c	0.05	2	2	38	11		4650	25	232.5	30	11	3	5	2	3.33	moderate
E Wash - Williamson		c	0.30	2	2	36	10		2450	25	122.5	30	10	2	5	2	3.00	moderate
Williamson - Jenifer		c	0.05	2	1	28	10		2800	25	140	30	10	2	5	2	3.00	moderate
Jenifer - Spaight		c	0.05	2	2	28	8		1500	25	75	30	8	1.5	5	2	2.83	moderate
Johnson - Packers		a	0.50	6	0	74	13		24200	35	403.3	40	11	5	4	4	4.67	very-poor
Monona - USH 51		c	0.84	2	2	44	14		13300	25	665	30	14	5	2.5	2	3.17	moderate
USH 51 - Mustang Way		c	0.70	2	2	44	14		13600	35	680	40	14	5	2.5	4	3.83	poor
Mustang Way - Vondron		c	0.20	4	0	64	16		13600	35	340	40	14	4	2.5	4	3.50	moderate
N CPL - Reider Rd		c	0.76	2	2	44	16		3650	30	182.5	35	16	2.5	1	3	2.17	good
Reider Rd - Parkside		c	0.74	2	2	44	16		4100	35	205	40	16	3	1	4	2.67	moderate
Parkside - E Wash (northbound)		c	0.07	3	0	44	24		4100	35	136.7	40	22	2	2	4	2.33	good
Parkside - E Wash (southbound)		c	0.07	3	0	44	13		4100	35	136.7	40	11	2	5	4	3.67	poor
Knollwood - Todd		c	0.30	2	2	44	16		2050	30	102.5	35	16	2	1	3	2.00	good
Todd - Fish Hatchery		c	0.74	2	2	44	16		4850	30	242.5	35	16	1.5	1	3	1.83	good
Hammersley - Raymond		c	0.51	2	2	44	16		1450	30	72.5	35	16	3	1	3	2.33	good
Raymond - Pilgrim		c	0.39	2	2	44	16		4200	30	210	35	16	3	1	3	2.33	good
Pilgrim - Putnam		c	0.20	2	2	44	16		2650	30	132.5	35	16	2	1	3	2.00	good
Putnam - Maple Grove Dr		c	0.75	2	2	44	16		4200	30	210	35	16	3	1	3	2.33	good
W Wash - Main		a	0.05	4	1	72	13		15100	30	377.5	35	13	4.5	3.5	3	3.67	poor
Main - North Shore		a	0.23	4	2	72	14		12650	30	316.3	35	14	4	2.5	3	3.17	moderate
McKenna - Prairie		c	0.63	2	2	32	8		2200	25	110	30	8	2	5	2	3.00	moderate
University - Johnson		a	0.04	4	0	40	10		8500	25	212.5	30	8	3	5	2	3.33	moderate
Johnson - Dayton		a	0.08	4	0	40	11		15500	25	387.5	30	9	4.5	5	2	3.83	poor
Dayton - Monroe (northbound)		a	0.10	4	0	40	21		18300	25	457.5	30	19	5	1	2	2.67	moderate
Dayton - Monroe (southbound)		a	0.10	4	0	40	11		18300	25	457.5	30	9	5	5	2	4.00	poor
Monroe - Spring		c	0.03	2	0	40	20		6700	25	335	30	18	4	1	2	2.33	good
Spring - Regent		c	0.13	2	1	32	11		6700	25	335	30	11	4	5	2	3.67	poor
Regent - St James		c	0.14	2	1	34	14		4300	25	215	30	14	3	2.5	2	2.50	good
St James - Drake		c	0.29	2	1	30	11		1900	25	95	30	11	1.5	5	2	2.83	moderate
87 W Gammon - 03 W Gammon		a	0.84	2	2	20	10		2250	45	112.5	50	10	2	5	5	4.00	poor
03 W Gammon - McKenna		a	0.62	2	0	20	10		6350	35	317.5	40	4	4	5	4	4.33	poor
McKenna - Westbrook		a	0.38	4	2	72	15		11900	35	297.5	40	15	3.5	1	4	2.83	moderate
Westbrook - Prairie		a	0.10	4	2	72	15		10950	30	273.8	35	15	3.5	1	3	2.50	good
Prairie - Whitney Way		a	0.61	4	2	68	14		12100	30	302.5	35	14	4	2.5	3	3.17	moderate
Whitney Way - Gilbert		a	0.15	4	2	72	14		8650	30	216.3	35	14	3	2.5	3	2.83	moderate
Gilbert - Verona		a	0.65	4	2	72	14		11600	30	290	35	14	3.5	2.5	3	3.00	moderate
Rosa - Mark Twain		c	0.08	2	2	56	20		1900	25	95	30	20	1.5	1	2	1.50	very-good

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Street Name	Section	Street Class.	Segment Length	# of Lanes	Parking	Roadway Width	Curb Lane Width	Bike Lane or Shoulder	AWT	Posted Speed Limit	VP/HL	85th %ile Speed	Effective Curb Lane Width	Volume Index	Width Index	Speed Index	Index Average	Primary Compatibility Rating
	Mark Twain - Whitney	c	0.42	2	2	44	14		2800	25	140	30	14	2	2.5	2	2.17	good
	Whitney - Eau Claire	c	0.27	2	2	44	14		3900	30	195	35	14	2.5	2.5	3	2.67	moderate
	Eau Claire - Segoe	c	0.48	2	2	44	14		4350	30	217.5	35	14	3	2.5	3	2.83	moderate
	Segoe - Midvale	c	0.17	2	2	44	14		5350	30	267.5	35	14	3.5	2.5	3	3.00	moderate
	Midvale - Meadow	c	0.07	2	1	46	15		4750	25	237.5	30	15	3	1	2	2.00	good
	Meadow - Blackhawk	c	0.18	2	2	36	10		4550	25	227.5	30	10	3	5	2	3.33	moderate
	Franklin - Farley	c	0.13	2	0	20	10		5200	25	260	30	8	3.5	5	2	3.50	moderate
	Farley - Highland/Speedway	c	0.26	2	0	24	12		5850	25	292.5	30	10	3.5	5	2	3.50	moderate
	Speedway - Prospect (no park side)	a	0.39	3	1	42	12		17350	25	578.3	30	12	5	4.5	2	3.83	poor
	Speedway - Prospect (park side)	a	0.38	3	1	42	11	3	17350	25	578.3	30	12	5	4.5	2	3.83	poor
	Prospect - Breese (no park side)	a	0.38	3	1	40	11		16000	25	533.3	30	11	5	5	2	4.00	poor
	Prospect - Breese (park side)	a	0.38	3	1	40	9	3	16000	25	533.3	30	12	5	4.5	2	3.83	poor
	Breese Ter - Monroe	a	0.05	4	0	48	12		25500	25	385	30	10	4.5	5	2	3.83	poor
	Monroe - Park (no park side)	a	0.58	3	1	48	11	5	25500	25	850	30	13	5	3.5	2	3.50	moderate
	Monroe - Park (park side)	a	0.58	3	1	48	11		25500	25	850	30	16	5	1	2	2.67	moderate
	Park - Murray	a	0.08	4	0	46	13		16450	25	411.3	30	11	5	5	2	4.00	poor
	Murray - W Wash (westbound)	a	0.30	4	0	54	19		16450	25	411.3	30	17	5	1	2	2.67	moderate
	Murray - W Wash (eastbound)	a	0.30	4	0	54	14		16450	25	411.3	30	12	5	4.5	2	3.83	poor
Rimrock	John Nolen - Expo Cntr	a	0.17	6	0	84	11.5	5.5	16250	35	304.2	40	14	4	1	4	3.00	moderate
	Expo Cntr - Burdette	a	0.63	4	0	58	11	5	13200	35	330	40	15	4	2.5	4	3.50	moderate
	Burdette - Maloney	a	0.40	2	2	28	11.5	2.5	6650	35	332.5	40	14	4	4	4	3.50	moderate
	Maloney - CTH MM	a	0.20	2	2	28	11	3	6650	35	332.5	40	14	4	2.5	4	3.50	moderate
Rogers	Spaight - Rutledge	c	0.06	2	0	30	15		1250	25	62.5	30	13	1.5	3.5	2	2.33	good
Rosa Rd	Old Middleton - Regent	c	0.48	2	2	40	12		4650	30	232.5	35	12	3	4.5	3	3.50	moderate
	Regent - Varsity	c	0.10	2	2	40	12		5250	30	262.5	35	12	3.5	4.5	3	3.67	poor
	Varsity - South Hill (Northbound)	c	0.14	2	2	40	12		5250	30	262.5	35	12	3.5	4.5	3	3.67	poor
	Varsity - South Hill (Southbound)	c	0.14	2	0	40	20		5250	30	262.5	35	18	3.5	1	3	2.50	good
	South Hill - Mineral Pt	c	0.25	2	0	40	20		6800	30	340	35	18	4	1	3	2.67	moderate
Rowley	Commonwealth - Spooner	c	0.14	2	1	30	11		1500	25	75	30	11	1.5	5	2	2.83	moderate
Rusk Ave, N	Koster - Mid Pt	c	0.08	2	0	24	12		80	25	4	30	10	1	5	2	2.67	moderate
Rutledge St	Rogers - Riverside	c	0.12	2	0	28	14		1800	25	90	30	12	1.5	4.5	2	2.67	moderate
	Riverside - Division	c	0.29	2	1	28	10		2700	25	135	30	10	2	5	2	3.00	moderate
Sawmill Rd	Westfield - Gammon	c	0.40	2	2	40	12		100	25	5	30	12	1	4.5	2	2.50	good
Schlingen	Sherman - Packers	c	0.44	2	2	36	10		2450	25	122.5	30	10	2	5	2	3.00	moderate
School Rd	Wheeler - Troy	c	1.00	2	2	36	10		1950	25	97.5	30	10	1.5	5	2	2.83	moderate
Schroeder Rd	Gammon - Chapel Hill	c	0.48	2	0	44	22		6300	35	315	40	20	4	1	4	3.00	moderate
Segoe Rd	Chapel Hill - Whitney Way	c	1.00	2	0	44	22		11300	35	565	40	20	5	1	4	3.33	moderate
	University - Sheboygan (northbound)	c	0.15	4	1	64	20		11550	30	288.8	35	20	3.5	1	3	2.50	good
	University - Sheboygan (southbound)	c	0.15	4	1	64	12		11550	30	288.8	35	12	3.5	4.5	3	3.67	poor
	Sheboygan - Regent	c	0.33	4	2	64	12		9150	30	228.8	35	12	2.5	4.5	3	3.50	moderate
	Regent - Odana	c	1.75	4	2	64	14		6900	30	172.5	35	12	2.5	4.5	3	3.33	moderate
Seminole Hwy	Nakoma - Manitou	c	0.26	2	1	36	14		8700	25	435	30	14	5	2.5	2	3.17	moderate
	Manitou - Beltline	c	0.35	2	0	36	12	6	8600	25	430	30	16	5	1	2	2.67	moderate
	Beltline Bridge	c	0.02	2	0	36	18		9150	25	457.5	30	16	5	1	2	2.67	moderate
	Beltline - City Limits	c	0.36	2	0	36	12	6	6400	25	320	30	16	4	1	2	2.33	good
Sheboygan Ave	Whitney Way - Segoe	c	0.55	2	2	42	13		7200	30	360	35	13	4.5	3.5	3	3.67	poor
Sheridan Dr	Woodward - Pleasure	c	0.43	2	2	32	8		500	25	25	30	8	1	5	2	2.67	moderate
	Pleasure - MacPherson	c	0.14	2	2	30	7		500	25	25	30	7	1	5	2	2.67	moderate
Sherman Ave	Breslay - Sidney	c	0.34	2	1	32	13		3850	25	192.5	30	13	2.5	3.5	2	2.67	moderate

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	Sidney - Marston (east bound)	C	0.10	2	0	34	12	14	6400	25	320	30	10	4	5	2	3.67	poor
	Sidney - Marston (west bound)	C	0.10	2	1	34	14	14	6400	25	320	30	14	4	2.5	2	2.83	moderate
	Marston - Thornton	C	0.13	2	0	34	17	17	6400	25	320	30	15	4	1	2	2.33	good
	Thornton - Lakewood Gardens	C	0.38	2	0	36	18	18	6400	25	320	30	16	4	1	2	2.33	good
	Lakewood Gardens - McGuire	C	0.17	2	0	36	18	18	4550	25	227.5	30	16	3	1	2	2.00	good
	McGuire - Fordem	C	0.15	2	2	44	14	14	4550	25	227.5	30	14	3	2.5	2	2.50	good
Sherman Ave. N	Fordem - Michigan	a	0.14	2	2	44	14	14	16500	30	825	35	14	5	2.5	3	3.50	moderate
	Michigan - RR	a	0.27	2	2	44	14	14	16800	30	840	35	14	5	2.5	3	3.50	moderate
	C & NW - Aberg	a	0.28	4	0	44	12	12	17500	30	437.5	35	10	5	5	3	4.33	poor
	Aberg - Northport	a	1.12	4	0	44	12	12	17450	30	436.3	35	10	5	5	3	4.33	poor
	Northport - Lakeview	C	0.44	2	2	44	14	14	8350	30	417.5	35	14	5	2.5	3	3.50	moderate
	Lakeview - 49 N Lakeview	C	0.49	2	2	44	14	14	7600	30	380	35	14	4.5	2.5	3	3.33	moderate
	49 N Lakeview - Wheeler	C	0.23	2	2	44	14	14	3650	35	182.5	40	14	2.5	2.5	4	3.00	moderate
	Wheeler - 21 N Wheeler	C	0.21	2	2	44	14	14	1500	35	75	40	14	1.5	2.5	4	2.67	moderate
Siggelkow Rd	W CPL - Mid Pt	C	0.17	2	2	20	10	10	300	35	15	40	10	1	5	4	3.33	moderate
	02 W Marsh - Marsh	C	0.02	2	0	21	10.5	10.5	300	35	15	40	8.5	1	5	4	3.33	moderate
	Marsh - E CPL	C	0.23	2	2	21	10.5	10.5	300	35	15	40	10.5	1	5	4	3.33	moderate
South Hill Rd	Rosa - Whitney	C	0.36	2	2	32	8	8	1650	25	82.5	30	8	1.5	5	2	2.83	moderate
	Whitney - Marathon	C	0.46	2	2	32	8	8	1550	25	77.5	30	8	1.5	5	2	2.83	moderate
	Marathon - Segpe	C	0.25	2	2	30	7	7	1550	25	77.5	30	7	1.5	5	2	2.83	moderate
South Towne Dr	Broadway - Bellline	a	0.23	6	0	80	11	11	19900	35	331.7	40	14	4	2.5	4	3.50	moderate
	Bellline - Industrial	C	0.15	4	0	54	14	14	12900	35	322.5	40	12	4	4.5	4	4.17	poor
	Industrial - RR	C	0.13	2	0	28	14	14	7050	35	352.5	40	12	4.5	4.5	4	4.33	poor
	RR - Moorland	C	0.47	2	0	32	16	16	7050	35	352.5	40	14	4.5	2.5	4	3.67	poor
Spaight St	Paterson - Baldwin (eastbound)	C	0.50	2	2	37	14	14	1950	25	97.5	30	14	1.5	2.5	2	2.00	good
	Paterson - Baldwin (westbound)	C	0.50	2	2	37	14	14	1950	25	97.5	30	14	1.5	2.5	2	2.00	good
	Baldwin - Dickinson (eastbound)	C	0.13	2	2	37	14	14	1350	25	67.5	30	14	1.5	2.5	2	2.83	moderate
	Baldwin - Dickinson (westbound)	C	0.13	2	2	37	14	14	1350	25	67.5	30	14	1.5	2.5	2	2.83	moderate
	Dickinson - Rogers (eastbound)	C	0.12	2	2	37	14	14	1350	25	67.5	30	14	1.5	2.5	2	2.00	good
	Dickinson - Rogers (westbound)	C	0.12	2	2	37	14	14	1350	25	67.5	30	14	1.5	2.5	2	2.83	moderate
Speedway	Mineral Pt. - Regent	a	0.71	4	0	48	13	13	21900	30	547.5	35	11	5	5	3	4.33	poor
Spooner St	Regent - Rowley	C	0.04	3	1	40	11	11	3450	25	115	30	11	2	5	2	3.00	moderate
	Bridge over RR tracks	C	0.04	2	0	20	10	10	3150	25	157.5	30	8	2.5	5	2	3.17	moderate
	Rowley - Monroe	C	0.20	2	0	24	12	12	3150	25	157.5	30	10	2.5	5	2	3.17	moderate
Spring Harbor Dr	University - Lake Mendota Dr	C	0.14	2	0	36	18	18	1650	25	82.5	30	16	1.5	1	2	1.50	very-good
Starker Ave	Acewood - Dondee	C	0.07	2	2	32	8	8	1000	25	50	30	8	1.5	5	2	2.83	moderate
Stewart St	Latham - Syene	C	0.42	2	2	40	12	12	4250	30	212.5	35	12	3	4.5	3	3.50	moderate
Stoughton Serv. W	Pflaum - Tompkins	C	0.26	2	1	32	12	12	835	25	417.5	30	12	1	4.5	2	2.50	good
Swanton Rd	Thompson - Milwaukee	C	0.41	2	2	44	14	14	8000	25	400	30	14	4.5	2.5	2	3.00	moderate
Sycamore Ave	Mendota - RR	C	0.20	2	0	24	14	14	300	25	15	30	12	1	4.5	2	2.50	good
	RR - Walsh	C	0.11	2	2	40	20	20	300	25	15	30	20	1	1	2	1.33	very-good
	Walsh - Wayridge	C	0.47	2	2	40	20	20	300	35	15	40	20	1	1	4	2.00	good
	Wayridge - Bultman	C	0.23	2	2	40	12	12	75	35	375	40	12	1	4.5	4	3.17	moderate
Syene Rd	Stewart - Post	C	0.24	2	2	22	11	11	3850	35	192.5	40	11	2.5	5	4	3.83	poor
	Post - 1 S to Mid Pt	C	0.10	2	2	22	11	11	3850	35	192.5	40	11	2.5	5	4	3.83	poor
Terminal Dr	USH 51 - McFarland CPL	C	1.00	2	2	24	12	12	4850	35	242.5	40	12	3	4.5	4	3.83	poor
	McFarland CPL - Siggelkow	C	1.00	2	2	24	12	12	4850	35	242.5	40	12	3	4.5	4	3.83	poor
Thierer Rd	E Wash - Lien	C	0.14	2	2	44	14	14	5050	25	252.5	30	14	3.5	2.5	2	2.67	moderate
Thompson Dr. N	CTH T - Swanton	C	0.17	4	0	50	13	13	11300	30	282.5	35	11	3.5	5	3	3.83	poor

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	Swanton - Divided (1 S of Swanton)	C	0.10	2	2	50	17		3850	30	192.5	35	17	2.5	1	3	2.17	good
	Divided - Milwaukee	C	0.69	2	2	40	12		2250	35	112.5	40	12	2	4.5	4	3.50	moderate
Thompson Dr, S	Cottage Grove - Buckeye	C	0.72	2	0	40	12		2600	25	130	30	12	2	4.5	2	2.83	moderate
Todd Dr	Beltline - McDivitt	C	0.12	2	0	32	16		5500	25	275	30	14	3.5	2.5	2	2.67	moderate
	McDivitt - 03 S Greenway	C	0.16	2	1	32	12		5500	25	275	30	12	3.5	4.5	2	3.33	moderate
	03 S Greenway - Post	C	0.34	2	2	36	10		3200	25	160	30	10	2.5	5	2	3.17	moderate
Tokay Blvd	Odana - Whitney Way	C	0.51	2	2	44	14		2700	30	135	35	14	2	2.5	3	2.50	good
	Whitney Way - Segoe	C	0.42	2	2	44	14		2650	25	155	30	14	2.5	2.5	2	2.33	good
	Segoe - Midvale	C	0.73	2	2	44	14		3100	25	132.5	30	14	2.5	2.5	2	2.33	good
	Midvale - Park Lane	C	0.43	2	2	44	14		3950	25	197.5	30	13	2.5	3.5	2	2.67	moderate
	Park Lane - Glen Dr	C	0.08	2	2	42	13		3200	25	160	30	13	2.5	5	2	3.00	moderate
Tompkins Dr	Monona - Camden	C	0.71	2	2	34	9		2600	25	130	30	9	2	5	2	2.83	moderate
	Camden - Stoughton Serv, W	C	0.06	2	2	32	8		2000	25	100	30	8	1.5	5	2	2.00	moderate
	Stoughton Serv, S - Seiferth	C	0.05	2	1	32	12		500	25	25	30	12	1	4.5	2	2.50	good
	Seiferth - Progress	C	0.24	2	2	36	10		500	25	25	30	10	1	5	2	2.67	moderate
Tree Ln	Mineral Pt - 16 N Mineral Pt	C	0.16	4	0	52	13		4100	30	102.5	35	11	2	5	3	3.33	moderate
	16 N Mineral - Gammon	C	1.02	2	2	40	12		2150	30	107.5	35	12	2	4.5	3	3.17	moderate
Troy Dr	Green - Hospital Dr	C	0.17	2	2	18	9		2250	25	112.5	30	9	2	5	2	3.00	moderate
	Hospital Dr - School Rd	C	0.60	2	2	40	12		2250	25	112.5	30	12	2	4.5	2	2.83	moderate
	School Rd - Northport	C	0.88	2	2	40	12		6500	25	325	30	12	4	4.5	2	3.50	moderate
	Northport - Hanover	C	0.05	2	0	40	20		2900	25	145	30	18	2	1	2	1.67	good
	Hanover - Sherman	C	0.25	2	1	32	12		2900	25	145	30	12	2	4.5	2	2.83	moderate
University Ave	WCPL - 04 W Allen	A	0.15	4	0	52	14		17400	35	435	40	12	5	4.5	4	4.50	poor
	04 W Allen - Heim (westbound)	A	0.10	4	0	65	15		6	35	733.8	40	19	5	1	4	3.33	moderate
	04 W Allen - Heim (eastbound)	A	0.10	4	0	65	14		6	35	733.8	40	18	5	1	4	3.33	moderate
	Heim - 09 W Capital (westbound)	A	0.41	4	0	65	15		29350	35	733.8	40	13	5	3.5	4	4.17	poor
	Heim - 09 W Capital (eastbound)	A	0.41	4	0	65	14		29350	35	733.8	40	12	5	4.5	4	4.50	poor
	09 W Capital - 03 W Spring	A	0.31	4	0	68	14		32750	35	818.8	40	12	5	4.5	4	4.50	poor
	03 W Spring H - Whitney Way	A	0.32	4	0	56	11		6	35	791.3	40	15	5	1	4	3.33	moderate
	Whitney Way - Old Middleton	A	0.47	4	0	48	13		26850	35	671.3	40	11	5	4	4	4.67	very-poor
	Old Middleton - Segoe	A	0.08	6	0	75	14		41550	35	692.5	40	12	5	4.5	4	4.50	poor
	Segoe - Farley	A	1.20	6	0	80	14		51750	35	862.5	40	12	5	4.5	4	4.50	poor
	Farley - Grand	C	0.14	1	0	15	15		7650	25	765	30	13	5	3.5	2	3.50	moderate
	Grand - Highland (westbound)	C	0.15	3	1	42	13		7650	25	255	30	13	3.5	3.5	2	3.00	moderate
	Grand - Highland (eastbound)	C	0.15	3	1	42	12		7650	25	255	30	12	3.5	4.5	2	3.33	moderate
	Highland - Allen	C	0.24	4	0	42	12		14500	25	362.5	30	10	4.5	5	2	3.83	poor
	Allen - Breese Ter	C	0.51	4	0	42	12		15100	25	377.5	30	10	4.5	5	2	3.83	poor
	Breese Ter - Campus Dr (westbound)	C	0.02	5	0	62	13		14100	25	282	30	11	3.5	5	2	3.50	moderate
	Breese Ter - Campus Dr (eastbound)	C	0.02	5	0	62	12		14100	25	282	30	10	3.5	5	2	3.50	moderate
University Bay Dr	Campus Dr - Bassett	C	1.00	3	0	34	13		29950	25	998.3	30	11	5	5	2	4.00	poor
	Willow - Haight	C	0.43	2	0	24	12		8250	25	412.5	30	10	5	5	2	4.00	poor
	Haight - Highland	C	0.18	2	0	30	15		8250	25	412.5	30	13	5	3.5	2	3.50	moderate
	Highland - Campus	C	0.74	2	0	33	16.5		8250	25	412.5	30	14.5	5	2	2	3.00	moderate
Verona Rd	Beltline - Service Rd	A	0.25	6	0	84	13		41650	40	694.2	45	11	5	5	5	5.00	very-poor
	Service Rd - Raymond	A	0.24	6	0	68	11		39700	40	661.7	45	9	5	5	5	5.00	very-poor
Voges Rd	Triangle - Marsh Rd	C	0.71	2	2	16	8		1990	30	99.5	35	8	1.5	5	3	3.17	moderate
Vondron Rd	Academy - Buckeye	C	0.32	2	2	32	8		750	25	37.5	30	8	1	5	2	2.67	moderate
	Buckeye - Thompson	C	0.41	2	2	44	14		4400	25	220	30	14	3	2.5	2	2.50	good
	Thompson - Pflaum	C	0.35	2	2	44	14		3600	35	180	40	14	2.5	2.5	4	3.00	moderate

A	B	C	D	E	F	G	H	I	J	K	M	N	O	Q	R	S	T	U
Street Name	Section	Street Class.	Segment Length	# of Lanes	Parking ?	Road way Width	Curb Lane Width	Bike Lane or Shoulder	AWT	Posted Speed Limit	VPH	85th %ile Speed	Effective Curb Lane Width	Volume Index	Width Index	Speed Index	Index Average	Primary Compatibility Rating
	Pflaum - World Dairy Rd	C	0.50	4	0	48	14	14	2300	35	57.5	40	12	1.5	4.5	4	3.33	moderate
	World Dairy Rd - Fernrite	C	0.26	2	2	24	12	12	2300	35	115	40	12	2	4.5	4	3.50	moderate
	Gifford Pinchot Dr - University	C	0.10	2	0	40	20	20	8000	25	400	30	18	4.5	1	2	2.50	good
	Walnut St	C	0.25	2	2	40	12	12	75	25	3.75	30	12	1	4.5	2	2.50	good
	Walsh Rd	C	0.46	2	2	36	10	10	6150	25	307.5	30	10	4	5	2	3.67	poor
	Waller St	C	0.19	2	1	36	14	14	6750	25	337.5	30	14	4	2.5	2	2.83	moderate
	Hargrove - Atwood	C	0.36	6	0	74	13	13	18400	30	306.7	35	11	4	5	3	4.00	poor
	Washington Ave (West)	A	0.18	6	0	94	16	16	24850	25	414.2	30	16	5	1	2	2.67	moderate
	Regent - Bedford	A	0.24	2	2	56	20	20	23400	25	1170	30	20	5	1	2	2.67	moderate
	Bedford - Broom	A	0.10	2	2	54	19	19	15100	25	755	30	19	5	1	2	2.67	moderate
	Broom - Henry	A	0.08	3	1	51	15	15	15100	25	503.3	30	15	5	1	2	2.67	moderate
	Henry - Fairchild (East Bound)	A	0.08	3	0	51	16	16	15100	25	503.3	30	14	5	2.5	2	3.17	moderate
	Henry - Fairchild (West Bound)	A	0.06	5	0	73	13	13	17150	25	343	30	11	4	5	2	3.67	poor
	Washington Ave (East)	A	0.06	5	0	73	20	20	17150	25	343	30	18	4	1	2	2.33	good
	Webster - Butler (eastbound)	A	0.13	6	2	82	12	12	23900	35	398.3	40	12	4.5	4.5	4	4.33	poor
	Butler - Franklin	A	0.06	6	1	78	13	13	25200	35	420	40	13	5	3.5	4	4.17	poor
	Franklin - Blair	A	0.06	6	1	82	13	13	42400	35	706.7	40	13	5	3.5	4	4.17	poor
	Blair - Ingersoll	A	0.65	6	2	82	13	13	43450	35	724.2	40	13	5	3.5	4	4.17	poor
	Ingersoll - First	A	0.74	6	2	82	13	13	38200	35	636.7	40	13	5	3.5	4	4.17	poor
	First - Sixth	A	0.60	6	2	82	13	13	41400	35	690	40	13	5	3.5	4	4.17	poor
	Sixth - Milwaukee	A	0.28	6	2	82	13	13	36300	35	605	40	13	5	3.5	4	4.17	poor
	Milwaukee - Johnson	A	0.10	6	2	82	13	13	39350	35	655.8	40	20	5	1	4	3.33	moderate
	Johnson - Marquette	A	0.30	6	0	72	22	22	39350	35	655.8	40	13	5	5	5	5.00	very-poor
	Marquette - Aberg (westbound)	A	0.30	6	0	72	13	13	39350	35	655.8	40	10	5	5	4	4.67	very-poor
	Marquette - Aberg (eastbound)	A	0.60	6	2	72	13	13	38500	35	593.3	40	13	5	3.5	4	4.17	poor
	Aberg - Wright	A	0.40	6	0	72	13	13	35600	35	641.7	40	11	5	5	5	5.00	very-poor
	Wright - USH 51	A	0.47	6	0	72	13	13	44600	40	743.3	45	11	5	5	5	5.00	very-poor
	USH 51 - Thierer	A	0.77	8	0	100	12	12	37050	40	463.1	45	10	5	5	5	5.00	very-poor
	Thierer - East Springs	A	0.50	8	0	100	12	12	32150	50	401.9	55	10	5	5	5	5.00	very-poor
	East Springs - I 90	C	0.49	2	1	32	12	12	4850	25	242.5	30	12	3	4.5	2	3.17	moderate
	Zeiler - Anniversary/Hayes	C	0.44	2	1	28	10	10	1500	25	75	30	10	1.5	5	2	2.83	moderate
	Milwaukee - Atwood	C	0.05	2	1	42	21	21	13300	25	665	30	21	5	1	2	2.67	moderate
	Dayton/Hamilton - Mifflin	C	0.09	2	2	42	13	13	13300	25	665	30	13	5	3.5	2	3.50	moderate
	E Wash - Main	A	0.07	3	1	44	11	11	10400	25	346.7	30	13	4	3.5	2	3.17	moderate
	Main - Doty/King	A	0.08	2	2	44	11	11	5	25	520	30	16	5	1	2	2.67	moderate
	Sawmill - Old Sauk	C	0.35	2	2	44	14	14	2900	25	145	30	14	2	2.5	2	2.17	good
	Old Sauk - Colony	C	0.55	2	2	44	14	14	4900	30	245	35	14	3	2.5	3	2.83	moderate
	Colony - Mineral Pt	C	0.58	2	2	44	14	14	5950	30	297.5	35	14	3.5	2.5	3	3.00	moderate
	School - Ilene	C	0.19	2	2	40	12	12	950	25	47.5	30	12	1	4.5	2	2.50	good
	Ilene - Delaware	C	0.20	2	2	40	12	12	4950	25	247.5	30	12	3	4.5	2	3.17	moderate
	Delaware - Sherman	C	0.60	2	2	44	14	14	4950	25	247.5	30	14	3	2.5	2	2.50	good
	Sherman - 14 E Sherman	C	0.14	2	0	20	10	10	4350	45	217.5	50	8	3	5	5	4.33	poor
	University - Old Middleton	A	0.16	4	0	68	17	17	14400	30	360	35	15	4.5	1	3	2.83	moderate
	Old Middleton - Regent	A	0.44	4	2	69	13	13	17100	30	427.5	35	13	5	3.5	3	3.83	poor
	Regent - South Hill	A	0.33	4	2	68	13	13	18650	30	466.3	35	13	5	3.5	3	3.83	poor
	South Hill - Mineral Pt	A	0.22	6	0	72	13	13	18850	30	314.2	35	11	4	5	4	4.00	poor
	Mineral Pt - Tokay	A	0.53	6	0	74	13	13	21500	35	358.3	40	11	4.5	5	4	4.50	poor
	Tokay - Odana	A	0.40	6	0	74	13	13	22950	30	382.5	35	11	4.5	5	3	4.17	poor
	Odana - .08 S Beltline	A	0.10	4	0	74	13	13	37600	30	940	35	11	5	5	3	4.33	poor

A	B	C	D	E	F	G	H	I	J	K	M	N	O	Q	R	S	T	U
Street Name	Section	Street Class.	Segment Length	# of Lanes	Parking	Road Width	Curb Lane Width	Bike Lane or Shoulder	AWT	Posted Speed Limit	MPH/L	%ile Speed	Effective Curb Lane Width	Volume Index	Width Index	Speed Index	Index Average	Primary Compatibility Rating
	.08 S Belline - Hammersley	a	0.52	4	2	64	12		22300	30	558.8	35	12	5	4.5	3	4.17	poor
	Hammersley - Raymond	a	0.52	2	2	48	16		13700	30	685	35	16	5	1	3	3.00	moderate
	Raymond - Kroncke	c	0.31	2	2	44	14		5250	30	262.5	35	14	3.5	2.5	3	3.00	moderate
Williamsburg Way	Kroncke - .09 S Kroncke	c	0.09	2	2	40	12		5250	30	262.5	35	12	3.5	4.5	3	3.67	poor
Williamsburg Way	Prairie Rd. - Verona Rd	c	0.25	2	2	44	14		2800	25	140	30	14	2	2.5	2	2.17	good
Williamson St	Wilson - Blair	a	0.04	4	0	44	12		9600	25	240	30	10	3	5	2	3.33	moderate
	Blair - Blount (westbound)	a	0.16	4	0	68	15		21100	25	527.5	30	13	5	3.5	2	3.50	moderate
	Blair - Blount (eastbound)	a	0.16	4	0	68	17.5		21100	25	527.5	30	15.5	5	1	2	2.67	moderate
	Blount - Baldwin (park side)	a	0.74	3	1	48	11	5	18950	25	631.7	30	16	5	1	2	2.67	moderate
	Blount - Baldwin (no park side)	a	0.74	3	1	48	13		18950	25	631.7	30	13	5	3.5	2	3.50	moderate
	Baldwin - Thornton (park side)	a	0.32	3	1	42	9	4	16550	25	551.7	30	13	5	3.5	2	3.50	moderate
	Baldwin - Thornton (no park side)	a	0.32	3	1	42	12		16550	25	551.7	30	12	5	4.5	2	3.83	poor
Wilson St	Bedford - Bassett	c	0.13	2	2	40	12		1250	25	62.5	30	12	1.5	4.5	2	2.67	moderate
	Bassett - Broom (eastbound)	a	0.13	2	1	40	14		6450	25	322.5	30	14	4	2.5	2	2.83	moderate
	Bassett - Broom (westbound)	a	0.13	2	1	40	18		6450	25	322.5	30	18	4	1	2	2.33	good
	Broom - Henry (eastbound)	c	0.13	3	0	40	14		8600	25	286.7	30	12	3.5	4.5	2	3.33	moderate
	Broom - Henry (westbound)	c	0.13	3	0	40	15		8600	25	286.7	30	13	3.5	3.5	2	3.00	moderate
	Henry - Martin Luther	c	0.21	2	2	40	12		8550	25	427.5	30	12	5	4.5	2	3.83	poor
	Martin Luther - King	c	0.20	2	2	40	12		6300	25	315	30	12	4	4.5	2	3.50	moderate
	King - Franklin (eastbound)	c	0.11	4	2	65	12		9600	25	240	30	12	3	4.5	2	3.17	moderate
	King - Franklin (westbound)	c	0.11	4	2	65	13		9600	25	240	30	13	3	3.5	2	2.83	moderate
	Franklin - Blair	c	0.07	4	2	58	12		9600	25	240	30	12	3	4.5	2	3.17	moderate
Wingra Dr	Mills - Fish Hatchery	c	0.56	2	2	36	10		9000	25	450	30	10	5	5	2	4.00	poor
	Fish Hatchery - Park	c	0.31	2	2	44	14		4750	25	237.5	30	14	3	2.5	2	2.50	good
Winnepago St	Williamson - Merry St	a	0.10	4	0	48	13		15400	25	385	30	11	4.5	5	2	3.83	poor
	Merry St - Atwood (eastbound)	a	0.25	3	0	42	13		9850	25	328.3	30	11	4	5	2	3.67	poor
	Merry St - Atwood (westbound)	a	0.25	3	0	42	9		9850	25	328.3	30	7	4	5	2	3.67	poor
	Atwood - E Wash	c	0.59	2	2	48	16		4250	25	212.5	30	16	3	1	2	2.00	good
	Bridge over Yahara	a	0.59	4	0	46	12		15400	25	385	30	16	4.5	5	2	3.83	poor
Wisconsin Ave	Langdon - Gorham	c	0.12	2	2	48	16		8050	25	402.5	30	16	5	1	2	2.67	moderate
	Gorham - Dayton	c	0.19	4	2	70	16		9950	25	248.8	30	16	3	1	2	2.00	good
Woodward Dr	Marcy - Sheridan	c	0.58	2	1	36	14		250	25	12.5	30	14	1	2.5	2	1.83	good
Wright St	Pierstorff - Kinsman	c	0.18	2	2	20	10		1500	25	75	30	10	1.5	5	2	2.83	moderate
	Kinsman - Divided	c	0.18	2	0	20	10		1500	25	75	30	8	1.5	5	2	2.83	moderate
	Divided - Anderson	c	0.20	4	0	64	16		4800	25	120	30	14	3	2.5	2	2.17	good
	Anderson - Straubel	c	0.21	4	0	54	16		8550	25	213.8	30	14	3	2.5	2	2.50	good
	Straubel - E Wash	c	0.29	2	0	32	16		8900	25	445	30	14	5	2.5	2	3.17	moderate
Yellowstone Dr	Blue Ridge - Inner Dr	c	0.20	2	2	32	8		2000	25	100	30	8	1.5	5	2	2.83	moderate
	Inner Dr - .05 S Gettysburg	c	0.16	2	2	32	8		2500	25	125	30	8	2	5	2	3.00	moderate
	.05 S Gettysburg - Offshore	c	0.15	2	2	32	8		1700	25	85	30	8	1.5	5	2	2.83	moderate
	Offshore - Mineral Pt	c	0.19	2	2	40	12		1900	25	95	30	12	1.5	4.5	2	2.67	moderate
Yuma Dr	Mineral Pt - Odana	c	0.40	2	2	40	12		4450	25	222.5	30	12	3	4.5	2	3.17	moderate
	Mohican - Midvale	c	0.10	2	2	30	7		500	25	30	30	7	1	5	2	2.67	moderate
	Midvale - Nakoma	c	0.42	2	2	30	7		2000	25	100	30	7	1.5	5	2	2.83	moderate
Zeiler Rd	E Wash - East Towne	c	0.05	4	0	52	14		13350	35	333.8	40	12	3	4.5	4	4.17	poor
	East Towne - .33 S East Towne	c	0.28	4	0	52	14		9800	35	245	40	12	3	4.5	4	3.83	poor
	.33 S East Towne - Lien	c	0.30	4	2	54	10		6200	35	155	40	10	2.5	5	4	3.83	poor

**APPENDIX D**

**BICYCLE COMPATIBILITY EVALUATION DATA SPREADSHEET  
FORMULAS**

10/19/00

Formulas for Bicycle Street Compatibility Evaluation										
Row #	K	L	M	N	O	P	Q	R	S	T
	VPH/L	85th %ile Speed	Effective Curb Lane Width	Volume Index	Width Index	Speed Index	Index Average	Primary Compatibility Rating		
6										
7		(7*0.1)/D7								
8										
9		(J9+5)								
10										
11			(G11+H11)							
12										
13				@IF(L13<=150.2,@IF(L13<=200.2,5,@IF(L13<=250.3,@IF(L13<=300.3,5,@IF(L13<=350.4,@IF(L13<=400.4,5,@IF(L13>400.5,L13))))))						
14										
15				@IF(N15<12.5,@IF(N15<13.4,@IF(N15<13.5,3.5,@IF(N15<14.3,@IF(N15<14.5,2.5,@IF(N15<15.2,@IF(N15>=15.1,N15))))))						
16										
17				@IF(M17<=25.1,@IF(M17<=30.2,@IF(M17<=35.3,@IF(M17>=40.4,@IF(M17>40.5,M17))))						
18										
19										
20										
21										@IF(S21<=1.5,"very-good",@IF(S21<=2.5,"good",@IF(S21<=3.5,"moderate",@IF(S21<=4.5,"poor",@IF(S21<=5,"very-poor",S21))))

Letters in the above formulas refer to spreadsheet columns (not shown) containing the data indicated below.  
 Numbers following letters simply indicate the row location of the data (all data taken from a single row).  
 Refer to the "Bicycle Compatibility Evaluation User Manual" for more detailed information.

- I = AWT, average weekday traffic
- D = number of lanes
- J = Posted (or statutory) speed limit
- E = whether or not parking is permitted
- G = Curb lane width (see User Manual for more detailed explanation)
- H = bike lane or shoulder width

**APPENDIX E**

**BICYCLE COMPATIBILITY EVALUATION DATA SPREADSHEET  
SHOWING AT-RISK STREET SEGMENTS FOR MADISON,  
WISCONSIN**



A	B	C	D	E	F	G	H	I	J	K	M	N	O	Q	R	S	T	U
Street Name	Section	Street Class.	Segment Length	# of Lanes	Parking ?	Road way Width	Curb Lane Width	Bike Lane or Shoulder	AWT	Posted Speed Limit	VPH/L	85th %ile Speed	Effective Curb Lane Width	Volume Index	Width Index	Speed Index	Index Average	Primary Compatibility Rating
<b>At Risk Street Segments: 100 vphpl will make segment poor compatibility</b>																		
Broom St	Doty - Wilson	a	0.05	3	0	40	14		7850	25	261.7	30	12	3.5	4.5	2	3.33	moderate
Fair Oaks Ave	Atwood - Dixon (north bound)	a	0.05	3	1	44	14		6800	25	226.7	30	14	3	2.5	2	2.50	good
Randall Ave	University - Johnson	a	0.04	4	0	40	10	0.04	8500	25	212.5	30	8	3	5	2	3.33	moderate
First St	Winnabago - Eastwood	a	0.07	3	0	37	12		6750	25	225	30	10	3	5	2	3.33	moderate
Williamson St	Wilson - Blair	a	0.04	4	0	44	12		9600	25	240	30	10	3	5	2	3.33	moderate
<b>Total:</b>																		
Allen St	Chadbourne - Regent	c	0.07	2	1	30	11		4200	25	210	30	11	3	5	2	3.33	moderate
Blackhawk Ave	Regent - Commonwealth	c	0.18	2	1	30	11		4900	25	245	30	11	3	5	2	3.33	moderate
Crystal Ln	University - Regent	c	0.50	2	2	36	10		4550	25	227.5	30	10	3	5	2	3.33	moderate
Farley Ave	Milwaukee - Acewood	c	0.11	2	2	32	8		4200	25	210	30	8	3	5	2	3.33	moderate
Glenway St	University - Kendall	c	0.14	2	2	36	10		4550	25	227.5	30	10	3	5	2	3.33	moderate
Hammersley Rd	Paunack - St Clair	c	0.30	2	1	32	12		5650	25	282.5	30	12	3.5	4.5	2	3.33	moderate
King St	.04 E Reetz - W Beltline Frt	c	0.09	4	0	40	10		4500	30	112.5	35	8	2	5	3	3.33	moderate
Lake Farm Rd	Doty - Wilson (inbound)	c	0.08	3	1	40	11		6100	25	203.3	30	11	3	5	2	3.33	moderate
Marquette St	Moorland - Libby	c	0.32	2	0	20	10		700	35	35	40	8	1	5	4	3.33	moderate
Paterson St	E Wash - Milwaukee	c	0.32	2	2	30	7		4400	25	220	30	7	3	5	2	3.33	moderate
Regent St	Miffin - E Wash	c	0.05	2	2	38	11		4650	25	232.5	30	11	3	5	2	3.33	moderate
Segoe Rd	Meadow - Blackhawk	c	0.18	2	2	36	10		4550	25	227.5	30	10	3	5	2	3.33	moderate
Sherman Ave. N	Regent - Odana	c	1.75	4	2	64	12		6900	30	172.5	35	12	2.5	4.5	3	3.33	moderate
Siggelkow Rd	Wheeler - 21 N Wheeler	c	0.21	2	2	44	14		1500	35	75	40	14	1.5	2.5	4	2.67	moderate
Siggelkow Rd	.02 W Marsh - Marsh	c	0.02	2	0	21	10.5		300	35	15	40	8.5	1	5	4	3.33	moderate
Stewart St	Marsh - E CPL	c	0.23	2	2	21	10.5		300	35	15	40	10.5	1	5	4	3.33	moderate
Todd Dr	Latham - Syene	c	0.42	2	2	40	12		4250	30	212.5	35	12	3	4.5	3	3.50	moderate
Tree Ln	McDwitt - .03 S Greenway	c	0.16	2	1	32	12		5500	25	275	30	12	3.5	4.5	2	3.33	moderate
University Ave	Mineral Pt. - 16 N Mineral Pt	c	0.15	3	1	42	13		4100	30	102.5	35	11	2	5	3	3.33	moderate
Wilson St	Grand - Highland (eastbound)	c	0.15	3	1	42	12		7650	25	255	30	12	3.5	4.5	2	3.33	moderate
	Broom - Henry (eastbound)	c	0.13	3	0	40	14		8600	25	286.7	30	12	3.5	4.5	2	3.33	moderate
<b>Total Secondary At Risk Segments</b>																		
<b>5.82</b>																		

Approved By

Evelyn A Howell

Date

August 21, 1996