The University of Manitoba

THE RATIONALE FOR PROVIDING AND PLANNING URBAN BIKEWAYS

by

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ABSTRACT

This paper examines the basis on which urban bikeways are presently planned in North America, and applies the reviewed principles to an investigation of the feasibility of a bikeway system for the city of Winnipeg.

The need for urban bikeways is examined in light of recent trends in bicycle use and considerations of bicycle safety. The planning of bikeways is studied from the conceptual stages to the details of design and construction. The questions of cost, financing and public participation in bikeway planning are discussed as parts of the broad topic of bikeway system implementation.

An investigation of the feasibility of a bikeway system for the city of Winnipeg is conducted as a case study. Bicycle use trends and bicycle accident statistics are used to identify the need for a bikeway system in Winnipeg. A preliminary bikeway system plan is evolved, and implementation possibilities are examined.

PREFACE

This thesis has been written as much from the viewpoint of a cyclist as from that of a planner. For more than ten years in Winnipeg the bicycle has been my major means of transportation for seven months of each year. Living in Copenhagen for three months, and cycling on bikeways in Denmark, France, Belgium, Holland and Germany increased my interest in the topic of bikeway planning.

My thanks are due to Dr. D. Styliaris, Prof. B. Rotoff and Dr. A. H. Soliman for their encouragement and help as I wrote this thesis, as well as to those agencies (too many to enumerate here) which provided me with the reports and data on which this thesis is based.

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INTRODUCTION

For several years the bicycle has been enjoying renewed popularity in North America. Adult use of the bicycle for both transportation and recreation has been increasing, as have accidents and fatalities involving bicycles. In response to these phenomena, many urban areas in North America have begun providing special facilities for bicycles in the form of bikeways.

The first part of this paper examines the concept of bikeways as it presently exists in North America. The reasons for which a need for bikeways has been perceived, the concepts and details of bikeway planning, and the ways in which bikeways are implemented, are all investigated.

In the second part of this paper a case study is presented; the ideas of the first part are applied to an investigation of the feasibility of a bikeway system for the City of Winnipeg. The need for bikeways is studied, a preliminary bikeway system design is evolved, and implementation possibilities are examined.

PART ONE:

BIKEWAYS: COMPILATION OF AVAILABLE LITERATURE

Chapter 1

THE NEED FOR BIKEWAYS

A. HISTORICAL PERSPECTIVE

During the eighteenth century in Europe several inventions variously labelled Celeriferes, Accelerators and Celeripedes were developed. All of these placed a rider astride a longitudinal bar supported by a front and back wheel, and were propelled and steered by the rider's feet. In 1816 Baron Karl von Drais invented the Draisine, which embodied the valuable improvement of a swivelling front wheel, and could be steered by an upright handlebar. In 1839 Kirkpatrick MacMillan developed a system of pedals, connecting rods and cranks which enabled the rider to propel his machine with his feet off the ground.

In 1865, however, the bicycling era really began, as Pierre Michaux in Paris built the first Velocipede, equipping its front wheel with foot-powered cranks. These machines became popular, and to increase their limited speed, front wheels were gradually enlarged to as much as five feet in diameter. The resulting high-wheeled "ordinary" or "penny-farthing" bicycles were extremely popular in both England and the United States.

In 1885 the "safety" bicycle with two wheels of equal size was introduced in Britain. By 1893 the addition of pneumatic tires, roller chain drive, and the "diamond" frame resulted in a bicycle essentially similar in form to that in use today. By the turn of the century the high-wheeler was almost completely supplanted.[1]

In the 1890s bicycling reached its peak. It was enormously popular, and in the United States bicyclists, organized into the group of American Wheelmen, demanded and obtained improved smooth roads, lighted streets in urban areas, and street name signs at intersections. Bicycle repair shops and hotels catering to bicyclists were widely distributed. The popularity of cycling even contributed to the emancipation of women, increasing their mobility and freedom from restrictions as well as revolutionizing their clothing.

After 1900 the infant automobile industry was able to make use of the experience in mass-production technology and of the system of roads and other facilities developed for the bicycle. In the first two decades of the twentieth century the ongoing development and growing popularity of the automobile led gradually to the almost complete elimination of the bicycle as a transportation mode in North America. There were brief increases in bicycle use for low cost transportation during the Depression and the two World Wars, when fuel and other resources were scarce. Until the

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[1] "A Bit of Bicycle History," Windsor Bikeways, April, 1973, p. 3.

late 1960s however, the bicycle in North America was primarily a children's toy, serving as transportation and recreation for those not yet old enough to drive an automobile.[2]

In other parts of the world, due primarily to economic factors, the bicycle has retained its importance as a form of urban transportation. In the less developed nations of Africa and Asia, for example, it is still one of the dominant modes of transportation. In Great Britain and some British-influenced areas, as well as in most of Europe, bikeways to serve work and other trips were often provided separately from motor vehicle roadways until after the Second World War. Even now, the bicycle is an integral part of the transportation system of many cities in Europe. In Copenhagen, Denmark 18 percent of total trips are made by bicycle. In Uppsala, Sweden the proportion is 20 percent, while in Rotterdam, Holland it is 43 percent of all traffic. In many British New Towns, too, the bicycle is important for transportation. In Stevenage, for example, one-third of all commuting is done by bicycle or on foot, and cyclists comprise 10 percent of total traffic.[3] In

[2]G. Fisher and others, Bikeway Planning Criteria and Guidelines (Los Angeles: Institute of Transportation and Traffic Engineering, University of California, 1972), pp. 5-6.

[3]A. Trent Germano and others, "The Emerging Needs of Bicycle Transportation," Highway Research Record, Number 436 (1973), p. 16.

almost all such cities with high bicycle use, separate rights of way are provided for bicycles and motor vehicles.

While the status of the bicycle declined in North America, bicycle technology continued to advance in Europe. Lightweight, multi-geared bicycles capable of being propelled at high speeds in all kinds of terrain were developed. The discovery of these European 10-speed bicycles by North Americans was a major cause of the resurgence of bicycling on this continent. During the late 1960s and early 1970s there was a bicycle boom in North America. Bicycle sales increased phenomenally, as did their use for both recreation and transportation, particularly among adults.

B. ADVANTAGES AND DISADVANTAGES OF THE BICYCLE TODAY

1. Urban Transportation

Lightweight, multi-speed bicycles are now available which make it possible to maintain average speeds of 10 to 20 mph and to climb hills without unreasonable effort. The bicycle is thus a viable form of transport for short trips up to at least 6 miles in length. It is characterized by mechanical reliability as well as extremely low capital and operating costs, and requires minimal storage space.

As North American cities become more and more congested with traffic, and parking spaces become scarcer and more expensive, alternatives to the automobile are sought by increasing numbers of people particularly for commuting.

Use of the bicycle has certain advantages over use of public transport, in that it is cheaper and more flexible. During fair weather, cycling can of itself be a pleasant activity. Public transit systems, moreover, are not particularly well-developed in many North American cities. The bicycle thus has many of the automobile's advantages for personal transport, without the severe disadvantages that are becoming so evident in today's cities. A high percentage of commuting could conceivably be done by bicycle, since the mean work-residence travel distance in the United States is estimated as between 5 and 6 miles.[4]

Besides the advantages of economy and flexibility, use of the bicycle can result in time savings for commuters.

> A comparison of the time-distance trade-off between bicycle and automobile commuting under conditions that are believed to be typical shows that a bike may be directly competitive with an automobile on a strict time-of-travel basis for distances of from one to four miles.[5]

During peak hours the average speed of motor vehicles in many cities is only 10 mph.[6] Cyclists on their small, highly-manoeuvrable vehicles, however are little affected by traffic jams. They also have no need to reach and start parked cars, or to catch buses. The result is that when

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[4] Bicycling! June 1974, p. 61.

[5] James P. Hamill, Planning and Development of Bikeway Systems (Management Information Service, April 1973), p. 2.

[6] Germano, p. 10.

experiments have taken place in Chicago, Washington, Boston and Atlanta involving races between bicycles, cars and mass transit, the cyclist has always been the easy winner, with the car driver next and transit rider third.[7]

The use of the bicycle for commuting results in benefits for society as a whole as well as for the individual. Since there is some direct trade-off between bicycle and automobile commuting, more use of bicycles will reduce the rate of growth of demand for additional roads and parking facilities. Bicycles occupy one-sixteenth the space of automobiles and a bicycle path constructed over raw land (where rough grading is required) costs approximately one-tenth as much as a secondary road.[8] Compared to the large sums of money required to provide for the automobile, the cost of providing facilities for bicycles is very low.

To some extent, the growing popularity of the bicycle for urban transport can also be seen as a result of the environmental movement. Much of the hydrocarbon, carbon monoxide and nitrogen oxides pollution of the air in North American cities is the result of automobile traffic. Cycling is the only form of vehicular transportation which does not create any air or noise pollution.

Unfortunately the bicycle also has its drawbacks as

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[7]Hamill, p. 2; Germano, p. 10.

[8]Hamill, p. 2.

an urban transportation mode. Chief among these is its severe seasonal limitation, where climate is not mild year round. Since most people find cycling pleasant only in fair weather, the bicycle as a transportation mode is very sensitive to weather conditions, and therefore inherently somewhat unreliable. Surprisingly, however, it has been observed that rainy or otherwise inclement weather has very limited effects in reducing utility-oriented bicycling during the cycling season.[9] Cities such as Copenhagen, Rotterdam, and Uppsala in Northern Europe are noted for high bicycle use throughout the year, although their climate is not particularly mild or dry. There are also a few dedicated cyclists who use their bicycles for transportation throughout the year, even where winters are as cold as in Winnipeg. Furthermore, human-powered vehicles, descendants of the bicycle, have been developed which enclose the rider, thus protecting him to some extent from the elements. Nevertheless, for the forseeable future, bicycles must probably be regarded as a seasonal mode of transportation in most parts of North America.

Other drawbacks to the use of the bicycle for urban transport arise not from the inherent limitation of the bicycle, but rather from the nature of the environment in

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[9]De Leuw, Cather and Company, Bicycle Circulation and Safety Study (City of Davis, California, August 1972), p. 8; W. Strok and Associates Limited, Bikeway System Within Metropolitan Toronto (Municipality of Metropolitan Toronto, April 1974), pp. 26, 29.

which it must function. Cities in North America are not designed for bicycle use, and they are unsafe for cyclists. Bicycles must share streets with automobiles which do not always respect their vehicular rights. Cyclists are usually relegated to edges of streets, where pavement tends to be in poor condition and littered with all kinds of debris.

Cyclists do not contribute to noise and air pollution, but they are adversely affected by it. Not being enclosed like automobile drivers, cyclists are exposed directly to automobile emissions of hydrocarbons and carbon monoxide as well as to photochemical oxidants produced in the atmosphere from the hydrocarbons acted on by solar emissions. Pollution levels during rush hours on major streets in cities are in some cases high enough to cause physiological effects such as decreased reaction time and slight dilation of the eye pupil, and may even result in headache and nausea.[10]

All in all, there are factors which can make commuter cycling in urban areas decidedly unpleasant. Many of these factors are a result of the incompatibility between bicycles and motor vehicles, when these two modes of transport are forced to share the same streets.

2. Energy

In North America automobiles account for over half

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[10] "Pollution: The Cyclist's Hazard," Windsor Bikeways, April 1973, p. 13; Hamill, p. 2.

of transportation energy demand. This amounts to 14 percent of total energy use and to over 25 percent of all petroleum products consumed. 90 percent of trips, and 14 percent of the miles travelled by automobile are short journeys--less than five miles in length.[11]

The bicycle is a very viable form of transportation for trips up to about 5 miles in length, given appropriate climatic conditions. The bicycle demands very little energy in comparison to other modes of transportation: 200 BTU per passenger mile as compared to the typical averages of 4000 BTU per passenger mile for mass transit and 7900 BTU per passenger mile for the urban auto.[12] The energy used by the cyclist is in the form of food, that by the automobile in the form of gasoline.

Since it is now generally accepted that rising petroleum prices and shortages in the future are inevitable, it is interesting to speculate on the amount by which increased bicycle use could reduce petroleum consumption. The 14 percent of total auto travel accounted for by trips of 5 miles or less amounted to 41.3 billion passenger-miles in the United States in 1971.[13] It has been estimated that given favourable conditions including better bicycle

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[11]Eric Hirst, "Cycling for Energy Conservation," Bicycling! June 1974, pp. 48-49.

[12]Mechanical Engineering, May 1975, p. 36.

[13]Hirst, p. 49.

facilities such as bikeways, secure and well-located bike parking, locker rooms and showers for commuters, as well as auto disincentives in the form of higher fuel prices and taxes and restricted auto parking, perhaps 25 percent of short automobile trips might become bicycle trips.[14] This may be an overly optimistic figure. In any case it would mean 10.3 billion passenger-miles per year occurring on bicycles rather than cars, resulting in an energy saving of 81.4 trillion BTU or some 14 million barrels of oil. This is an amount of oil worth $182 million, at the international oil price of about $13 per barrel. As a percentage of total petroleum consumption in the United States, however, the saving is relatively small, amounting to roughly 0.875 percent. In Canada, with its harsher climate and generally superior mass transit in urban areas, a petroleum consumption reduction of one half of one percent might be possible. This would be about one million barrels of oil, worth $13 million annually. It must be noted that these estimates are very rough indeed, but do give some approximate idea of the magnitude of possible energy savings with which we are dealing.

The lower external costs for street and parking construction, as well as for noise and air pollution and medical treatment, which would result from increased bicycle use replacing automobile use, have not been included in

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[14] Darryl Skrabak, "Bike Law," Bicycling! February 1976, pp. 51-52.

the above calculations. Further, it should be noted that to produce an automobile, energy and resource inputs 100 times as great as those for producing a bicycle are required.[15] Nevertheless it is obvious that shifting traffic from cars to bicycles will not solve the problems of urban transportation and future petroleum shortages.

3. Recreation and Exercise

In the United States, a country which has become increasingly oriented to outdoor recreation, the Bureau of Outdoor Recreation has reported cycling as the fastest growing recreational activity.[16] Cycling has many attractive characteristics. It is relatively inexpensive (in comparison to other forms of outdoor recreation such as golf, boating and camping) requiring only a small initial expenditure and very little maintenance. It is possible to cycle almost anywhere, and residential areas are often particularly suitable. No elaborate equipment or plans made ahead of time are required. Cycling is extremely flexible and can occur for as long or short a time period as desired, whenever the weather is suitable.

In groups or individually, cycling can be enjoyed by anyone, at any level of proficiency, as special skills or long practice are not necessary to enjoy this activity. As Fox, a Washington cardiologist has said:

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[15] Hamill, p. 2.

[16] Germano, p. 10.

> It takes a long time before previously sedentery persons can gain the skill really to enjoy tennis or downhill skiing, and by that time many of them have given it up. Almost anyone can learn to ride a bicycle which allows him to view his surroundings in leisurely perspective and gives him exercise at the same time.[17]

Cycling is an excellent form of exercise, ranking third behind running and swimming as the best all around exercise. Cardio-vascular circulation and muscular efficiency are increased. Up to 1200 calories per hour can be burned by cycling. White, the famous heart specialist who has done much to promote cycling for physical fitness reasons, has provided abundant evidence of the health benefits of bicycling:

> For people from 50 to 95 cycling helps prevent the hardening of the arteries and high blood pressure so common to this age group.[18]

Another reason why cycling is becoming increasingly popular as a way to acquire and maintain physical fitness is that it is an enjoyable activity which need not be solely exercise-motivated, as it can also fulfill transportation and recreation needs. Cycling also tends to be less monotonous than other forms of exercise such as jogging, running in place, isometrics and so on.

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[17] Noel Grove, "Bicycles are Back---and Booming!" National Geographic, May 1973, p. 676.

[18] R. Seypka, The Scarborough Bicycle Pathway System (Scarborough: Pollution Probe Scarborough, 1972), p. 4.

C. RECENT TRENDS IN BICYCLE USE

1. Sales

Bicycle sales, particularly to adults, have been increasing at a phenomenal rate in North America. In the United States annual sales rose from an estimated 8 or 8.5 million in 1971 to over 14 million in 1973, exceeding sales of the automobile. Adult bicycles account for over half of total bicycle sales in recent years, and of these the greatest portion are 10-speed models.[19]

In Canada too, bicycle sales have been increasing rapidly. From Figure 1 it can be seen that the large sales increase is in adult bicycles and that sales of children's bicycles have not been increasing significantly.

The continuous increase in adult bicycle ownership by Canadians is also evident from Table 1 below:

Table 1

Canadian Households with Adult-Size Bicycles
(estimates in thousands)

Year	Total Households	Households with Adult-Size Bicycles	
		one or more	two or more
1972	6,108	1,704 (27.9%)	686 (11.2%)
1973	6,266	1,825 (29.1%)	765 (12.2%)
1974	6,493	1,971 (30.4%)	830 (12.8%)
1975	6,703	2,266 (33.8%)	1,018 (15.2%)

Information: Statistics Canada, Household Facilities and Equipment, Cat: 64-202, 1972, 1973, 1974, 1975.

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[19] Dan Smith, Bikeways: State of the Art 1974 (San Francisco: De Leuw, Cather and Company, July 1974), p. 1.

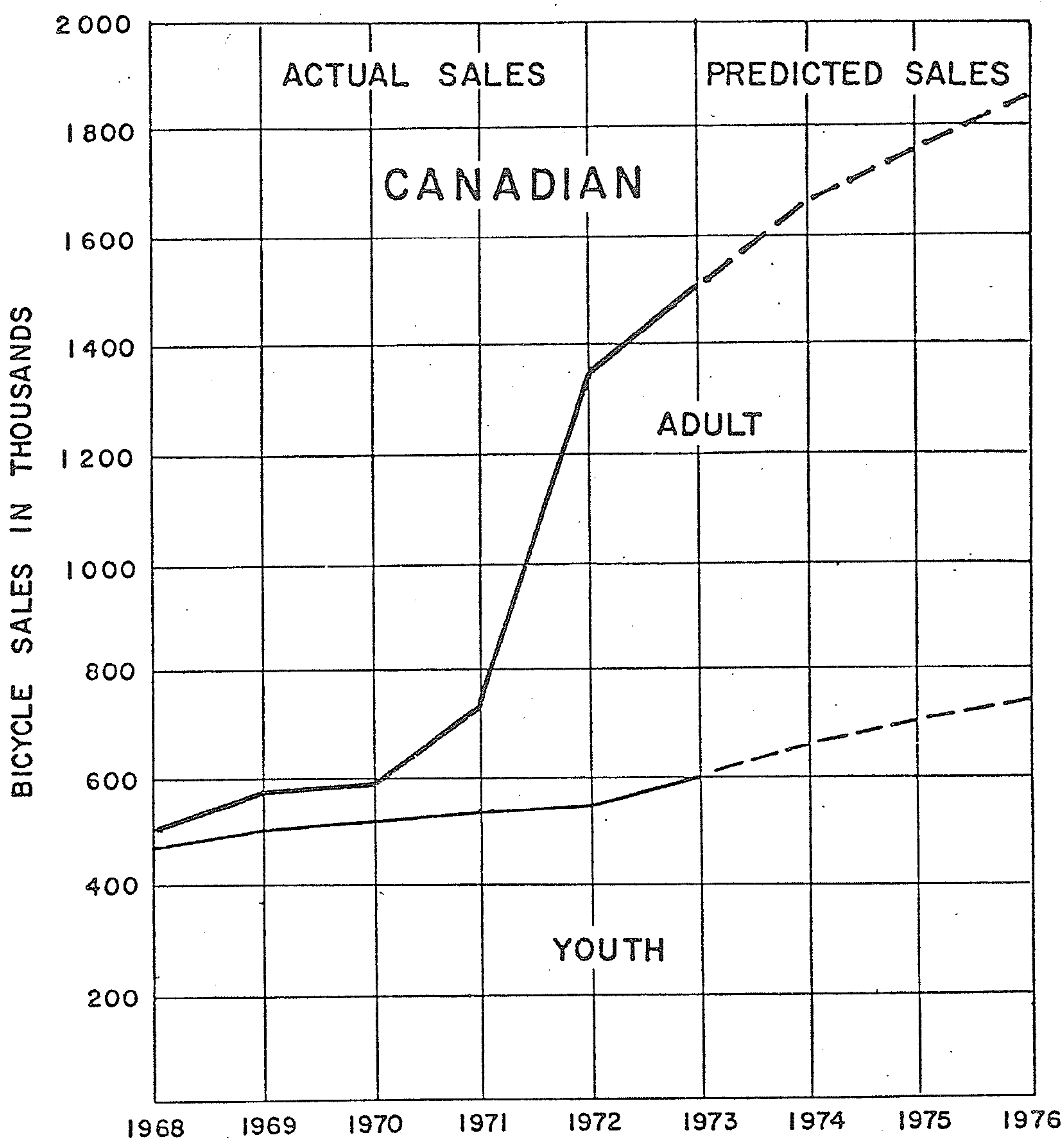

FIGURE 1. CANADIAN BICYCLE SALES

SOURCE: ONTARIO MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, A REVIEW OF THE MINISTRY'S POSITION WITH RESPECT TO BICYCLING (ROUTE PROJECTS PLANNING OFFICE, OCTOBER 1974), P.6.

2. Patterns of Bicycle Use

Bicycle use is increasing rapidly. In 1974 it was estimated that there were 100 million active cyclists in the United States, a sharp increase over the 1958 estimate of some 50 million.[20] In Canada the estimated number of bicycles in use rose from 2.5 million in 1968 to 6 million in 1972.[21]

Not only is bicycle use increasing, the patterns of bicycle use are changing. In large part this can be attributed to the development of the lightweight 10-speed bicycle, which has been available only since about 1960, and has been in widespread use since 1967.[22] Before this time, the bicycle in North America was primarily a children's plaything. It was also used to a certain extent for transportation by children and adolescents who did not have access to automobiles, and for recreation or exercise by a limited number of adults. Now however, the availability of bicycles which can cope with hills and wind force, and which can easily attain average speeds of 10 to 15 mph on level ground for long periods of time, has made the bicycle a viable alternative mode of transportation.

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[20] Ibid.

[21] Ontario Ministry of Transportation and Communications, A Review of the Ministry's Position with Respect to Bicycling (Route Projects Planning Office, October 1974), p. 4.

[22] Fisher, p. 1.

3. Transportation

Without benefit of subsidy or any special facilities, bicycles during the early 1970s emerged as a significant "new" mode of urban transportation in North America. There has been phenomenal growth in commuter bicycling in many cities, both large and small. This has been particularly evident in cities with acute traffic problems, as for example Chicago, New York, San Francisco and Washington, D.C.[23]

Davis, California, a city of 27,000 (in 1972) and site of one of the seven campuses of the University of California, is a famous example of the American bicycle renaissance. The bicycle there is an essential element of the total transportation system. Over 20,000 bicycles are owned by a population of 27,000, and some 30 percent of total person trips are made by bicycle.[24]

The in North America unparalleled importance of the bicycle as a major transportation element in Davis is a result of a number of factors. The mild climate and level terrain are significant. The layout of the city itself with its wide streets and relatively small area, and its nature as a closely defined and rather self-sustained community, also serve to make the bicycle a viable form of transport. The high proportion of young adults in the population as a consequence of the presence of the uni-

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[23]Hamill, p. 2. [24]De Leuw, pp. 3, 4.

versity campus is also significant. Probably the most important of all factors promoting the bicycle as a viable form of transport has been the attitude of Davis residents, and the foresight of city officials in providing facilities for bicycles during the 1960s. In 1966 the City of Davis introduced the concept of on-street lanes exclusively for bicycles to the United States. An areawide system of bicycle facilities, including on-street lanes, separate pathways, grade separations, streets closed to motor vehicles, and greenbelt trails, was developed.[25]

In other surveys of bicycle use in the United States, high proportions of transportation use were found. In Lexington, Kentucky, for example, 34 percent of bicycle trips are to school, university or work, while 15 percent are for shopping. In California 23 percent of bicycle trips were found to be for shopping, another 23 percent for work, and 14 percent for school, with the remaining 40 percent being for recreation.[26]

A typical picture of urban bicycle use in North America is provided by Toronto. Tables 2 and 3 below, as well as Figures 2 and 3 summarise the results of a

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[25]Ibid.

[26]Nina Dougherty, "The Bicycle as it Relates to the Energy Crisis," <u>Proceedings of the Seminar on Bicycle/Pedestrian Planning and Design: December 1974, Florida,</u> Metropolitan Association of Urban Designers and Environmental Planners (New York: American Society of Civil Engineers, 1974), pp. 331-351, (The Association is hereafter referred to as M.A.U.D.E.P.).

Table 2

Metropolitan Toronto Bicycle Survey
Data Summary

		% of interviewed households
Total number of households interviewed	1127	100.0
Number of households interviewed reporting bicycle ownership	504	44.7
Number of households interviewed reporting no bicycle ownership	623	55.3
Number of bicycles owned by the sample households	1008	
Number of persons in the sample	3648	
Number of households interviewed reporting no bicycle trips	976	86.6
Number of households interviewed reporting bicycle trips	151	13.4
Total number of bicycle trips reported by interviewed households	606	
Average number of persons per interviewed household	3.24	
Average number of bicycles per interviewed household	0.89	
Average number of bicycles per household reporting bicycle ownership	2.00	
Average number of bicycles per person	0.28	
Average number of bicycle trips per person	0.17/day	
Average number of bicycle trips per interviewed household	0.54/day	
Average number of bicycle trips per interviewed household reporting bicycle ownership	1.20/day	

Table 2 (continued)

	% of interviewed households
Average number of bicycle trips per interviewed household reporting bicycle trips	4.01/day
Average number of bicycle trips per bicycle	0.60/day

Source: W. Strok and Associates Limited, _Bikeway System Within Metropolitan Toronto_ (Municipality of Metropolitan Toronto, April 1974), p. 27.

telephone survey of 1127 Metropolitan Toronto households conducted in 1973.[27]

Table 3

Toronto Bicycle Trips By Purpose And By Age Group

	AGE									
	0 - 5		6 - 12		13 - 16		17 & Over		TOTAL	
PURPOSE	NO. OF TRIPS	%	NO. OF TRIPS	%	NO. OF TRIPS	%	NO. OF TRIPS	%	NO. OF TRIPS	%
SOCIAL - RECREATIONAL	18	90.0	201	66.6	94	56.3	44	37.6	357	59.0
SHOP	2	10.0	37	12.2	38	22.7	31	26.5	108	17.8
SCHOOL	-	-	54	17.9	31	18.6	6	5.1	91	15.0
WORK	-	-	8	2.6	4	2.4	14	12.0	26	4.3
EXERCISE	-	-	-	-	-	-	19	16.2	19	3.1
MISCELLANEOUS	-	-	2	0.7	-	-	3	2.6	5	0.8
TOTAL	20	100.0	302	100.0	167	100.0	117	100.0	606	100.0

Source: W. Strok and Associates Limited, Bikeway System Within Metropolitan Toronto (Municipality of Metropolitan Toronto, April 1974), p. 27.

In Toronto 59 percent of total bicycle trips are social-recreational in nature. A significant proportion

[27]Strok, pp. 25-30.

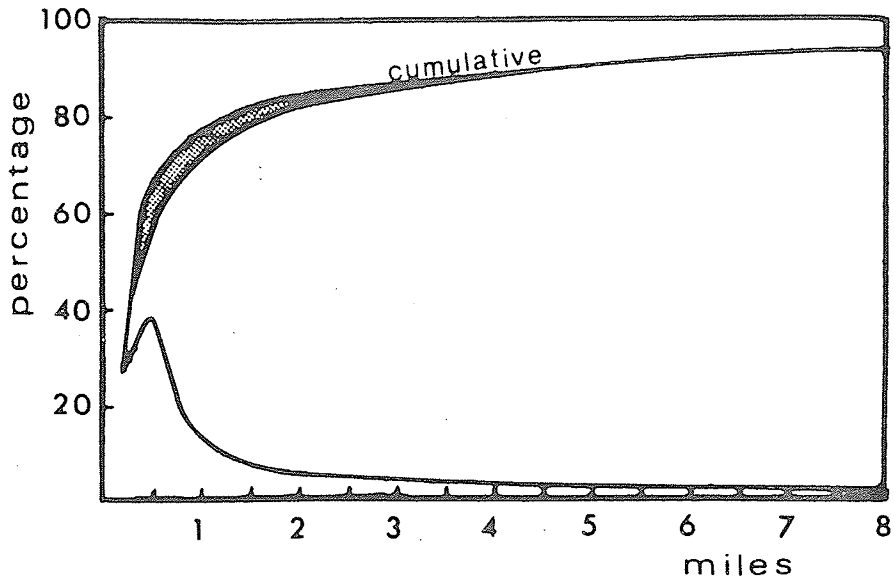

FIGURE 2. TORONTO BICYCLE TRIP LENGTH
SOURCE: STROK, P.28.

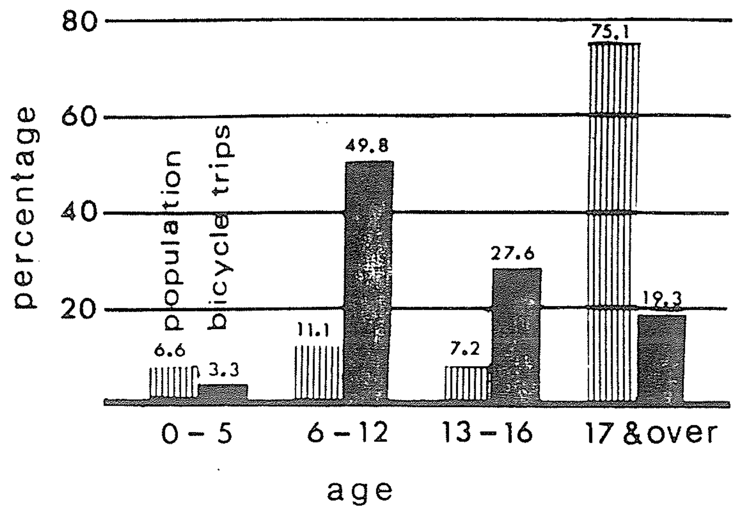

FIGURE 3. TORONTO BICYCLE TRIP GENERATION BY AGE GROUP
SOURCE: STROK, P.28.

of trips, 37.1 percent, however, is compromised of utility trips to shop, school and work. The social-recreational trip grouping also contains a sizeable number of destination-oriented utility trips (to friends' homes, parks, clubs and so on). Without a doubt, these 1973 statistics represent a significant growth in bicycle use for transportation purposes. Similar surveys from the early 1960s are unfortunately unavailable. Furthermore it should be noted that although the age group of 6 to 12 years old is responsible for almost half of all bicycle trips, the 19.3 percent of trips made by adults (17 and over) represent a phenomenal increase in bicycle use (particularly destination oriented) by this age group during the last few years. It is reasonable to expect that this kind of bicycle use will continue to increase, particularly if provision for it is introduced to the city.

Commercial areas, parks, schools, colleges and universities are the destinations for about 60 percent of all bicycle trips made in Toronto. The remaining 40 percent have no focal point, being attracted to residential and non-determinable locations in response to such needs as "visit a friend, run around," and so on.[28]

To study patterns of bicycle attraction, the numbers of bicycles accumulated (both standing and moving) at the most important cycling destinations in Toronto were deter-

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[28] Ibid., p. 24.

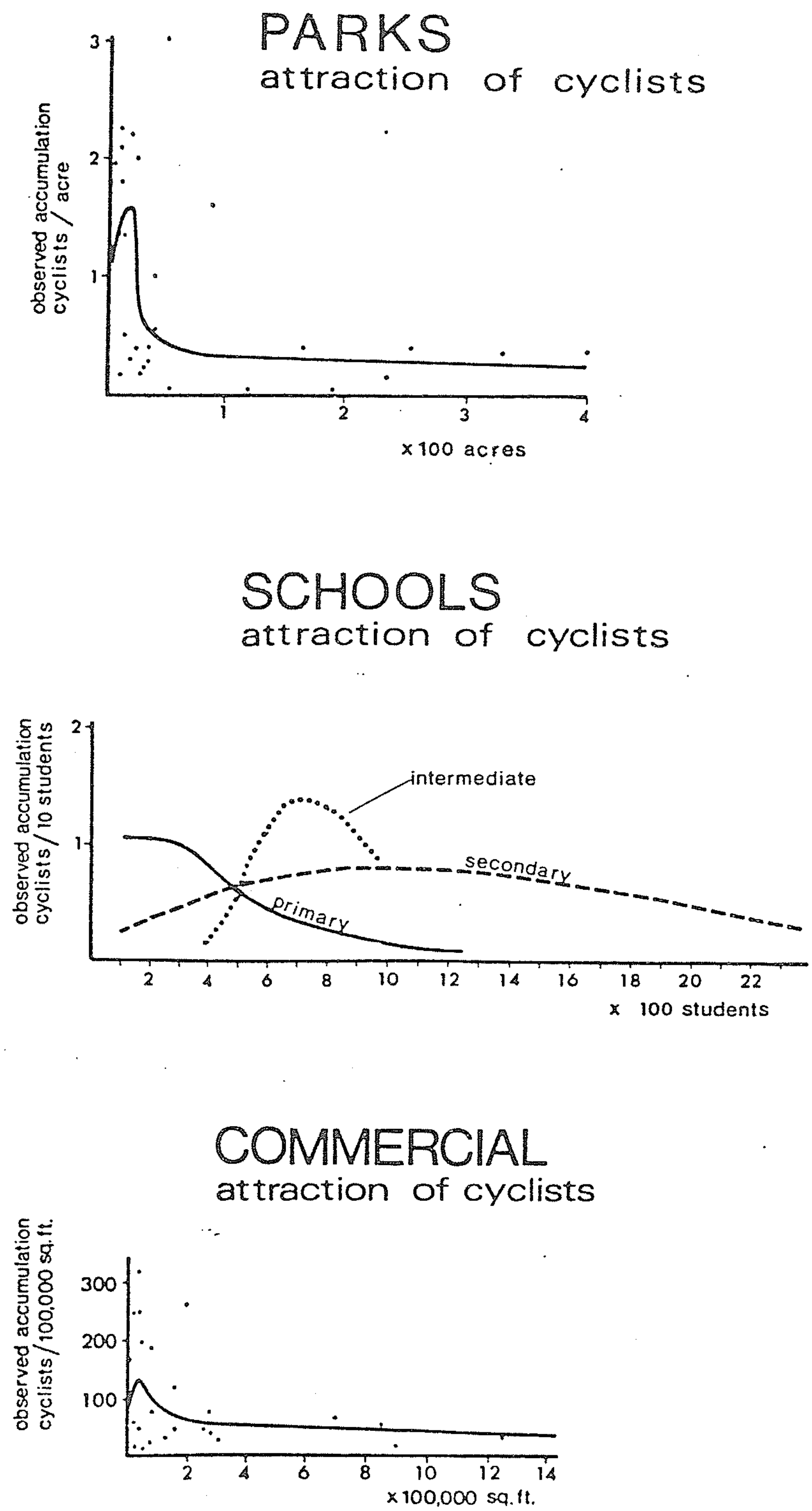

FIGURE 4. TORONTO BICYCLE TRIP ATTRACTION

SOURCE: STROK, PP. 32,34,36.

mined. Parks were surveyed on weekdays and weekends during afternoon and evening hours. The number of bicycles at schools, colleges and universities were counted on typical weekdays with good weather. Bicycle counts at shopping centres and strip retail areas were made during peak shopping periods (Thursday and Friday evenings and Saturday afternoons).[29]

The results of these surveys relating the size of facilities to their attraction of cyclists, are summarized in Figure 4. Generally speaking, parks and schools attracted more cyclists than did shopping centres or strip retail areas. The University of Toronto downtown campus attracted the largest number of bicycles (over 760) of any location surveyed, while most other university and college campuses in Toronto attracted fewer cyclists than secondary and intermediate schools.

Household surveys (by telephone, questionnaire, or personal interview) are the most common means of determining patterns of bicycle use. The transportation use of bicycles can also be measured through surveys of trip attractions, as the Toronto example described above demonstrates. Less common has been the application of a procedure standard for the determination of automobile traffic patterns: the traffic volume count.

Surveys of bicycle traffic volume at different times

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[29]Ibid., pp. 24-25.

of day, can also result in data from which transportation use of bicycles can be inferred. Figure 5, for example, shows typical bikeway useage for a weekday in comparison to bikeway useage for a weekend in Oregon communities. This data was used by the Oregon Highway Division to verify that the demand for bikeways in urban areas was at least as much for transportation use by commuters, students and shoppers as for recreational or exercise use.[30]

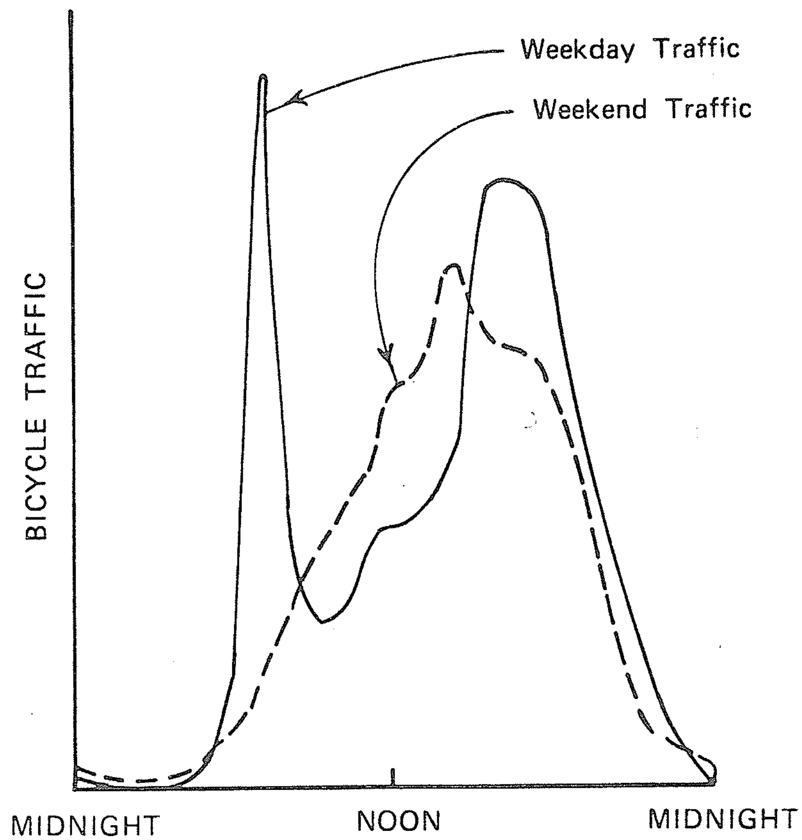

FIGURE 5. OREGON BICYCLE TRAFFIC VOLUME: WEEKDAYS AND WEEKENDS

Source: Oregon Department of Transportation, P. 3.

[30]Oregon Department of Transportation, Highway Division, Location Section, Oregon Footpaths and Bikeways Progress Report (Salem: Oregon State Highway Division, April 1975), p. 3.

4. Recreation

In the Toronto example, which seems to be quite typical for North America, surveys found that over 60 percent of bicycle trips are made for transportation purposes. A portion of these trips might also be classed as recreational-social, as they end at friends' homes, parks and other recreational facilities. A significant proportion of all bicycle trips is, however, made for the recreational purpose of simply enjoying bicycle riding.

Neighbourhood riding is a kind of cycling commonly done by children, and comprises a substantial proportion of total cycling activity. It occurs primarily on residential streets, and is characterized by a short radius of activity from individual residences, pairs or small groups of riders, play rather than purposes, and unpredictable behaviour.

Sightseeing and touring cycling is done primarily for enjoyment of the act of cycling. The preference is for visually interesting and scenic routes, including roads and highways with low volumes of automobile and truck traffic, as well as paths and trails. Much of this type of cycling occurs within urban areas, but it can also be a regional activity, extending 50 or more miles from urban centres. Touring-sightseeing cycling peaks on weekends, holidays and evenings. It is basically a fair weather activity.

Since bicycling is such a healthy and pleasant form of exercise, many persons are motivated to cycle for health and physical fitness reasons. The cycling engaged in generally falls into the recreational category of touring and sightseeing but may also be utility-oriented.

5. Potential Bicycle Use

A United States federal transportation official has said that

> current bicycle travel characteristics and current bicycle travel volumes do not reflect the number of people who would like to use their bicycles, but rather the lack of good facilities for bike travel.[31]

Considering the conditions cyclists must face in most North American urban areas, it is indeed amazing that as much cycling as presently exists is engaged in. Many cyclists are willing to put up with a great deal of inconvenience and even danger in order to cycle. It is reasonable to expect that given opportunities to cycle in pleasant surroundings, in relative safety and convenience, many more people would engage in bicycling for both transportation and recreation.

Utility-oriented cycling, especially for commuters, is particularly unattractive in today's cities where no facilities for bicycles are provided. Doubtless there are many people who are afraid to cycle under these conditions, or simply find it too unpleasant.

> There is no question that there is a latent demand for bikeways. . .but its extent and the amount of

[31]John E. Hirten, Deputy Administrator, Urban Mass Transportation Administration, "Balancing Transportation," M.A.U.D.E.P. Proceedings 1974, p. 71.

> potential bicycle use in North American cities is difficult to ascertain. This can only be determined through actual monitoring of a sufficiently extensive system capable of providing full outlet for this latent demand.[32]

Some indications exist, however, that the dimensions of potential bicycle use in North American cities might be quite large.

> Attitude surveys conducted in Buffalo, Washington and the Twin Cities of St. Paul and Minneapolis indicated that up to 40 percent of commuters are potential bicycle users if safe bicycle paths are provided.[33]

The accuracy and objective values of these surveys are open to question. Surveys in the San Francisco Bay Area show that only 10 percent of commuters would consider riding a bike to work, while in Philadelphia a survey indicated that with the establishment of conditions favourable to bicycling, only 5 to 10 percent of commuters to the CBD would be willing to cycle rather than drive.[34]

Where facilities have been provided for bicycles, bicycle use has indeed increased greatly. Recreational cycling boomed in cities, for example New York[35] and Winnipeg, where parks were opened to bicyclists and closed

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[32]Strok, p. 38. [33]Ibid.

[34]Skrabak, "Bike Law", p. 52.

[35]Constantine Sidamon Eristoff, "The Pedestrian and Bicyclist in the Urban Setting," Proceedings of the Pedestrian/Bicycle Planning and Design Seminar San Francisco, 1972, M.A.U.D.E.P. (Berkeley: Institute of Transportation and Traffic Engineering, July 1973), p. 162.

to motorists on weekends. In Oregon, the bikeway program in existence since 1972 has concentrated on the provision of facilities for utility-oriented riding as much as for recreational biking. The effect of the construction of bikeways in increasing bicycle traffic is evident from the bicycle traffic counts which have been conducted there. Use of any bikeway tends to increase dramatically in the months following its construction. Overall, in the early stages of the bikeway construction program in Oregon, the average of selected bikeway traffic counts rose from 46 bikes per day in 1973 to 120 bikes per day in 1974.[36] In Chicago "special bicycle counts were taken during the first two months of operation of bike lanes. These counts indicated steadily increasing useage."[37]

D. BICYCLE SAFETY

1. The Increase in Bicycle Accidents

As bicycle sales and use have increased rapidly during recent years, so has the number of injuries and fatalities in bicycle accidents. Almost all the accidents involve collisions between bicycles and motor vehicles. There are 100,000 such accidents annually in the United States, 40,000 of them resulting in injuries. Fatalities too are rising rapidly. In the United States in 1973 bicy-

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[36] Oregon Footpaths and Bikeways Progress Report, pp. 73-79.

[37] Mary Ann Zimmerman, "The Chicago Experience in Bicycle Facility Planning and Design," M.A.U.D.E.P. Proceedings 1972, p. 207

cle fatalities accounted for 1,100 deaths (or 1.97 percent of the total 55,800 traffic fatalities). This is an increase of almost 100 percent since 1963, and an increase of 22 percent over the previous year 1972.[38]

The increasing rate of bicycle injuries and deaths is attributed primarily to the greater accident exposure brought about by the ever-increasing number of cyclists travelling on facilities designed for other purposes. During the energy crisis of the winter of 1973 to 1974, in the months of November, December, January and February, bicyclist deaths increased 39 percent, while auto-occupant and pedestrian deaths decreased 25 percent as compared to the same months in the winter of 1972 to 1973.[39]

In Canada, bicycle injuries and deaths, like bicycle sales, have increased much more rapidly than the population. As can be seen from Figure 6, the big increase has occurred between 1970 and 1971, when injuries increased by 28 percent. During the decade 1963 to 1973 bicycle injuries increased by 86 percent, while deaths increased by 43 percent.

There were 187 bicyclist fatalities and 6,819 bicyclists injured in Canada in 1973. These represented 2.79 percent of the total traffic fatalities and 3.05 per-

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[38] Grove, p. 679; United States Department of Transportation, National Highway Traffic Safety Administration, Pedestrian and Bicycle Safety Study (Washington, D.C.: March 1975), p. 4.

[39] U.S. Department of Transportation, Pedestrian and Bicycle Safety Study, p. 65.

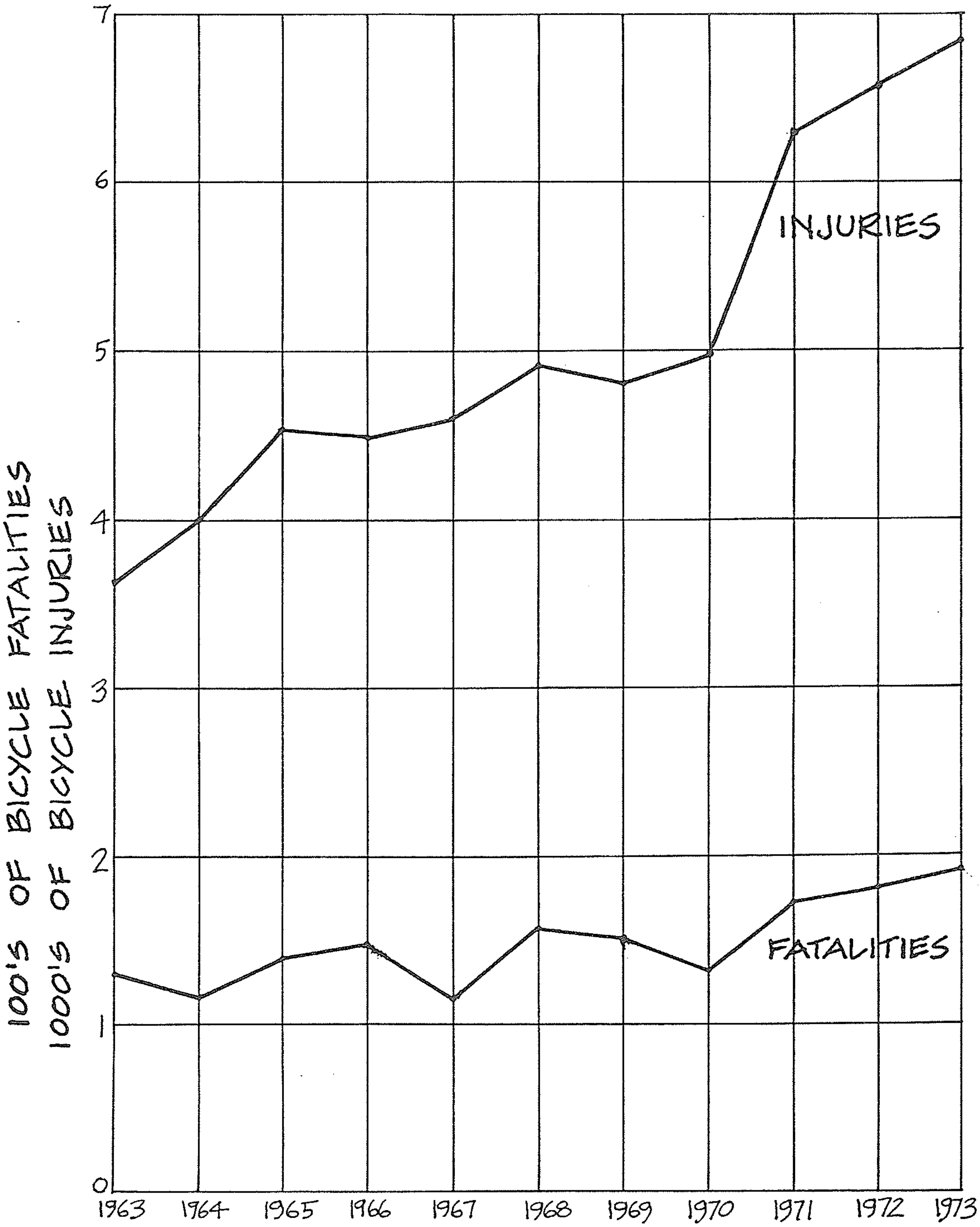

FIGURE 6. CANADIAN CYCLIST INJURIES AND FATALITIES

SOURCE: STATISTICS CANADA, MOTOR VEHICLE TRAFFIC ACCIDENTS, 1956 TO 1973.

cent of the total traffic injuries in Canada during 1973, a significant increase over the 1970 ratios of 2.60 and 2.75 percent, respectively.[40]

2. Factors Causing Bicycle Accidents

To some extent, bicycle accidents are due to the nature of bicycle riding itself. Bicycles can be rather unstable vehicles, particularly where pavement is imperfect, and some degree of skill is required for adequate control, especially in complicated urban situations. An over-whelming concern of the cyclist is to maintain his balance and his momentum, and to avoid the large expenditure of energy required to accelerate. STOP signs are therefore often regarded as YIELD signs. Cyclists often feel that the provisions of the vehicle code do not apply directly to them. Unpredictable behaviour is a common characteristic of bicycle travel. Many cyclists may lack the skill necessary to hand-signal turns while maintaining balance and executing turning movements; other cyclists may feel signalling unnecessary, particularly when they do not perceive any clear danger to themselves. Swerving and weaving to avoid obstacles or road debris and to maintain balance are also causes of unpredictable cycling movements.[41]

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[40] Statistics Canada, Motor Vehicle Traffic Accidents, 1956 to 1973.

[41] R. D. Bartholomew, "Bicycle Control," M.A.U.D.E.P. Proceedings 1972, pp. 159-160.

Earlier studies of bicycle safety have generally examined the behaviour of children involved in bicycle accidents, and concluded that increased cyclist education is necessary.

> A Detroit traffic study [The Child in Detroit Traffic, 1970, HS 009 684]. . . [identified] major accident-causing actions: cycling out of driveways into path of car, cycling into street from an area between parked cars, entering intersections without due care, changing direction in front of car, disobeying traffic signs, riding on sidewalks and failing to observe vehicles using driveways and alleys, and midblock crossing.
>
> A study conducted by the American Association for Automotive Medicine. . .found that bicyclists do not conform to traffic regulations whereas motorists are trained to obey a set of formal rules even in the absence of apparent risk. . .the bicyclist is usually young, untrained, and seldom ready to cope with the unexpected. Young bicyclists do not comprehend complex traffic rules, and some ride before they are able to effectively control the bicycle. The safety of young riders is further endangered by riding bicycles which are too large for them. . .
>
> . . . .
>
> The research seems to recommend traffic safety education that could be implemented into the school curriculum. Young bicyclists are careless and often take risks that prove to be fatal. It is often suggested that education programs teach bicycle riders road discipline, roadway placement, and priority, as well as how to respond to traffic conflicts. Unfortunately no data exist which prove the effectiveness of bicycle safety training programs as they are currently designed.[42]

More recent studies of bicycle accidents result in

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[42] U.S. Department of Transportation, Pedestrian and Bicycle Safety Study, pp. 85, 87; very similar conclusions are reached in an Ontario study of 5 to 14 year old cyclists: Ontario Department of Transport, Technical Bulletin 70-01, An Investigation of Rider, Bicycle and Environmental Variables in Urban Bicycle Collisions (Toronto: October 1970), p. 31.

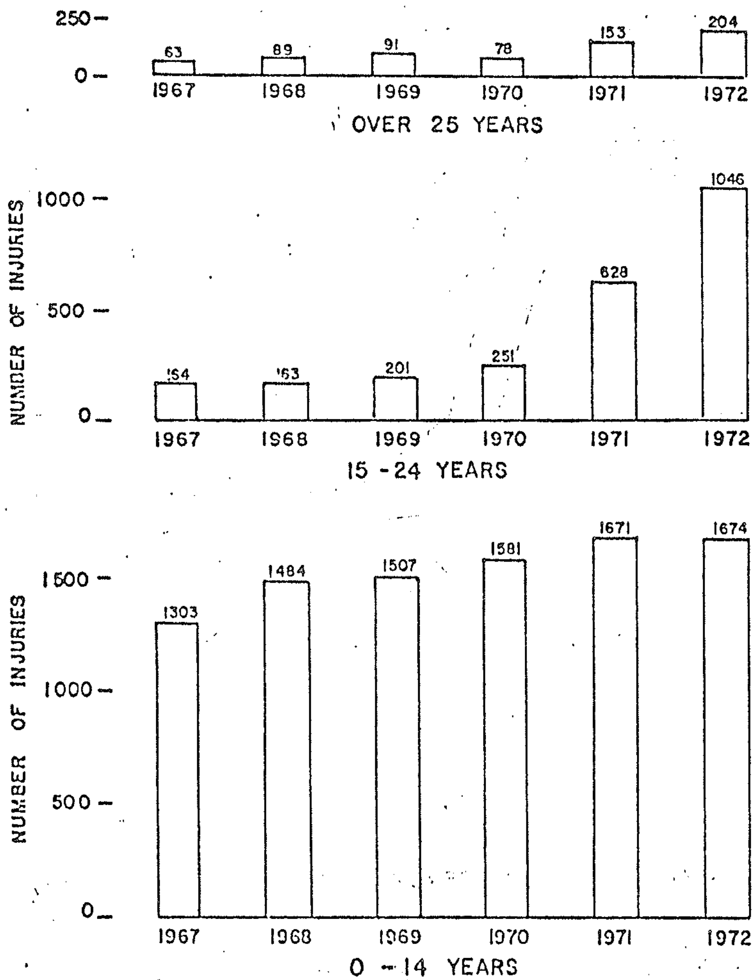

FIGURE 7. ONTARIO CYCLIST INJURIES BY AGE GROUP
SOURCE: ONTARIO MINISTRY OF TRANSPORTATION

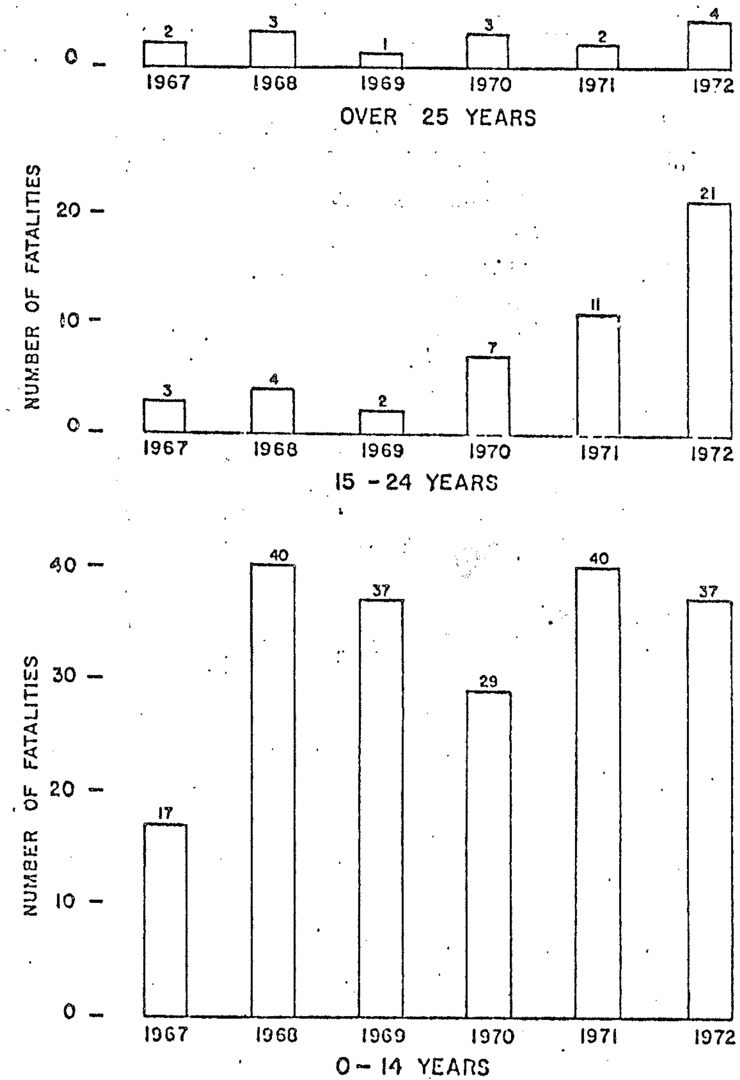

FIGURE 8. ONTARIO CYCLIST FATALITIES BY AGE GROUP
SOURCE: ONT. MINISTRY OF TRANSPORT.

rather different conclusions. The proportion of bicycle accidents involving cyclists aged 15 years and over is rising sharply. This can be seen, for example, from the cyclist injury and fatality statistics for Ontario presented in Figures 7 and 8.

A comprehensive analysis[43] of the nearly 8,000 accidents involving cyclists in Ontario between July 1, 1971 and December 31, 1973 is summarized in Tables 4, 5 and 6.

In contrast to the older studies quoted earlier, it was found that 76.1 percent of cyclists (but only 66.2 percent of motorists) involved in bicycle accidents were moving properly and legally. Cyclists caused 6.5 percent of the accidents by failing to yield right-of-way to motorists. Motorists, however, caused 12.4 percent of the accidents by failing to yield right-of-way to cyclists. This would suggest that while traffic and safety education may be an important means of reducing bicycle accidents, it is at least as necessary for motorists as for cyclists.

To rely on increased education to stem the increasing number of bicycle accidents as bicycle use increases, is however a simplistic and partial solution to a serious problem, This problem, of which the accident statistics are simply the most alarming manifestation, is the use of two incompatible forms of transportation, the motor vehicle

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[43]Ontario Ministry of Transportation and Communications, pp. 28-41.

Table 4

Ontario Bicycle Accidents: Cyclist Analysis

BICYCLE AND CYCLIST

		Percent
Bicycle Condition	- no apparent defect	78.5
	- unknown	15.0
	- defective lights	1.9
	- other defects	4.6
		100.0
Bicycle Maneuver	- going ahead	65.1
	- overtaking	1.2
	- turning left	11.6
	- turning right	3.1
	- making 'U' turn	0.8
	- changing lanes	2.9
	- merging	0.4
	- reversing	0.1
	- stopped or parked	0.9
	- pulling away from shoulder	2.4
	- pulling into shoulder	0.3
	- not known other	11.2
		100.0
Cyclist Action	- riding properly	76.1
	- following too close	0.1
	- speeding too fast	1.6
	- improper turn	3.6
	- disobey traffic signal	0.2
	- disobey stop sign	0.5
	- fail to yield right-of-way	6.5
	- improper passing	1.6
	- lost control	0.7
	- wrong way	0.0
	- not known, other	9.1
		100.0

Source: Ontario Ministry of Transportation and Communications, p. 37.

Table 5

Ontario Bicycle Accidents: Motorist Analysis

MOTORIST		Percent
Motorist Condition	- normal	91.7
	- alcohol involved	3.7
	- other	4.6
		100.0
Motor Vehicle Maneuver	- going ahead	59.9
	- overtaking	5.6
	- turning left	13.9
	- turning right	8.0
	- making 'U' turn	0.2
	- changing lanes	0.7
	- merging	0.3
	- reversing	2.1
	- stopped or parked	6.8
	- pulling away from shoulder	0.4
	- pulling into shoulder	0.5
	- not known, other	1.6
		100.0
Motorist Action	- driving properly	66.2
	- following too close	0.2
	- speeding	1.8
	- improper turns	3.8
	- disobey traffic signal	0.4
	- disobey stop sign	0.5
	- fail to yield right-of-way	12.4
	- improper passing	1.3
	- lost control	1.0
	- wrong way	0.1
	- not known, other	12.3
		100.0

Source: Ontario Ministry of Transportation and Communications, p. 38.

Table 6

Ontario Bicycle Accidents: Environmental Analysis

SITE CONDITIONS		Percent
Visibility	- clear	93.1
	- rain, snow, fog	6.9
		100.0
Light	- daylight	81.8
	- dawn, dusk, dark	18.2
		100.0
Road Alignment	- straight, level	83.5
	- other	16.5
		100.0
Road Condition	- good	97.5
	- other	2.5
		100.0
Road Type	- paved	97.7
	- other	2.3
		100.0
Road Surface Condition	- dry	89.3
	- wet or other	10.7
		100.0
Road Location	- non-intersection	37.9
	- intersection related	11.1
	- at intersection	38.1
	- intersection with private drive	12.8
	- at railway crossing	0.1
		100.0

Source: Ontario Ministry of Transportation and Communications, p. 36.

and the bicycle, on urban street systems which were designed without any regard for the bicycle.

Even though bicycles and cars are both vehicles and have speeds and patterns of movement which are much more similar to each other than to those of pedestrians, they differ greatly in size, weight and speed. Cyclists, on their small, light, manoeverable but somewhat unstable and slower vehicles, are infinitely more vulnerable than motorists. Motorists, used to watching for massive automobiles, and to a somewhat lesser extent for slow-moving pedestrians, often tend not to see bicycles, or to misjudge their speed. Furthermore, priorities of passage and proper cyclist behaviour on streets are not spelled out for all situations, or maybe unknown to either cyclists or motorists. There is also a reluctance on the part of some motor vehicle drivers to yield right-of-way and to afford other vehicular rights to "inferior" vehicles.

On most streets no specific place is provided for cyclists; they must squeeze in wherever there is room, inconveniencing both themselves and motorists. Generally cyclists are required to ride next to the curb on the right side of the road. The pavement there is typically in worse condition than the rest of the road, rough with cracks and potholes, and there is often a dangerous ridge where the roadway pavement meets the gutter. Storm sewer grates, some with slots wide enough to catch a bicycle wheel, are located on this side of the road. Dirt, gravel, broken glass, bits of cars and other debris collect here. It can be dangerous for a cyclist travelling at a fair speed to hit one of these obstructions. Attempting to avoid them, however, may cause him to swerve into the path of an automobile approaching from behind.

Driving to the right of all motor traffic becomes particularly dangerous where roadways are too narrow to provide adequate space, or where the traffic consists of a large proportion of wide-bodied vehicles such as buses or trucks. Parked cars to the right of the cyclist often aggravate his problems, exposing him to the danger of running into a suddenly-opened car door, or swerving into a traffic lane to avoid it. Buses, too, with their frequent stops and starts, interfere with cyclists' progress.

There is also reason to believe that motorists tend not to respect a bicycle as a vehicle when it is hugging the side of the road. The cyclist is not nearly as visible here as he is out in the centre of a lane, and he is in substantially greater danger from vehicles cutting in front of him to turn right (the cause of 8.0 percent of the bicycle accidents in Ontario analyzed in Table 5).

As might be expected, intersections, where conflicts between bicycles and motor vehicles become most intense, are the location of a substantial proportion of bicycle accidents. In Ontario, this proportion was 38.1 percent with an additional 11.1 percent related to intersections (for example, weaving actions near intersections) and another 12.8 percent involving intersections with private drives (Table 6). Left turns by motorists account for 13.9 percent of all accidents, right turns by motorists for 8.0 percent, and left turns by cyclists for 11.6 percent (Tables 4 and 5).

These statistics suggest the importance of lessening the conflicts between motor vehicle and bicycle traffic, and of defining formally positions and paths where drivers and cyclists may expect each other. At the very least there is the necessity of educating both cyclists and motorists to increase their awareness of the presence of other road users.

In regard to cyclist visibility, much is often made of night-time cycling without lights. Yet Table 4 indicates that only 1.9 percent of bicycles involved in Ontario accidents had defective lights, although from Table 6 it can be seen that 18.2 percent of accidents occurred at dawn, dusk or night-time.

Table 6 also indicates that visibility, road condition, road type and road surface condition had negligible effects on accident rates in Ontario. There is some indication, however, that accidents more frequently involve road alignments which have significant vertical and horizontal curvature as these account for 16.5 percent of all bicycle accidents.

3. The Effect of Bikeways

It would seem reasonable to expect that bicycle safety might be improved by establishing bikeways, which physically separate bicycles from motor vehicle traffic, or at least provide adequate space for cyclists and define a pathway where motorists must expect them.

Some authorities, however, believe that bikeways within street rights-of-way would only minimally increase cyclist safety, as they do not separate bicycles from motor vehicles at intersections, where a large proportion of bicycle accidents typically occurs.[44] It has even been charged, in fact that bikeways might reduce cyclist safety. In some poor bikeway designs, cyclists have been forced to enter intersections from awkward positions, where motorists were not used to expecting them. In the worst cases planting between road and bikeway could even hide the cyclist from the motorists' view.[45]

Much opposition to bikeways, however, ignores the fact that the substantial proportion of bicycle-motor vehicle collisions which occurs at mid-block could virtually be eliminated. Furthermore, with proper bikeway design, some significant factors will also tend to reduce the intersection accident rate. At intersections, bikeways can dictate specific safe, visible and predictable ways for

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[44] John Williams, "Bikeways: Another View" (Mimeographed); L. N. Popish and R. B. Lytel, <u>A Study of Bicycle-Motor Vehicle Accidents</u> (Santa Barbara, California: June 1973).

[45] Darryl Skrabak, "The Bikeway Backlash," <u>Bicycling!</u> September 1975, p. 26.

cyclists to execute both turns and straight movement.

> Even mid-block treatments may have a significant effect on movement patterns and predictability of cyclists' behaviour at intersections . . . Bike lanes constitute a physical reminder to both cyclist and motorist which can reinforce cyclist obedience to the rules of the road and predictable behaviour . . . and raise motorist consciousness relative to the presence of cyclists.[46]

Empirical evidence exists which suggests that the provision of bikeways does indeed increase bicycle safety. In 1952 a study conducted in the Netherlands compared the accident rate on 680 km of two-lane roads with bike traffic but no bike lanes, with the accident rate on 1230 km of two lane roads where cycling on the road was prohibited and bike lanes were provided. The number of accidents per km of roadway was found to be a straight function of density of traffic for both kinds of road, and to be over twice as high for roads without bikeways as for roads with bikeways. Accidents occurring at intersections were, however, not compiled.[47]

A more recent Dutch study surveyed bicycle accident histories on several roads between 1955 and 1962, concluding that where no bike lanes were provided the accident ratio followed the same course as the increase in traffic density.

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[46] Smith, p. 11.

[47] Koninklijke Nederlandsche Toeristenbaud, Fietspaden en Oversteekplaatsen (Bicycle Paths and Cycle Crossings), (2d rev. ed.; Amsterdam: Verkeersafdeling van de Algemene Nederlandse Wielrijders Bond, December 1967).

Where bike lanes were provided, however, the accident ratio dropped substantially after their completion.[48]

A Danish study conducted in Copenhagen compared accident rates along heavily used arterial streets with and without bicycle tracks (bikeways separated from the roadway by a curb, ending at intersections). Personal injury bicycle accident rates per bicycle-km were approximately 60 percent lower on streets with bicycle tracks than on streets without them. The bicycle accident rate at intersections was found to be negligibly higher (by 0.9 percent) on streets with bicycle tracks. The percentage of accidents at intersections involving right-turn motorists was 35 percent on streets with bike tracks as compared to 23 percent on streets without tracks. The percentage of accidents at intersections involving left-turn motorists was, however substantially lower on streets with bicycle tracks --10 percent versus 26 percent.[49]

In North America very little research has been done to determine the effect of bikeways on bicycle safety. The Statewide Bicycle Committee of California, in fact, decided in 1975 that there was no conclusive evidence to substantiate that bikeway facilities constructed in California

are safer or more dangerous than no facility at

[48]Fisher, p. 44.

[49]Radet for Trafiksikkerhedsforskning, Cypelstiers Betydning for Faerdselssikkerheden, Rapport 1 (Copenhagen: Statens Trykningskontor, 1969).

> all . . . Committee member viewpoints and viewpoints of public testimony vary between two extreme positions. The first is that bicycle lanes are dangerous because they encourage behaviour that is not in conformance with the rules of the road and create a false sense of security. The second is that bike lanes enhance safety because they separate the two modes of traffic and create a greater sense of security.[50]

Much research is required to quantitatively assess the safety implications of bikeways, and to evaluate and compare various alternative designs which have recently been implemented in North America.

Meanwhile, the experience of Davis, California suggests that the provision of bikeways can substantially increase bicycle safety.

> In the period of 1967 to 1968 before the city's comprehensive bikeway program was implemented, an average of 23 bicycle-motor vehicle accidents (mid-block and intersection) were experienced annually. In 1971, after implementation of the bikeway system, some 31 bicycle-motor vehicle accidents were reported, an increase of some 35 percent. Yet over the intervening period both motor-vehicle and bicycle traffic had increased by more than 100 percent.[51]

Of the three Davis street segments presently having the highest rates of bicycle accidents per mile, two have no facilities for bicycles, while the third has only partial provisions. These three streets serve significantly lower bicycle traffic volumes than other streets with bike lanes

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[50] Statewide Bicycle Committee, Final Report (Sacramento: California Department of Transportation, February 1975), p. 15.

[51] Smith, p. 11.

or paths and lower accident rates. Accident rates per bike-mile on the three accident-prone, no-bike-facility streets are several times the rate on the most accident-prone streets with bicycle facilities.[52]

The provision of bikeways is not the only means by which it should be attempted to lower bicycle accident rates. In fact, education and safety programs are considered more cost-effective in increasing bicycle safety by some authorities. John Williams, a Canadian planner and cyclist, for example, is convinced that bicycle accident rates in Holland are low because of the high levels of skill learnt by Dutch cyclists, and because Dutch motorists respect and yield right-of-way to cyclists (or are severely punished), rather than because of the numerous bikeways. He suggests that only half the European approach, the idea of bikeways without the idea of increased respect for bicycles, has been imported to North America.[53]

The California Statewide Bicycle Committee, too, has concluded that besides bikeway provision, the increased education of both cyclists and motorists is essential. Furthermore, bicycle law enforcement will also reduce bicycle accidents.[54]

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[52] De Leuw, p. 12.

[53] Williams, "Bikeways: Another View," p. 5.

[54] Statewide Bicycle Committee, pp. 16-19.

E. OPPOSITION TO BIKEWAYS

It might seem reasonable to expect opposition to the establishment of bikeways from members of the public who view their construction as a waste of taxpayers' money, and an encroachment on the rights of the automobile within the city. Similarly the planning, public works, and engineering departments of cities may feel that bicycling is a trivial matter, unworthy of serious consideration, and may be willing to give no more than lip service to the idea of bicycle facilities. The city engineer may have a

> deep-seated protective attitude towards 'his' roads. He probably feels that devoting a lane to bicycles is a waste of precious roadway that rightfully belongs to 'his' automaniacs.[55]

Such opposition may be expected to continue, although many members of the public and of municipal administrations in North America have come to strongly support the idea of bikeways.

Some cycling enthusiasts and groups have also begun to strongly oppose the bikeway idea in North America. Basically, this has been due to dissatisfaction with poorly designed and badly maintained bikeways, and a fear of being legislated from roads onto inferior bicycle facilities.

John Williams, as both cyclist and planner, typifies the mistrust with which bikeway planning has sometimes come to be viewed:

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[55] John Williams, "Cycling and City Hall," Bike World, June 1975, p. 37.

> We are well on the way to turning the bicycle into a weekend toy for those with access to a bike path. Bikeway planning in North America has nothing to do with increasing "safety" or "convenience" or "encouraging cycling". It is first and foremost a way of nullifying any challenge the bicycle might pose to the sovereignty of the automobile.[56]

Many unsatisfactory bikeways have been built in North America in recent years. Often they have been planned with no clear objectives in mind, and designed by planners who have never cycled and who sometimes have no idea of the requirements of cyclists.

Bikeways have been built lacking adequate width, road surface, drainage and lighting. Often they have been designed for low speed cycling and proceed to destinations in a meandering, indirect manner.[57]

Intersections were often handled poorly, thrusting cyclists awkwardly amongst other traffic, sometimes even hiding them from view, and not uncommonly requiring bicyclists to dismount and walk across streets.[58]

Bikeway transitions and endings too, have often been handled poorly, dumping cyclists awkwardly into motor vehicle traffic lanes, often at points of maximum conflict and danger.[59]

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[56]John Williams, "Separate ≠ Equal", (Mimeographed).

[57]Darryl Skrabak, "N.C.U.T.L.O. Spells 'Power'," Bicycling! December 1975, p. 59.

[58]Williams, "Bikeways: Another View," p. 3.

[59]Smith, pp. 74, 76.

Often bike lanes have been striped where roadway width is adequate and then ended at conflict areas such as where the pavement narrows.[60]

Use of bikeways by pedestrians who interfere with cyclists' travel has also been a common complaint.[61]

Poor bikeway maintenance has probably been more common than poor bikeway design. Deterioration of the pavement, potholes, flooding as well as accumulations of all kinds of debris and lack of sweeping are often mentioned by cyclists discussing bikeways. The following descriptions of some bad bikeways around Denver (where there are, however, also good bikeways) provide an example of this:

> The probability of puncturing a tubular tire within the first mile on this bike path was about 90 percent. For a wired-on tire the probability was about 50 percent. Our club schedules six to eight rides a year . . . and on each ride the leader tells the assembled group to stay off the bike paths . . . Thorn-bearing weeds grow right up to and over the paving. Another hazard is sand, often at the bottom of a hill or around a blind curve. The quality of the surface along a part of that path that was paved only last year is terrible.
>
> . . . The path . . . is almost completely closed by weeds. Converging riders along this stretch cannot see each other. Thorns, tin cans and broken bottles abound. Water seeps and drains onto the pavement at a number of places.
>
> . . . a stretch of path behind George Washington High School . . . has the worst collection of broken beer and pop bottles I have ever seen and is sure death to tires! Riding west on the path, one soon leaves an excellent section and is dumped out (without a curb cut) onto a major thoroughfare. The path then resumes (again

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[60]Statewide Bicycle Committee, p. 9.

[61]Smith, p. 96; Skrabak, "The Bikeway Backlash," p. 25.

sans curb cut) along a sidewalk . . . One of the greatest hazards of this bikeway is from left-turning motorists on the section that runs along the left side of the street. It is a very scary experience to have an automobile appear from behind you and to the right and then turn left in front of you.

> The Alameda bike path . . . becomes very poor--nothing more than loose-packed gravel in spots. The path crosses residential driveways without any markings and, here and there, ends for a bit at a gas station apron or a shopping center parking lot. One trip on the bikeway convinced me I was better off on Alameda Avenue than on the bikeway.[62]

The chief fear of cyclists confronted with such inadequate bikeways is that they will eventually be legislated onto them, losing their rights to ride on the streets. This is not an irrational fear. In the United States, thirty-six states have adopted the following section of the Uniform Vehicle Code recommended by the National Committee on Uniform Traffic Laws and Ordinances:

> Wherever a useable path for bicycles has been provided adjacent to a roadway, bicycle riders shall use such path and shall not use the roadway.[63]

The medium-sized college community of Palo Alto, California provides an example of the pernicious potential of such mandatory bikeway use laws:

> 40 to 50 miles of various bikeways [were implemented]. Most were on public streets and some on sidewalks (the

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[62]Sid Russak, "Bikeways: The Way They Are," Bicycling! September 1975, p. 33-34.

[63]Skrabak, "N.C.U.T.L.O. Spells 'Power'," p. 55.

pedestrian space). Bikeways were generally narrow and inadequate. An accompanying ordinance required cyclists to ride in the bike lanes on certain streets. That obviously played havoc when cyclists, riding in right-hand side-lanes, attempted to make lefthand turns, and motorists turning right would often cut in front of cyclists moving forward in the bike lane. Bicyclists were rightfully upset for their lives were being endangered, as well as their rights to use any part of the road.[64]

Such developments led to the League of American Wheelmen and other groups of cycling enthusiasts, fearful of losing bicycles' "equal rights" as vehicles, to adopt anti-bikeway positions as official policy. Members of these groups, generally experienced and highly-skilled cyclists, feel that with proper training, cyclists could learn to adapt and ride safely in auto traffic.

> They believe that rather than providing for the well-being of cyclists with bikeways, a strategy of bike safety training and stressing motorists' responsibility toward other forms of traffic will be sufficient to allow bicycles and automobiles to safely mix.[65]

Not all cyclists, however are as highly skilled as these enthusiasts, or as willing to suffer the inconvenience and aggravation of mixing with motor traffic. Bikeways which make riding more pleasant and safer can, and have been built, and many cyclists and potential cyclists want more of them. In fact, interviewers of cyclists have

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[64]"Point of View: An Anti Bikeway Movement," Bicycling! June 1974, p. 77.

[65]Ibid., p. 78.

noticed a pervasive tendency:

> . . . that many cyclists were so grateful for any kind of bikeway that they were reluctant to be critical of it. This seemed to be mostly a function of cyclists' past experiences in being excluded from many roads and in having to ride in such residual space as gutters or narrow shoulders.[66]

Furthermore while by no means all cyclists have used bikeways where they were available, their provision generally results in greatly increased feelings of security on the part of most cyclists.

The elimination of mandatory bikeway use laws is, however, highly desirable, as the Panel on Bicycle Laws of the National Committee on Uniform Traffic Laws and Ordinances reported in 1975:

> UVC section 11-1205 (c) provides that where a usable bike path has been provided adjacent to a roadway bicyclists must use the path instead of the roadway. It was argued that use of a path should not be mandatory. Such paths may be adequate for some bicyclists, during certain times of the year, or in certain weather conditions, but such paths are often inconvenient and unsafe for at least some bicyclists. High speed commuters, for example, should not be required to use a low speed trail. No bicyclists should be required to use a trail which has not been properly constructed or maintained. Trails frequently lack adequate road surface, drainage lighting, width and other important characteristics of the adjacent roadway. The roadway may be much safer.
>
> . . . The consensus of the Panel following discussion was that if a trail is safe and convenient it will be used without the necessity of a law mandating its use.[67]

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[66] Smith, p. 90.

[67] quoted by Skrabak, "N.C.U.T.L.O. Spells 'Power'," p. 59.

California's Statewide Bicycle Committee has recommended the following law:

> Whenever a bicycle lane has been established on a roadway . . . any person operating a bicycle upon such highway, traveling in the direction of the bicycle lane, shall normally ride within the bicycle lane except when overtaking and passing another bicycle proceeding in the same direction within the lane, when preparing for a left or right turn at an intersection or into a public or private road or driveway, when overtaking and passing a pedestrian or vehicle within the lane or about to enter the lane, or when reasonably necessary to avoid road hazards such as, but not limited to, debris, gravel buildup or road surface deterioration or in other emergency situations.[68]

The above discussion makes it clear that bikeway planning must be approached seriously, and that participation from experienced cyclists, cycling groups and the general public is highly desirable. Planning objectives and concepts for bikeway systems must be clearly established to meet needs. Just as important to ensure bikeway adequacy and usage however, is design of all small details of every bikeway, as well as proper maintenance of all bikeways after they are built.

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[68] Statewide Bicycle Committee, p. 9.

Chapter 2

THE DESIGN OF BIKEWAYS

A. BIKEWAY SYSTEM OBJECTIVES AND CONCEPTS

Bikeway systems can be designed with many objectives in view: to integrate the bicycle mode of transportation into the urban fabric, to connect certain centres of activity, to increase safety for cyclists, to provide a space for recreational cycling, to get bicycles out of the way of automobiles, to promote a population's physical fitness, or to reduce congestion and air pollution in a city. Most bikeway planning will have many if not all of these objectives. To increase safety for cyclists, for example, is an important element of all bikeway planning. Nevertheless, concepts of bikeway systems can vary considerably, and planners should be certain of their prime objectives. These must be based on demand surveys, studies of cycling activity and accidents, and specifics of the existing urban form.

1. Recreational Facilities

Planners often regard bicycles as primarily recreational vehicles. When bicycle use survey results have been analyzed, the typically almost 50 percent of trips made for recreation have been emphasized over the other 50 percent of destination-oriented trips made for a variety of purposes.[1] This has resulted in facilities planned solely for recreational use being built in response to the tremendous upsurge in bicycle use in many localities. In part, this may have been due to a superficial commitment to bikeway provision, as well as to preconceived notions. It is fairly simple to plan and construct bikeways in parks, along riverbanks and creek beds, on hydro rights-of-way and other bits of open space if there are no goals or objectives other than to provide space for "recreational" cycling. If the resulting bikeways are not located to meet demand, or are unattractive, they will not, however, be extensively used.

In many areas residential streets are available for relatively safe and attractive recreational cycling. On-street bikeways have little purpose as primarily recreational bikeways. Independent bikeways, however, are typically conceived as recreational facilities. They are best located in or near residential areas giving access to parks and other recreational facilities. Recreational bikeways, like all bikeways, require route continuity. Wherever possible, without compromising recreational usefulness,

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[1] Dan Smith, Bikeways: State of the Art 1974 (San Francisco: De Leuw Cather and Company, July 1974), p. 4; Nina Dougherty, "The Bicycle as it Relates to the Energy Crisis," Proceedings of the Seminar on Bicycle/Pedestrian Planning and Design: December 1974, M.A.U.D.E.P. (New York: American Society of Civil Engineers, 1974), pp. 331-351.

consideration should also be given to providing access to bicycle trip attractors which are not recreational in character. This, of course, increases the utility of the bikeway. In fact, an independent bikeway within a green system could become a truly significant public resource.

> A carefully planned bicycle route could act as a "seam" or focal element that links a community together: it could become a controlled edge limiting incompatible and diverse land use densities, making public access available as it buffers local, natural, and scenic resources, and acting as a cultural and socializing device . . . a bikeway can, if developed to its fullest potential become a significant and meaningful element of a community, an element which can lace together dispersed elements, e.g., public services and facilities: schools, parks, libraries, museums, hospitals and civic centres.[2]

Aesthetic appeal is an important part of recreational bikeways. They should pass through scenic and interesting districts. Landscaping can be an important element of recreational bikeways. Senseless weaving back and forth of bikeways on flat land, as is sometimes recommended, does not however provide interest and variety for cyclists.

2. Transportation Facilities

Another approach to bikeway planning regards the bikeway system as an element of the urban multi-modal transportation system. In this approach destination-

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[2]Sanji Yano, "Bicycling and Bikeways," Proceedings of the Pedestrian/Bicycle Planning and Design Seminar San Francisco, 1972, M.A.U.D.E.P. (Berkeley: Institute of Transportation and Traffic Engineering, July 1973), pp. 198-199.

oriented cycling is provided for, and bikeways attempt to connect bicycle trip attractors and generators, often using origin-destination studies just as in other transportation planning processes.

The bicycle route recommendations in a report on Downtown Toronto provide an example of this approach:

> Goal: To provide for pleasant and safe access within the Core Area by bicycle at all times of the day and night.[3]

Another report on the Toronto situation also emphasizes the importance of providing bikeway routes for utility cycling.

> There presently exists in Metropolitan Toronto a significant collection of routes that are suitable for cycling as a light recreational exercise in a park environment. In many neighbourhoods the local street system permits safe, careful cycling within the neighbourhood. However, the most convenient routes connecting the neighbourhoods with parks and other important community facilities are the collector and arterial roads on which the cyclist must without special legislation and facilities mix with the motorized traffic. It is on these latter roads that consideration must be given to separating bicycles from other traffic.[4]

The experience of the Oregon Bikeway Program provides evidence of demand for bicycle facilities serving transportation needs.

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[3]George Baird and others, On Building Downtown: Design Guidelines for the Core Area (Toronto: City of Toronto Planning Board, September 1974), p. 111.

[4]H. Abrams, Toward a Metropolitan Toronto Bicycle Route System (Toronto Roads and Traffic Department, May 1973), pp. E2-E3.

> Initial efforts by the Highway Division in bike-route planning were oriented toward recreational routes because it was assumed that the bicycle was primarily a recreation vehicle. We found, by public meetings and contacts with individuals, that the primary need was for bikeways to serve commuters, students and shoppers in the populated areas. A desire was also expressed for recreational bikeways in urban areas.
>
> Our experience in developing bikeways which serve both utility (commuters, students and shoppers) and recreation purposes has proved to be the most successful alternative since it satisfies the major public desires. Present goals are directed toward joint-use bikeways in populated areas, with emphasis placed on service to schools.
>
> . . . .
>
> Cycling on urban arterials and collector streets will continue because many destination points lie along or close to these facilities. Meandering or inconveniently located bikeways will not receive much utilitarian use because cyclists will ignore poorly located bikeways and signed low-volume streets in favor of more direct routes . . . Providing bikeways with maximum convenience to the cyclist will result in a reasonable alternate mode of transportation with reduced dependance upon motorized transportation.[5]

To plan bikeways for destination-oriented use, but so that they will also be attractive for recreational cycling, appears to be a reasonable and practical approach. A major study[6] outlining the design of a bikeway system for Toronto was based on a similar concept. An important part of demand analysis was the mapping and ranking of bicycle trip attractors such as parks, schools, colleges, univer-

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[5] W. H. Tebeau, "Evaluation of the Oregon Bikeway Program" (Salem: 1976), pp. 1-3. (Mimeographed.)

[6] W. Strok and Associates Limited, <u>Bikeway System Within Metropolitan Toronto</u> (Municipality of Metropolitan Toronto, April 1974).

sities and commercial facilities. The resulting plan was for Metropolitan Arterial Bikeways, which

> are the main interconnecting systems of bikeways within Metropolitan Toronto, catering mainly to the social-recreational trip purpose, but capable of satisfying work and exercise trips and in some instances additional local school and shop trip purposes. Bikeways were planned to be no more than one mile from every Metropolitan Toronto residence, and were expected to attract all bicycle trips over one mile in length.[7]

Central Business Districts tend to be one of the most important attractors of trips, including bicycle trips, within any urban area. The high degree of congestion already existing in downtown areas, together with the high cost and scarcity of land make the provision of bicycle facilities here difficult, however.

> Moreover some planners hold that bike facilities, particularly on-street lanes, are completely ineffective in central business districts because of the intense activity -- the sheer volume of traffic, high turning movements, high turnover parking interference, double parking in the lanes, pedestrian interference, access and egress traffic from parking garages and lots, buses intruding on the lanes to reach curbside load points, inevitable construction zones -- bike lanes are completely disfunctional and the cyclist is better off left to fend for himself.[8]

In many cities therefore, bikeway systems, such as for example the Denver commuter system, have been planned with the CBD feeder bike lanes terminating as they reach the edge of the central core.

The effectiveness or ineffectiveness of bikeways in

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[7]Ibid., p. 15. [8]Smith, p. 80.

downtown cores has not been empirically determined. The reasons advanced for not providing bikeways there, however, sometimes would seem more convincing as reasons for restricting private automobile use in downtown areas.

3. The "Bottleneck" Approach

A 1975 United States Department of Transportation study concluded that:

> The tendency is to build bikeways where there is room for them rather than to serve user needs. Improvements are rarely made for bicycles on the basis of where accidents are occurring. More emphasis is needed on how to bridge hazardous spots on both onstreet and offstreet bicycling facilities and how to establish overall route continuity.[9]

Starting with similar beliefs, Robert M. Shanteau of the Santa Clara Valley Bicycle Association presents some useful ideas about planning for bicycles based on the ways in which cyclists perceive urban road networks and plan their trips. Growing numbers of people are attempting to transport themselves by bicycle, on streets which were neither intended nor designed for bicycles. Nevertheless

> the road system forms a grid on which bicyclists may begin and end their trips almost anywhere. However, there are problem spots in the grid, called bottlenecks, that make a bicycle trip either inconvenient or dangerous. An appealing solution is to fix the existing grid by removing the bottlenecks rather than to try to design and build a separate one for

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[9] quoted by Darryl Skrabak, "The Bikeway Backlash," <u>Bicycling!</u> September 1974, p. 27.

bicyclists.[10]

Benjamin O. Davis, Jr., Assistant U.S. Secretary of Transportation has elaborated on this planning approach:

> Bottlenecks are most often points--traffic circles, intersections, expressways--on a grid, but they are occasionally linear, such as bridges. Repairing a single spot, one bottleneck, can allow a cyclist to use miles of safe roads impossible to use otherwise.[11]

It is not always easy for non-cycling planners to recognize bicycle bottlenecks. Sometimes accident data for a city will reveal specific points on the urban street network which are particularly dangerous for cyclists. This cannot be relied on, however, since bicyclists will tend to avoid bottlenecks where possible, and may exercise extraordinary caution at such locations. Thus many bottlenecks will result in inconvenience, irritation, detouring and forestalling bicycle trips, rather than in accidents and injuries.

Transportation planners have knowledge about route decision-making by motor vehicle drivers. Planners must now extend this to cyclists, learning to see the urban road system as a cyclist does:

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[10] Robert M. Shanteau, "Bicycle: Bottlenecks: Bicycle Planning from a Bicyclist's Point of View" (paper presented at the M.A.U.D.E.P. conference, San Diego, December, 1974.)

[11] speech to the League of American Wheelmen, April 1975, quoted in Bicycling! September 1975, p. 28.

> as a series of situations that require riding between and merging into streams of vehicles 100 times more massive than his. The bicyclist decides his route for a relatively long trip by considering which bottlenecks he will traverse and then connecting these bottlenecks with regular streets. He prefers, for instance, to avoid a high speed high volume interchange, but at the same time, he does not want to cross major streets without the benefit of traffic signals.[12]

Narrow streets, bridges and underpasses are common bottlenecks, as are right-turn-only lanes. Streets which have very heavy traffic or prohibit non-motorized traffic, but form the only link in a traffic network are also bottlenecks to cyclists. Similarly major arterials to which there are no alternative routes are bottlenecks, particularly where the outside lane is narrow, strewn with debris or in poor repair. Where low-volume alternative streets are available, intersections with major streets may form bottlenecks where there are no traffic lights or only traffic-actuated signal loops which bicycles cannot trip. Similarly, where there are barriers such as rivers or railroad lines within the urban fabric, the alternative low volume traffic routes cyclists choose will be forced into the bottlenecks of arterial bridges and underpasses.

After bottlenecks are identified they must be resolved. The planner must imagine cycling through a problem area, following vehicular rules of the road, and keeping in mind that it is safest for a cyclist not to be forced

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[12] Shanteau.

into riding in the middle of a traffic lane, and not to allow himself to be cut off by turning cars. A safe, legal and obvious way to ride through a problem area must be provided. Pavement additions and traffic control devices are often useful. In the worst problem areas, bikeways can be constructed going through or around bottlenecks.

The "bicycle boulevard" concept provides an excellent related approach to bikeway planning. This involves turning a lightly travelled road into a bicycle arterial by selectively blockading motorized traffic and constructing new bikeway facilities to fix bottlenecks, connecting gaps in the continuity of the selected roads.[13]

4. Continuity

> In order for a bikeway to succeed in encouraging high levels of use it must be a system and go some place. The system must be areawide and must offer continuity.[14]

No matter which concept is used to approach bikeway planning, route continuity is an essential criterion. The importance of the concept of "continuity" cannot be overemphasized. In the "bottleneck" approach continuity is, of course, an explicit prime component of the concept; the object is to improve, for cyclists, the continuity of the

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[13]Artemas A. Ginzton, "The Bicycle Boulevard (or Bikeway Arterial) Concept" (paper presented to the National Highway Safety Advisory Committee, Washington, D.C., April, 1974.)

[14]John E. Hirten, "Balancing Transportation," M.A.U.D.E.P. Proceedings 1974, p. 7.

existing street network by removing bottlenecks. Where bikeways are conceived as a transportation system, catering to destination-oriented cycling, the importance of continuity, of bikeways connecting origins with significant destinations, is self-evident. Even for purely recreational cycling, however, routes must be continuous, or they are useless.

Continuity means many things. It operates on various scales and it must be related to bikeway function. On the city-wide scale an arterial bikeway network serving an entire urban area, must connect all parts of the area it is to serve, avoiding disruptive gaps, terminations and strained transitions, to avoid becoming a series of disconnected system elements which may or may not be useful in themselves. It is just as important to maintain continuity on the small scale, on each individual bikeway section. This is not always done.

> There is a bikeway in Toronto alongside a wide boulevard which intersects many little side streets. At each intersection a large barrier crosses the bikeway with a sign that tells cyclists to dismount and walk.[15]

Similarly bikeways have too often been established on back streets with stop signs at every corner, or on sidewalks with poor or non-existent curb cuts every hundred feet.

There is obviously no set distance over which a bike-

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[15] John Williams, "Bikeways: Another View" (mimeographed), p. 3.

way should have continuity.

> Each facility must be considered in relation to its specific functional role as a single-strand route and/or an area network element. Thus a bikeway extending only 3 or 4 blocks and providing accessibility between a school and a neighbourhood might have good continuity in relation to its function, whereas a recreational route of several miles interrupted at two or three points due to physical constraints might be described as having poor continuity.[16]

Poor continuity has not been uncommon in recent North American bikeway design. Superficial commitment to bikeways and a "helter-skelter" planning process tends to lead to provision of bikeways only where it is simple--where design is straightforward, ample right-of-way is available and construction requirements are minimal.

> A common failing in the current practice of many jurisdictions is termination of designated bikeway facilities wherever an obstacle is encountered--at a narrow section of roadway, a structure with little or no shoulder or pedestrian way, a freeway interchange where severe conflicts at ramps are likely.[17]

In such cases cyclists are in effect being led into traps, being left to fend for themselves where conditions are most hazardous.

Related to continuity, <u>imageability</u> is another essential characteristic which bikeway systems should possess. This means that routes should be laid out in a way that gives cyclists a clear sense of where they are

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[16]Smith, p. 78. [17]Ibid., p. 76.

going. Bikeway systems must form patterns which cyclists can grasp and retain in their minds.

Interruptions in continuity in the form of gaps, bikeways without specific destinations, and complicated routings of bikeways shifting from one street to another or to independent bikeways and back again, all impair system imageability. Efforts to achieve imageability, on the other hand, will result in systems with continuity, strong destinations, and direct routes, wherever possible in distinctive surroundings, or easily related to major landmarks.

In urban areas these criteria might mean that bikeways should often be located on or along streets having continuity through the city. Such streets tend to be major arterials, and because of the arterial road systems imageability, and the accessibility of activity centres from arterial roads, destination-oriented cycling tends to be heavy on major arterial streets. For these reasons, and because it seems sensible to provide protection to cyclists where they are most exposed to traffic hazards, it has been recommended that bikeways be provided predominantly in existing arterial transportation corridors.[18] This is not necessarily the best solution. It should generally be possible to provide cyclists with a new imageable route system, oriented to their specific needs and different from the arterial road system and image provided for motorists.

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[18] Ibid., p. 76.

B. THE CLASSIFICATION OF BIKEWAYS

The nomenclature of bicycle facilities can be confusing. The terms bicycle way, route, track, path, trail and lane are among those used in recent literature. Different terms have been used to describe the same type of facility, and, sometimes, the same term has been used to label more than one kind of facility.

Recently in North America, however, the terminology developed by the University of California Institute of Transportation and Traffic Engineering has been widely adopted. In this terminology the word "bikeway" is used to define all facilities which explicitly provide for bicycle traffic. Bikeways are classified according to the degree of exclusiveness with which the facilities are preserved for bicycle use (as illustrated in Figure 9):

Class I: A completely separated right-of-way designated for the exclusive use of bicycles. Crossflows by pedestrians and motorists are minimized.

Class II: A restricted right-of-way designated for the exclusive or semi-exclusive use of bicycles. Through-travel by motor vehicles or pedestrians is not allowed, however vehicle parking may be allowed. Cross-flows by motorists, for example to gain access to driveways or parking facilities, is allowed; pedestrian cross-flows, for example to gain access to parking facilities or associated land use, is allowed.

Class III: A shared right-of-way designated as such by signs placed on vertical posts or stencilled on the pavement. Any bikeway which shares its through-traffic right-of-way with either or both moving (not parking) motor vehicles

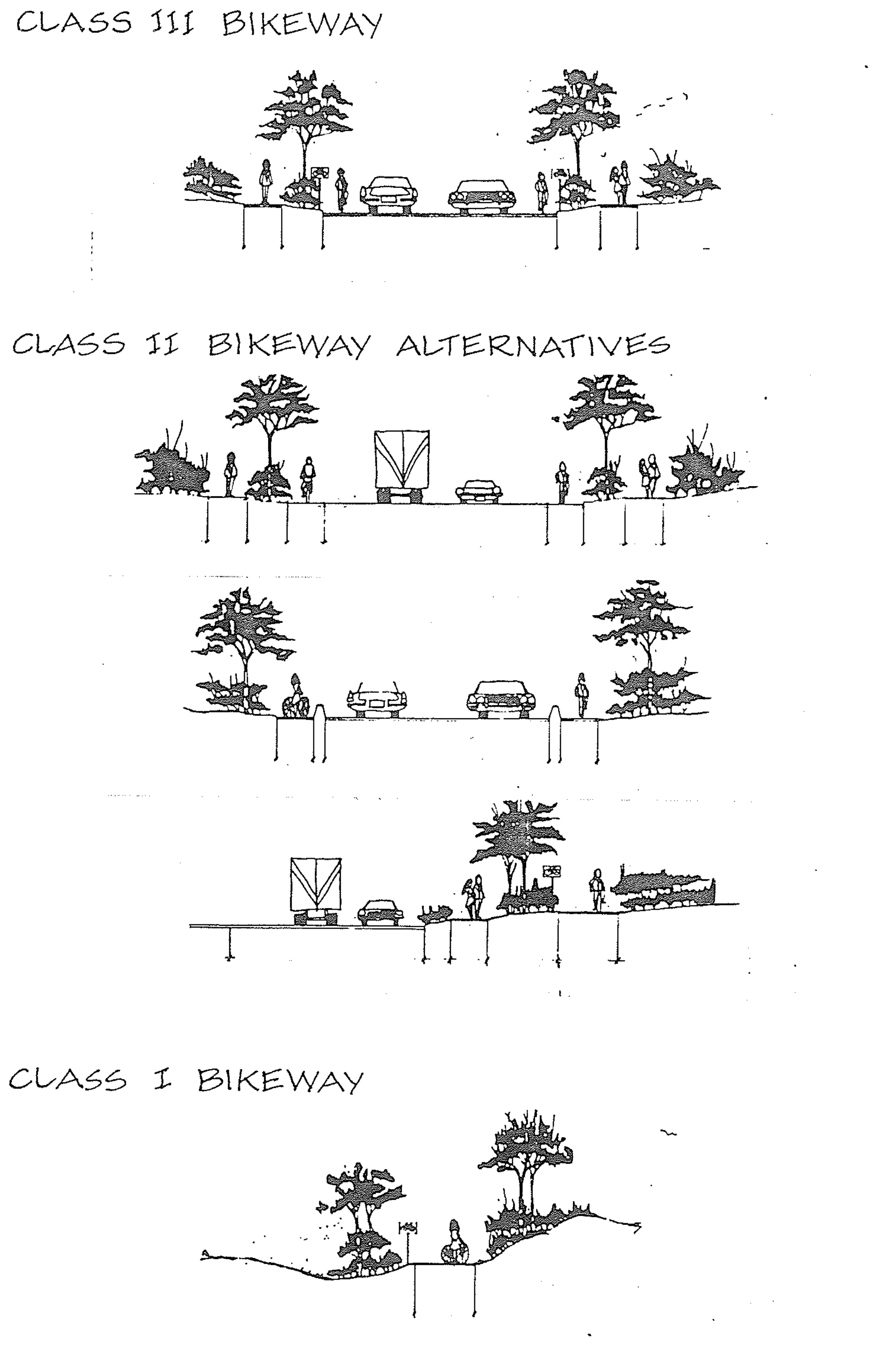

FIGURE 9. CLASSIFICATION OF BIKEWAYS
SOURCE: M.A.U.D.E.P. PROCEEDINGS 1974, P.604.

and pedestrians is considered a Class III bikeway.[19]

C. BASIC DESIGN CRITERIA

In order that expected benefits are achieved from the construction of bikeways, it is important that cyclists make use of them. Therefore all bicycle facilities should be constructed according to adequate design standards in every detail, making them more attractive than roadways to cyclists.

1. Widths

Bikeway dimensional standards are based on the space occupied by a cyclist, plus an allowance for lateral movement and lateral and vertical clearance to obstructions. Widely-adopted minimum standards have been developed in Germany and are illustrated in Figure 10.

Multi-lane bikeway widths must provide a comfortable manoeuvring zone between cyclists. The German specification of 0.66 feet (0.20 metre) manoeuvring allowance on each side of bicycle handlebars results in a cyclist separation (handlebar edge to handlebar edge) of 1.32 feet (0.40 metre), as illustrated in Figure 11. In the United States experiments have been conducted to determine the lateral separation maintained by cyclists riding abreast, given available space.

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[19] G. Fisher and others, Bikeway Planning Criteria and Guidelines (Los Angeles: Institute of Transportation and Traffic Engineering, University of California, 1972), pp. 19-20.

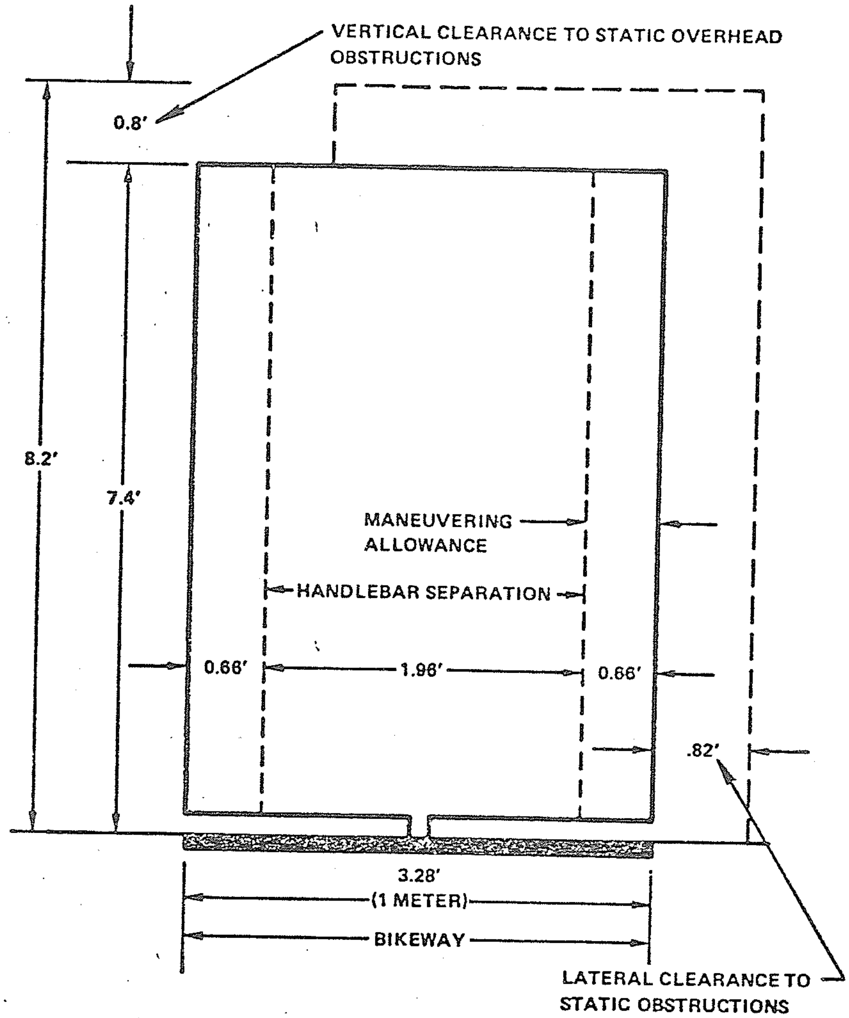

FIGURE 10. SINGLE LANE BIKEWAY: MINIMUM EFFECTIVE WIDTH AND CLEARANCES
SOURCE: FISHER, P. 24.

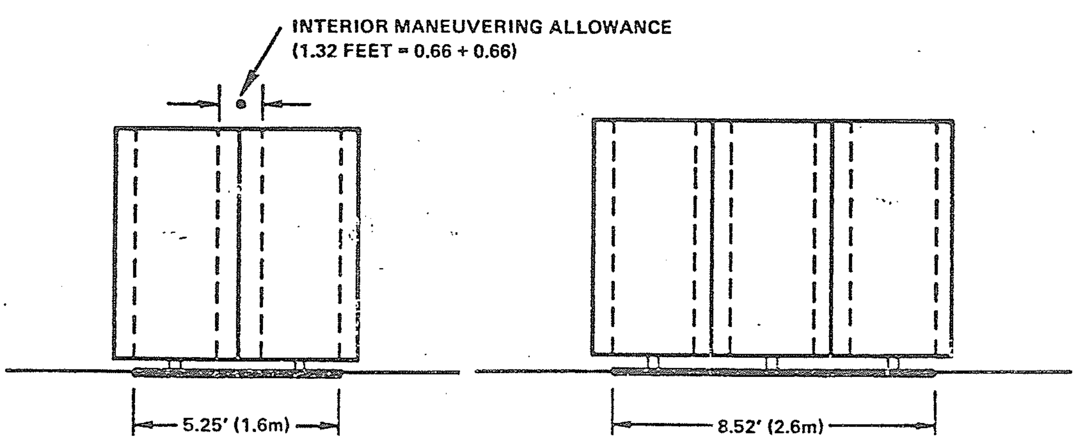

FIGURE 11. MULTI-LANE BIKEWAYS: MINIMUM EFFECTIVE WIDTHS
SOURCE: FISHER, P. 25.

As might be expected, the mean distance between the handlebar edges increased with velocity; at a speed of 10 mph the mean measured separation was 2.5 feet (0.75 metre).[20]

The use of this empirically determined separation of 2.5 feet (0.75 metre) instead of 1.3 foot (0.40 metre) German manoeuvring allowance, increases the minimum width of multi-lane bikeways as shown in Table 7 below.

Table 7

Minimum Effective Widths for
Class I and Class II Bikeways

Number of Lanes	Minimum Effective Width	
	German Specifications	U.S. Modification For A Comfortable Manoeuvring Allowance At A 10 MPH Design Speed
1	3.3 feet (1.0 metre)	3.3 feet (1.0 metre)
2	5.3 feet (1.6 metre)	6.4 feet (1.9 metre)
3	8.5 feet (2.6 metre)	10.9 feet (3.3 metre)
4	11.8 feet (3.6 metre)	15.3 feet (4.6 metre)

Whenever possible, to ensure a higher level of service, the more generous, modified minimum width specification should be used. Furthermore, other considerations such as the width of construction equipment and maintenance vehicles may indicate even wider widths for one or two lane bikeways.

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[20]Ibid., pp. 25-26.

To reduce the occurrence of accidents involving cyclists striking fixed obstacles (or swerving to avoid them) it is important to provide adequate lateral clearance along bikeways. The recommended minimum clearance (which may be paved or not) between the edges of bikeways of minimum widths and obstructions or hazards such as trees, utility poles, sign standards, fences, rocks and drainage ditches, varies from 0.8 foot (0.24 metre) in Germany to 1.6 foot (0.48 metre) in the Netherlands.[21] Where restricted clearances are unavoidable, obstructions should be clearly marked.

2. Curves

Curve guidelines are based on design speeds. Average bicycle travel speeds on level pavement have been observed to be between 8 and 12 mph, and 10 mph has been specified as a design speed for bikeways in many reports. On even slight downgrades, however, average speeds tend to be 20 mph or more. Thus the design speed of 10 mph has resulted in the planning of many facilities with relatively sharp curves requiring braking at the foot of downgrades. Furthermore, since even on level terrain, speeds of 30 mph are achievable and many cyclists travel at above the 10 mph average speed, many level facilities have been designed with too low design speeds to accommodate a significant proportion of cyclists.[22]

Bikeway design standards recently published in Oregon

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[21] Ibid., p. 28.

[22] Smith, p. 31; Fisher, p. 21.

attempt to accommodate more than the average cyclist. A design speed of 20 mph is recommended for bikeways with grades between +3% and -7%. On sections with grades steeper than -7% the design speed is 30 mph, while on one-way climbing grades greater than +3% the design speed is 15 mph.[23]

Where bikeways are located along motor vehicle roadways, motor vehicle turning radii are normally the controlling factor. For other bikeways, however, minimum curve radii should permit unbraked turns at the design speed. An empirical relationship between radius of curvature and velocity has been determined:

$$R = 1.25 V + 1.4$$

where, R = the unbraked radius of curvature in feet

V = the velocity in mph[24]

This results in the following minimum curve radii:

Design Speed (mph)	Radius (feet)
10	13.9
15	20.2
20	26.4
30	38.9

Guidelines for superelevation of bikeway curves are also available.[25] It should be noted that the supereleva-

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[23] Oregon State Highway Division, Bikeway Design (Salem: January, 1974), p. 3.

[24] Fisher, p. 31.

[25] Oregon State Highway Division, Bikeway Design, p. 4.

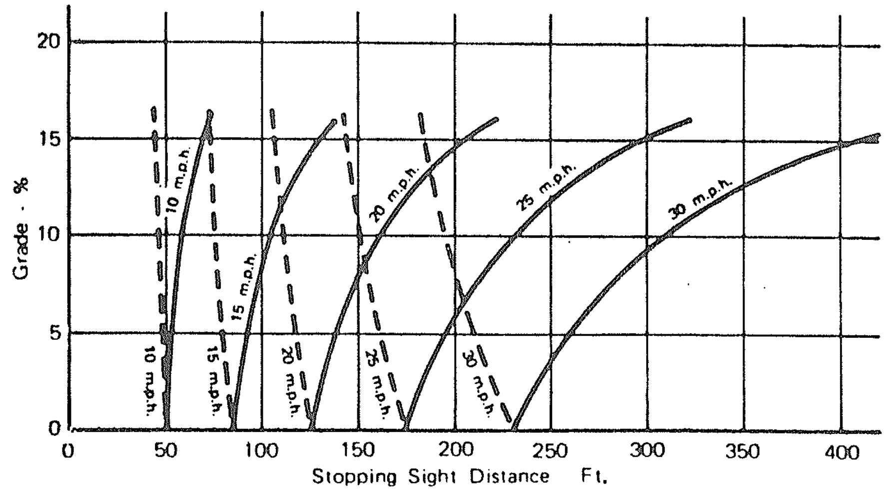
tion should in no case exceed 0.12 foot per foot.

Curve widening is another aspect of curve design. Since cyclists lean to the inside of a turn, the lateral space they occupy increases considerably on curves, particularly at high speeds. It is therefore advisable to widen bikeways (particularly two-way bikeways) on short radius curves.

3. Sight Distance

In the design of bikeways, safe sight distances are of the utmost importance. Where bikeways are on street rights-of-way more demanding sight clearances for motor vehicles are provided, and where these are inadequate traffic control devices are installed. On bikeways placed some distance to the outside of other traffic lanes, however, buildings and vegetation may obscure the cyclists' view of cross traffic at intersections. On independent, Class I bikeways at intersections with motor vehicle roadways or other bikeways, cyclists at a safe stopping distance from the crossing must be able to see any opposing traffic which would pose a conflict threat at the crossing.

Stopping distances at a range of bicycle speeds and on various grades are shown in Figure 12. This bicycle stopping distance together with crossing width, and bicycle and motor vehicle speeds, determines the corners of a parallelogram defining intersection sight clearance area, as shown in Figure 13.



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

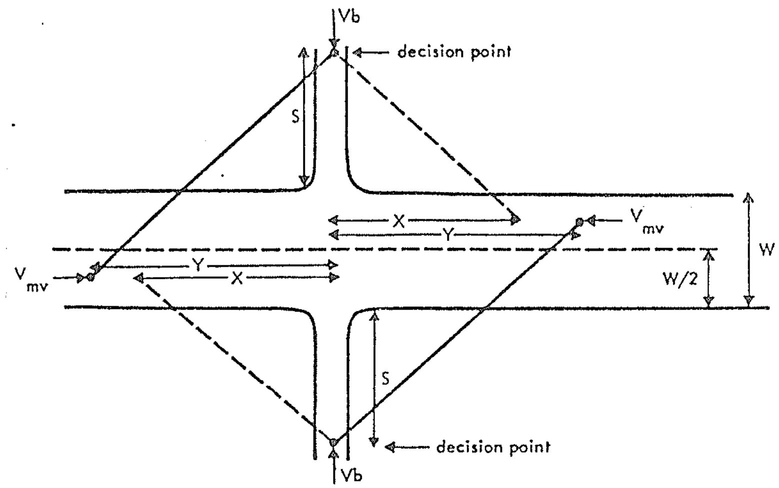
Where: S = stopping sight distance, ft.
V = velocity, m.p.h.
f = coefficient of friction (use 0.25)
G = grade, ft./ft. (rise/run)

Descend ————

Ascend – – – – –

FIGURE 12. BICYCLE STOPPING SIGHT DISTANCE

SOURCE: OREGON STATE HIGHWAY DIVISION, P. 8.



Time for full intersection clearance from the "stop-go" decision point is given by:

$$\frac{S + W + 6}{Vb} = t_1$$

Where S = Stopping Distance (including perception and reaction time) at design speed taken from Figure 19

W = Width of crossing

Vb= Actual bikeway typical approach speed (rather than design speed)

Time for near side lane(s) clearance is given by:

$$\frac{S + W/2 + 6}{Vb} = t_2$$

A crossing cyclist at the "decision point" must be able to see any vehicle which would threaten conflict in the crossing within time t_1 or t_2. Thus, the cyclist at the decision point must be able to see approaching vehicles at the following distances:

near side $x = t_2 V_{mv} = \frac{V_{mv}}{Vb}(S + W/2 + 6)$

for side $y = t_1 V_{mv} = \frac{V_{mv}}{Vb}(S + W + 6)$

Projections between the "stop-go" decision points and the points given by x and y define the sight clearance areas.

FIGURE 13: INTERSECTION SIGHT CLEARANCES

SOURCE: SMITH, P. 37.

Where physical constraints preclude the provision of adequate sight clearance areas

> devices should be employed to slow or stop the cyclist so as to prevent unsafe entry into the crossing. Since cyclists tend to regard STOP signs as YIELD signs, use of berms, unramped curbing, deceleration curves, or use of posts and ballards to constrain operating space in the bikeway (hence constraining speed) is appropriate to ensure that the cyclist exercises due caution in entering the crossing.[26]

On Class I bikeways used bi-directionally by cyclists it is extremely important to maintain sight distance on curves and grades. This is also very important where cyclists are directed to ride "facing traffic".

4. Grade

Maximum acceptable bikeway grades, and the distance for which various grades can be tolerated are determined by the physical characteristics of the cyclist (age, weight, conditioning, oxygen uptake, etc.), the characteristics of his bicycle (gear ratios, type, tires, weight, etc.) and by external conditions such as wind velocity and roadway surface.

Grade criteria for bikeways are available, although there is little documentation of background data and assumptions used in establishing them. Several European standards are shown in Figure 14.

If, due to terrain, certain grades must be continued for longer than the recommended maximums, it has been sug-

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[26]Smith, p. 35.

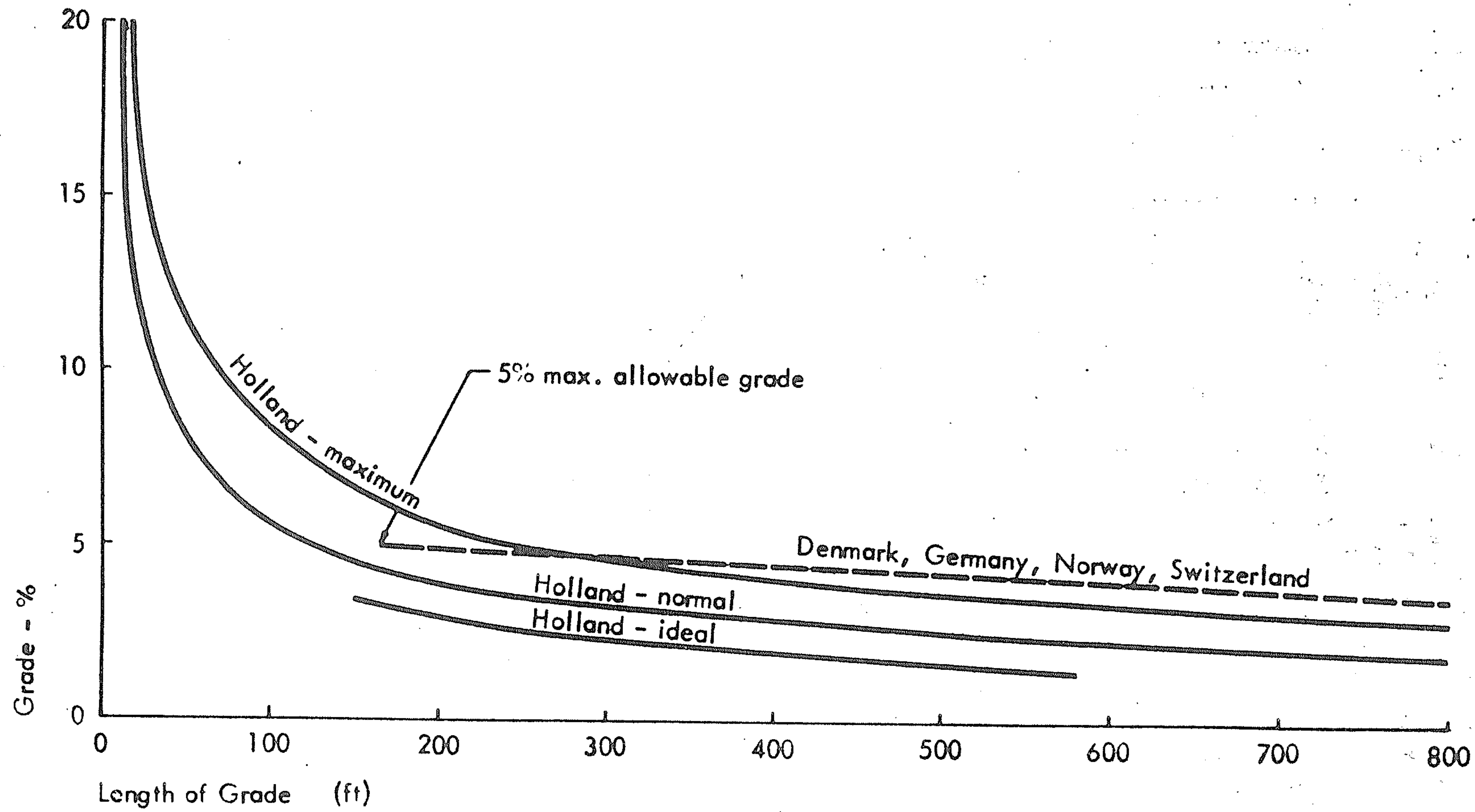

FIGURE 14. BIKEWAY GRADE STANDARDS

SOURCE: SMITH, P. 41.

gested that horizontal sections of 330 foot minimum length be introduced before or at the maximum distance at which the bikeway ascending grade is resumed. Rest stops and switchback curves have also been suggested.[27]

5. Capacity

The international literature on bikeways contains varied and somewhat conflicting estimates for the capacities of single and multiple lane bikeways. It is, however, clear that one-lane bikeways providing the necessary basic operating space have sufficient capacity for all but the most extreme future demands. Level of service considerations rather than capacity should therefore usually determine the width and type of bikeway to be built. Figure 15 presents bikeway capacity as a function of lane width. On intense bicycle activity areas, such as near college campuses, this information might be useful to ensure adequate capacity.[28]

Criteria for the recommendation of separate bikeways (Class I, II) on the basis of motor vehicle and bicycle (sometimes including moped) volumes are very inconsistent. Some international standards are presented in Table 8; North American criteria do not yet exist. It is generally agreed, however, that Class I or II (separated) bikeways

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[27] Fisher, p. 29.

[28] Smith, pp. 35, 40; Fisher, pp. 36-37.

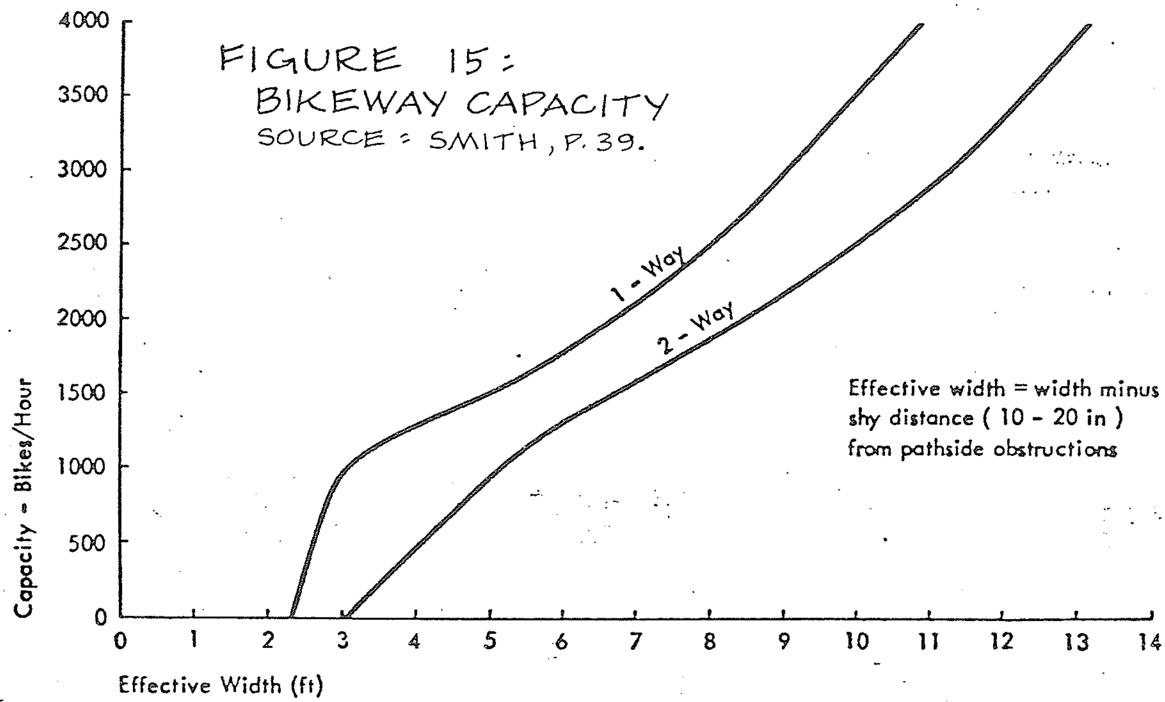

TABLE 8
CLASS I AND II BIKEWAY VOLUME CRITERIA

SOURCE	MOTOR-VEHICLE VOLUME	BICYCLE VOLUME	RECOMMENDATIONS	REMARKS
Germany (26)	> 2000 M.V./day	> 500 cycles/day	Separate bikeway	Urban Areas
	> 3000	> 200 cycles/day	Separate bikeway	Urban Areas
	> 2500	< 200 cycles/day	(Class III) Use Shoulder	Rural Areas
	> 2800	< 30 cycles/hr.	(Class III) Use Shoulder	Rural Areas
	> 2500	> 200 cycles/day	Separate bikeway	Rural Areas
	> 2500	> 30 cycles/hr.	Separate bikeway	Rural Areas
	> 2500	> 100 cycles/day	Separate bikeway when no shoulder exists	Rural Areas
Netherlands (35)	-	≦ 5000 cycles/day	2-lane separate bikeway	one-way bike flow
	-	≧ 5000	3-lane separate bikeway	one-way bike flow
	-	≦ 5000	3-lane separate bikeway	two-way bike flow
	-	≧ 5000	4-lane separate bikeway	two-way bike flow
India (61)	100-200 M.V./hr.	> 400 cycles/hr.	"bikeway"	type undefined
U.S.S.R. (6)	> 250	> 100 cycles/hr.	"bikeway"	type undefined
Switzerland (66)	> 700	"Few" bicycles	Separate bikeway	
	400-700	> 50 cycles/hr.	Separate bikeway	
	"Few" M.V.	> 500 cycles/hr.	Separate bikeway	

SOURCE: FISHER, P.39

are recommended where:

1) significant regular bicycle traffic exists, and/or

2) significant future bicycle traffic is forecast, and/or

3) significant motor vehicle traffic is present on the roadway.[29] As well as volume criteria, the specific conditions of the existing roadway and its hazards should be considered.

6. Pavement

Bicycles do not usually have shock absorbing suspension systems, and modern bicycles particularly, with their tires inflated to pressures of 80 pounds or so per square inch, provide very stiff rides. Pavement surfaces should therefore be as smooth as possible. Pavement must be designed to adequately support the load of bicycles and the occasional light maintenance vehicle.

Cobblestones or paving tiles are not recommended as a bikeway surface. These are widely used for paving European bikeways and often result in very uneven riding surfaces. Gravel, stone chip or packed sand bikeways are undesirable since loose gravel, sand or crushed aggregate can induce dangerous skidding. Various types of soil or earth bikeways tend to be unusable in wet weather.

Asphalt provides a very suitable surface for bicycles, is relatively inexpensive in both construction and maintenance costs, and is commonly used for many purposes

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[29]Fisher, p. 39.

in North America. Therefore asphalt generally provides the most feasible bikeway pavement.

The use of full depth hot-mix asphalt pavement laid directly on the sub-grade, and varying in depth from 3 to 6 inches (depending on the quality of the sub-grade) has been recommended.[30]

Where good drainage exists along the whole length of the bikeway it may be advantageous to place a 3 to 4 inch aggregate base of gravel, crushed stone or slag on the sub-grade, laying a 1.5 to 2 inch asphalt surface course over the base.[31]

To eliminate the potential hazard of running off the bikeway pavement, and to retard pavement edge chipping, "the area along the bikeway surface should be backfilled to grade using topsoil, sod or other acceptable material" whenever new bikeways are constructed.[32]

Where Class II bikeways are established, or Class III bikeways are designated on existing streets, pavement conditions must be carefully examined and improved where necessary. The right-hand pavement edges to which cyclists are usually relegated often have the worst paving conditions of the entire street. Common hazards are expansion and paving joints, patching, chuck holes, collections of debris

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[30]National Asphalt Paving Association, "Effective Design for Bicycle Paths," Paving Forum, April 1966, p. 7.

[31]Fisher, p. 33. [32]Smith, p. 42.

and drainage grates. Where bikeways are to be established on existing sidewalks, concrete cracking and upheaval and the necessity for smoothly ramping curb cuts are important considerations.

It cannot be too heavily stressed that the proper maintenance of bikeways is as important as their proper design and construction. Cyclists are extremely reluctant to make use of facilities which are not properly maintained. Thus if bikeway pavement is not maintained in a good state of repair, any advantage to be gained from bikeway provision is lost.

D. CLASS I BIKEWAYS

Independent Bikeways on their own right-of-way are in many ways the most desirable. They are completely separated from motor vehicle and pedestrian traffic, and have a minimum number of interactions and conflicts with other travel modes. These advantages hold true, regardless of whether bikeways are conceived as primarily transportation or recreational routes. Due to the difficulty which often exists in establishing bikeway rights-of-way where they would be useful for transportation in built-up urban areas, and because of preconceived notions linking the concepts of independent bikeways and open space, Class I bikeways are often conceived as mainly recreational facilities in parks and other recreation areas.

Public parks, recreation areas and other open spaces offer feasible opportunities to install Class I bikeways in built-up urban areas. Wherever possible bikeway construction in these areas should coincide with transportation lines of desire. This provides facilities useful to utility cyclists, and does not detract from their usefulness to recreational cyclists. Where it is not possible to provide attractive utility-oriented Class I bikeway routes, and a significant desire for recreational cycling facilities exists, Class I bikeways of purely recreational usefulness can justifiably be constructed in parks and other open space areas.

> Other likely locations for urban Class I bikeways are continuous linear spaces such as railroad and electrical transmission line rights-of-way, river banks, dry creek beds, beach fronts, flood control channel levees, and irrigation canal embankments. These and other similar types of infrequently interrupted spaces . . . provide, in theory, the initial framework for the large scale development of Class I bikeway systems.[33]

Examples of the use of such corridors of opportunity exist in the United States. The Elroy-Sparta Trail of the Wisconsin Bikeway System and about 4000 feet of the Sausalito-Mill Valley (California) Bikeway are situated along railroad rights-of-way. In Culver City, California, a section of urban bikeway is located along a flood control channel, while in Chicago bikeways have been provided along Lake Michigan.[34] In Ottawa bikeways along the Rideau River

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[33]Fisher, p. 48. [34]Ibid.

and Canal penetrate from outlying areas into the downtown core of the city.

The cost of using, leasing, oreven purchasing such rights-of-way is often minimal. Safety considerations, however, may present difficulties in the establishment of bikeways on some such rights-of-way. To protect the leasor's facilities and cyclists, some leasing agreements have required fencing without breaks on both sides of bikeways for extended distances--so undesirable a situation that it might be better to forego use of the right-of-way. In any case, attempts by bikeway planners to make use of such open space corridors require careful investigation of specific possibilities.

Sometimes there may be a temptation to construct Class I bikeways somewhere simply because suitable opportunities exist. If available rights-of-way would not give effective linkages paralleling transportation desire lines, or provide attractive surroundings for recreational cycling, bikeways should not be built.

Where new development (whether subdivision or new town) occurs, integration of Class I bikeways with both transportation systems and park and open space systems is simplified greatly. Where bikeways are desirable in such cases, developers should be encouraged to provide them; as a minimum, sufficient right-of-way for future provision of bikeways should be reserved when planning. There are examples in the United States where

> independent pathways have been designed specifically for utility use, as has been done in new town communities or subdivisions where green belt bikeways extensively penetrate the neighbourhood areas and provide bikeway accessibility to residences completely independent of the motor vehicle roadway structure.[35]

Important considerations in planning such systems are to provide bikeways as parts of continuous open space and park systems incorporating schools, recreation and community centres and facilities as well as access to shopping and the quiet residential streets. Furthermore, to provide the maximum possible commuting usefulness such open space bikeway systems should run in the direction of the strongest travel desire lines (i.e. usually paralleling the direction of major arterial streets serving the development).

Recommendations for the width of Class I bikeways vary. Two-way independent bikeways are far more common than one-way facilities. Even on one-way facilities, however, two lanes are highly desirable to permit passing, and side by side operation of bicycles. The minimum recommended paved width of one-way bikeways would thus be 5.3 to 6.4 feet (Table 7, p. 73). Two-way class I bikeways are, however, far more typical a case, and for maximum flexibility should provide proper operating space for the simultaneous passage of at least three bicycles. Provision for passing cyclists travelling in the same or opposite direction is obviously essential. Furthermore, it must be remembered

[35] Smith, p. 22.

that cycling is often a social activity, and that wherever possible, facilities should allow cyclists to travel two abreast, particularly on bikeways where a significant amount of recreational cycling is expected to occur.

> Many U.S. jurisdictions have adopted standards calling for 8 foot pavement width on independent pathways . . . which would allow simultaneous passage of three bicycles.[36]

Table 7 (p. 73) would, however, suggest that the minimum width for three-lane Class I bikeways was 8.5 to 10.9 feet. Furthermore, in areas where unusually high levels of bikeway utilization are anticipated (perhaps on university campuses or in popular recreation areas) 4 lane bikeways with a paved width of 11.8 to 15.3 feet should be provided. On Class I bikeways the demarcation of lanes through painted definition stripes is not necessary or even desirable, except perhaps at curves.

Considerations of construction and maintenance also influence the width of Class I bikeways.

> Most asphalt pavement is placed with spreaders and mixing plants are geared to the high rates of production that can be achieved with spreaders. Conventional spreaders can place widths ranging from 8' to 12'. If narrow widths are used that preclude the use of conventional spreaders, the cost of hand laying may boost the price per ton of the mix to the point where the narrow hand spread walk will approach the cost of a wider machine laid walk.[37]

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[36] Ibid., p. 24.

[37] National Asphalt Paving Association, p. 7.

Furthermore, to permit passage of a maintenance vehicle such as a pickup truck, Class I bikeways should be at least 8 feet wide.

E. CLASS II BIKEWAYS

1. Street Bikeways

When an attempt is made to introduce a useful bikeway system into a built-up urban area, Class II bikeways on existing street rights-of-way are a common solution. These bikeways must somehow be separated from traffic lanes for motor vehicles. Symbolic separation achieved through striping or pavement markers is common in the United States. In Europe bikeways are often made of pavement types and/or colours different from motor vehicle traffic lanes to achieve the same result. Since the two modes can still easily encroach upon each other, voluntarily or involuntarily, the improvement in safety, where there is no adequate clearance between adjacent travel modes, is marginal at best.

Physical barriers can also be used to separate bikeways from motor vehicle lanes. Such barriers may consist of grade separations, curbs or berms (continuous or not), set backs, pylons, trees, hedges, planter boxes and so on. These physical barriers both delineate the edge of the bikeway and minimize encroachment, and are thus inherently safer than symbolic barriers, particularly where adequate horizontal clearance between the two traffic modes is unavailable.

> In France, the National Highway Safety Council has concluded that physical barriers should be provided for all bikeways that are immediately adjacent to traffic lanes. In the United States the City of Palo Alto, California has recommended physical barriers on bikeways at the approaches to major intersections. The City of Davis, California has provided physical barriers where bikeways have been placed between the parking lane and the curb.[38]

Physical barriers have certain disadvantages, however. They

> make it difficult for cyclists to cross the street at mid-block when necessary to get into the proper directional lane. As a result, they tend to produce bidirectional use with the attendant problems of both bike-bike conflicts in the lane and bicycle-motor vehicle traffic stream conflicts at intersections and driveway crossings.[39]

Certain types of physical barriers (for example trees or parked cars) may also create sight distance problems at intersections and driveways. Maintenance may prove a problem on physically separated Class II bikeways. Where the bikeway is not wide enough for operation of mechanical street sweepers, debris tends to accumulate, discouraging use. These kinds of problems are making the provision of physically-separated Class II bikeways less popular and common in the United States. Some cyclists have stated that they would "prefer a 14 foot wide outside traffic lane to an exclusive 6 foot barricaded bicycle expressway."[40]

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[38]Fisher, pp. 74-75. [39]Smith, p. 18.

[40]John Williams, "Cycling and City Hall," Bike World, June 1975, p. 37.

Single-lane on-street Class II bikeways can be recommended for certain low-traffic-level situations. Effective bikeway width in this case must be at least 3.3 feet, and when the necessary shy distance is added to this, the minimum recommended bikeway width becomes 4.1 feet.[41]

> Observations indicate that when less than 4 feet of bike lane space is provided, the cyclists tend to align their wheel track as closely as possible to the lane definition stripe, increasing the amount of shy distance and physically occupied space, in effect "stolen" from the motor vehicle lane.[42]

On more heavily cycled routes, and where bikeways are physically separated from motor vehicle lanes, Class II bikeways must be two lanes wide to permit passing and/or side-by-side riding. When shy distances are added to the recommended effective bikeway width (5.3 or 6.4 feet from Table 7, p. 73) the actual bikeway width recommended becomes 6.8 to 7.9 feet.

When Class II bikeways are proposed for existing streets, or planned as part of new streets, total street width requirements must be calculated. Bikeway widths have been summarized above. Lanes for motor vehicles should be a minimum of 11 feet wide (local and collector streets in single family residential areas may have 10 foot lanes)[43], while car parking lanes require a width of 8 feet plus in some cases (i.e. where single lane, or heavily used 2 lane

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[41]Fisher, pp. 78-79. [42]Smith, p. 24.

[43]Fisher, p. 81.

bikeways are immediately adjacent) a 2 foot door opening allowance.

Two way Class II bikeways are not recommended, due to the dangers and difficulties of introducing them to motor vehicle and pedestrian traffic at the intersections of an urban street network.[44] Thus the Class II bikeway alternatives to be presented in this section are all one-way and described for one side of the street only. They can be employed symmetrically, or, where conditions warrant, different alternatives can be employed on each side of the street. One-way bike lane couplets along parallel streets which operate bidirectionally for motor vehicle traffic are not recommended, as they often lead to wrong way riding on or out of the bikeways, and lower their utilization.[45]

Figure 16 illustrates alternative forms of Class II bikeways on street rights-of-way.

Alternative A consists of a single bikeway lane located between the outside motor traffic lane and a car parking lane with a 2 foot allowance for opening doors. Parking vehicles must cross the bikeway, and cyclists may have to encroach on car lanes for passing and certain manoeuvres. Consequently the bikeway can only be delineated symbolically (striping or pavement colouring) and considerable encroachment of the bikeway is to be expected. Never-

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[44]Smith, p. 16; Fisher, p. 53. [45]Smith, p. 13.

X = BIKEWAY DEMARCATION SYMBOLS OR BARRIERS

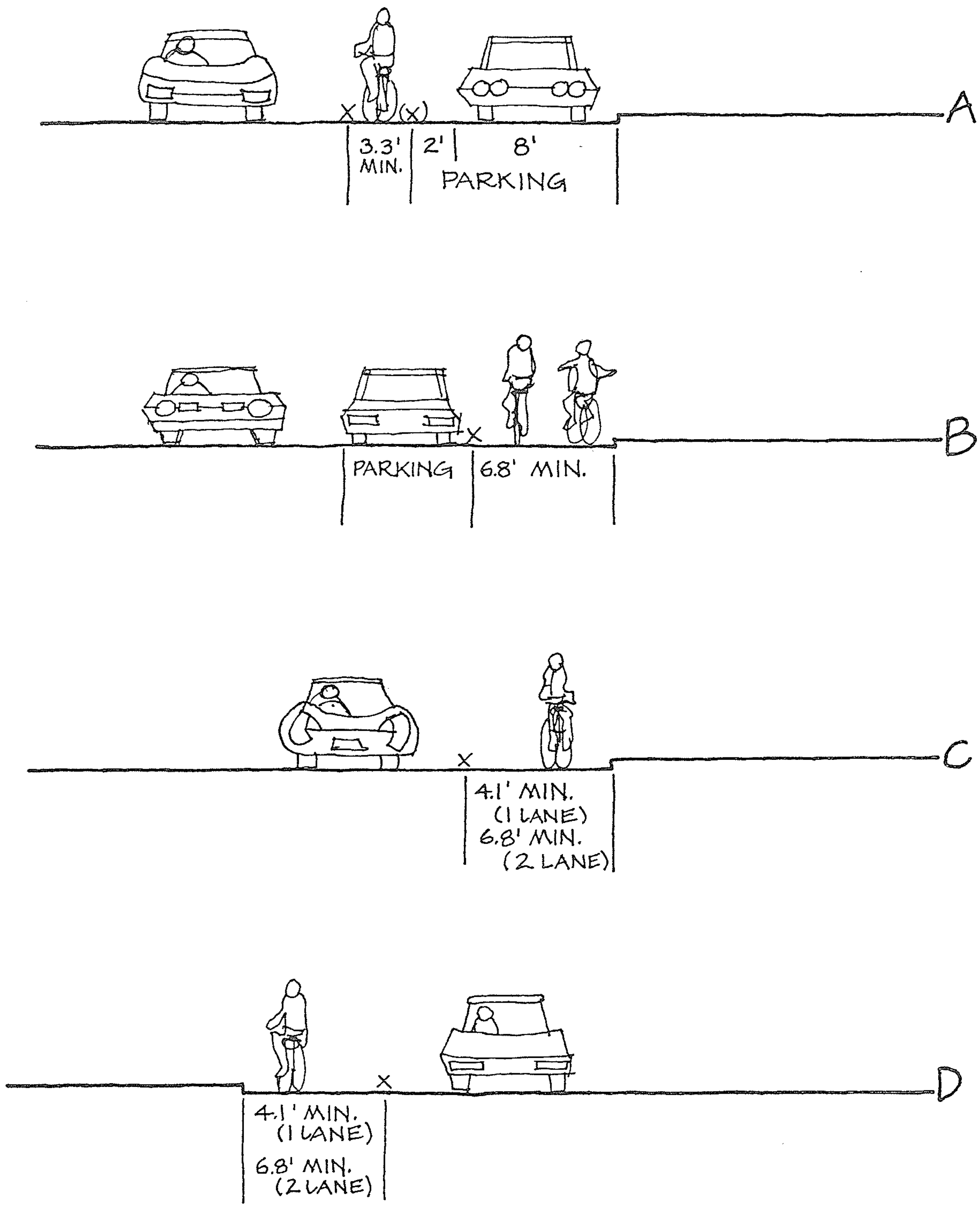

FIGURE 16. CLASS II STREET BIKEWAYS

theless this Class II bikeway alternative clearly defines a space for cyclists, where motorists will expect them to be, and thus reduces parallel moving motor vehicle-bicycle conflicts. This type of bikeway may thus be feasible where bicycle traffic is not heavy, where parking turnover is low, and the outside motor traffic lane is characterized by low volume and low mean speed. Where motor traffic is heavy and fast, contains a high proportion of trucks, wide and multi-axle vehicles, and where the bikeway runs along a bus route, this alternative is not recommended. Where cycle traffic is heavy at certain times of the day or week, as for example commuter cycle routes during weekday rush hours or recreational routes on weekends, it is possible to prohibit parking at these times. The width, capacity, safety and level of service of the bikeway is thus greatly increased during periods of peak demand. The restricted parking concept greatly increases the feasibility of Alternative A in many cases.

Alternative B, by placing the bikeway (two lane minimum width) to the right of the parked car lane, avoids conflicts with both parallel moving traffic and parking cars. A physical barrier between the parking lane and bikeway will prevent encroachment of the bikeway by parked cars. Bicycle-opening car door conflicts, and bicycle conflicts with pedestrian crossflow from parked cars are disadvantages of this alternative. Furthermore, since parked cars may create sight distance problems at driveways and intersections, parking must be prevented at the appropriate distance from the cross street. Finally, where this alternative is used in commercial areas, there may be adverse results on the adjacent land use. Despite these problems, this bikeway alternative, when properly designed, is appropriate on streets with high traffic volumes, and high parking occupancy with low turnover rates.

Alternative C has the bikeway on the right side of a street without parking. The lack of parking is highly desirable, but may be difficult to achieve in many cases. Conflicts with parked cars and associated pedestrians are eliminated. Physical barriers or setbacks between traffic lanes and the bikeway can be used to eliminate conflicts between bicycles and parallel-moving motor vehicles where more than one bikeway lane is provided. As mentioned earlier, maintenance problems and costs may, in low traffic volume cases, make physical separation inappropriate.

Along bus routes there may be significant conflicts between cyclists and buses pulling in, pulling out and stopped at bus stops, or with bus passengers. These are possible under all three of these right hand street Class II bikeway alternatives (Figure 6 A, B, C). Where the bus stopping space is located to the right of the bikeway, bus-bicycle conflicts are inevitable as the bus pulls across the bikeway. Even less desirable is the case where the bus must stop on the bikeway, and there is no provision for cyclist passing. In alternative B the bus stop would normally be placed in the parking lane to the left of the bikeway. In alternatives A and C a similar result could be achieved by swinging the bikeway out to the right around a bus stop islet. To lessen bicycle conflicts with bus passengers, particularly during loading and unloading, it would be desirable to incorporate passenger waiting zones on these islets to the left of the bikeway. To reduce conflicts with passenger cross-flows, to and from the waiting zone, these might well be located at already existing controlled intersections. At other locations passenger crossing-bikeway intersections should be carefully articulated. Due to the numerous problems arising from the routing of bikeways along bus routes of any significant volume, it is recommended that this be avoided if possible.

The final on-street bikeway alternative D (Figure 16) places the bikeway to the left of motorized traffic going in the same direction. This alternative is only possible on one-way streets or streets with a wide median boulevard. Conflicts between bicycles and parking vehicles and stopping buses, as well as with their associated pedestrian crossflows are eliminated. On two-way divided streets cross conflicts between bicycles and motor vehicles are greatly reduced, as those vehicles entering and leaving driveways along the street between intersections, do not come into contact with the bikeway. The left side placement of bikeways also improves

visibility relationships between the cyclist and motor vehicle drivers travelling in the same direction because of the availability of the outside rear view mirror on the left side of the motor vehicle and the driver positioning on the left side.[46]

Left side bikeway positioning, compared to the conventional right side bikeway positioning, exchanges some typical conflict situations for others. Right hand turns, rather than left hand turns become difficult for cyclists. Left rather than right turns by motor vehicles result in conflicts with cyclists travelling in the same direction on the bikeway. On two-way divided boulevard streets, left turns by opposing traffic still result in bicycle-motor vehicle conflicts. Due to the more visible location of the bikeway for the left-turning motor vehicle, however, safety gains are to be expected in this situation.

The single real disadvantage of left side bikeway positioning is that it places cyclists where motorists would not normally expect them. With proper articulation of the bikeway emphasizing the fact of its presence (as is imperative for all bikeways) and, perhaps, physical separation from motor vehicle traffic, this problem can be overcome. In view of its many advantages, it is surprising that alternative D has not been more widely applied. It is, however, used along one way streets in Denver, Colorado, and along two-way divided boulevard streets in Seattle, Washington.[47]

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[46] Smith, p. 13. [47] Ibid.

2. Sidewalk Bikeways

Sidewalk bikeways have been recommended and established, but they have not proved to be desirable. Pedestrian and bicycle traffic are not really compatible. In fact, the operating characteristics of the bicycle (speed, momentum, patterns of movement) are vehicular in nature, and far more similar to those of automobiles than to those of pedestrians. Only in size, mass and vulnerability are cyclists more similar to pedestrians.

> Pedestrians are extremely mobile directionally and often do change direction unpredictably. This factor, coupled with the difference in travel speed (average travel speed for a bicycle is 3 to 4 times the average walking speed) leads to a high conflict potential. Small children often use sidewalks as play areas and they together with their toys can comprise an obstacle course. Older pedestrians and blind persons are particularly uneasy at meetings with cyclists along sidewalks.[48]

Where only symbolic separation of bicycle and pedestrian rights of way is achieved (through signing, striping and/or pavement differentiation) encroachments and resulting conflicts are impossible to avoid.

Visibility problems also tend to arise on sidewalk bikeways. At intersections poor visual relationships are common between motorists and cyclists. Where turning motorists do not expect high speed bicyclists to enter crosswalks, dangerous conflicts result. At driveways also, landscaping, vegetation and fences tend to impair sight

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[48]Ibid., p. 19.

distances.

Furthermore, attempts to route bicycles onto existing sidewalks may prove unsuccessful. Sidewalk surfaces are often of poor quality, and pavement widths may be too narrow. Enough attention is not always paid to the necessity of providing smooth curb cuts for bicycles. In Germany, the numerous very steep curb cuts common on sidewalk bikeways (originally constructed as such, moreover) greatly reduce their utility. The very bumpy ride, and constant slowing-down required, tends to make all cyclists except very small children prefer the street to the bikeway.

Nevertheless, where these potential problems are adequately considered, and there is very low pedestrian usage, or where physical separation between pedestrians and bikeway is possible and pedestrian crossflows are minimal, sidewalk bikeways can be very attractive and effective facilities (Figure 17).

Class I bikeways in parks or recreational areas as described earlier, could through the addition of a pedestrian pathway (minimum width 1.3 feet) become Class II facilities. This is common in German parks, where separation of the two types of traffic is generally symbolic only, achieved with signs and pavement striping or differentiation. This works well where cyclist and/or pedestrian traffic volumes are light, adequate widths are provided for each, and mutual respect between the two forms of traffic prevails. Physical separation of the bikeway

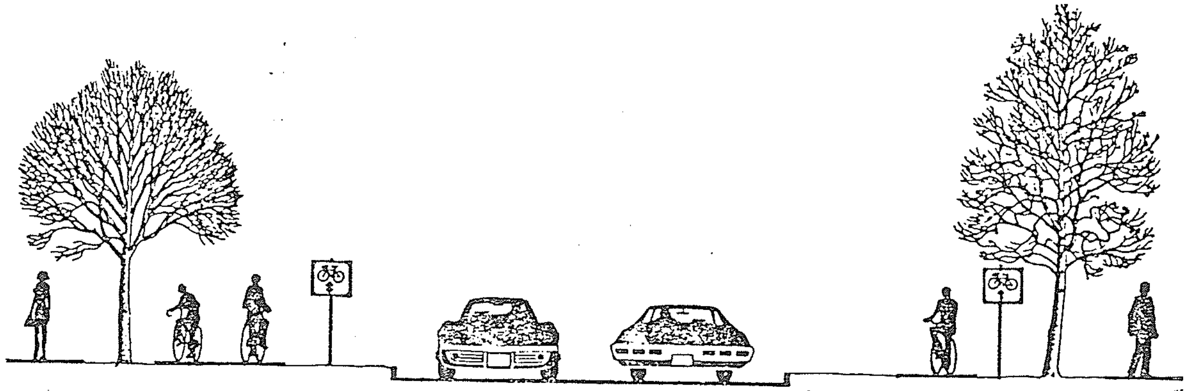

FIGURE 17. CLASS II SIDEWALK BIKEWAY
SOURCE: WINNIPEG, CITY OF, TRANSPORTATION DIVISION, PLANNING DIVISION, WINNIPEG BICYCLE ROUTE STUDY (WINNIPEG: APRIL 1973), P.10.

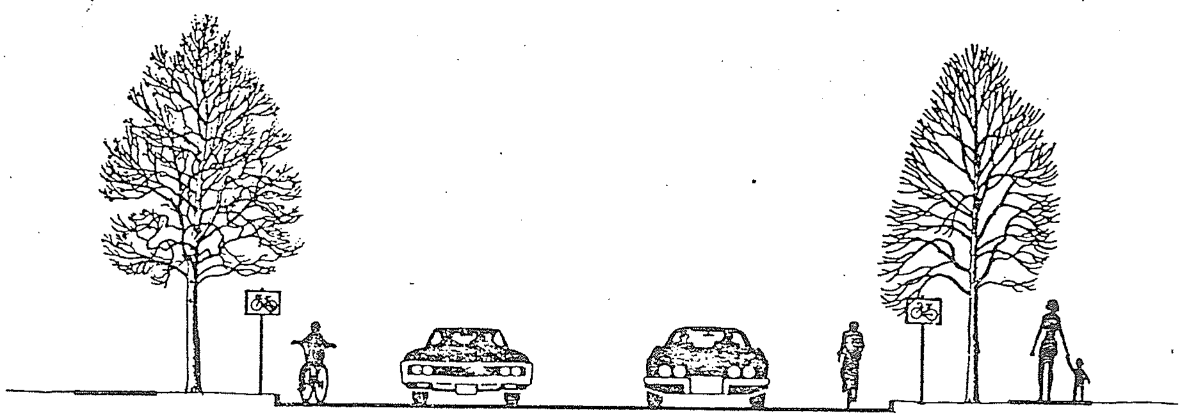

FIGURE 18. CLASS III BIKEWAY
SOURCE: WINNIPEG BICYCLE ROUTE STUDY, P.14.

and pedestrian paths would increase the independence of each right-of-way, but increase the costs of construction and maintenance.

F. CLASS III BIKEWAYS

On the great majority of Class III Bikeways, bicycles share a right-of-way with motor vehicles, just as they do on undesignated, unsigned city streets. Figure 18 shows a typical example.

> The signed bike route or route system has typically been the first step in many jurisdictions' attempts to deal with the bicycle activity boom . . . Establishment of signed routes has unfortunately been used as a temporizing device or to create the illusion of providing facilities by public officials who are unconvinced of bicycle facility needs or uncertain how to implement more advanced types of treatment.[49]

The experience of Palo Alto, California provides an example of the limited effectiveness of a Class III Bikeway.

> In 1967 Palo Alto implemented a 27 mile signed bike route system (a full 15% of the city's street miles) as a one year test demonstration. Results of this demonstration program were indicative of the inadequacies of the signed-route system. In a survey of Palo Alto cyclists, more than 65% of respondents reported that they seldom or never used the signed routes and where usage was reported, it was most frequently incidental and coincidental rather than intentional. Part of the explanation for lack of route utilization was the fact that in many cases the routes did not serve desired activity center destination points. But more importantly cyclists simply were unwilling to ride any distance out of their way in order to use a signed bike route that appeared to offer no obvious travel or safety advantages. The 24% increase in city-wide bicycle-motor vehicle in-

[49]Ibid., p. 7.

cidents in the year after implementation of the bicycle route system offers further evidence of the ineffectiveness of the facilities.[50]

It is, however, impossible to conclude from this example that a properly conceived bikeway system should not make significant use of Class III bikeways. Signs can provide guidance to touring and commuting cyclists, indicating roads with low traffic volumes or desirable grade profile characteristics which function as a part of a continuous bikeway system linking activity centres. For recreational cyclists, routes having the possibility of scenic views or continuity to points of interest, recreational facilities and Class I recreational bikeways may be indicated. Furthermore, some gain in safety should result from guiding cyclists from major arterials and bottlenecks to safer, quieter routes with cycling continuity, where route signs, moreover, alert motor vehicle drivers to anticipate them.

Certain minimum widths are necessary on roads to be designated as Class III bikeways. Where parking occurs the width of the outside lane should be at least 22.1 feet (8 feet for parked cars, 4.1 feet for the cyclist without a door-opening allowance, and 10 feet for motor vehicles). Where parking is prohibited, or the average separation between parked cars is more than 150 feet, the outside

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[50]Ibid.

traffic lane should have a minimum width of 14.1 feet.[51] It is recommended that, whenever possible, parking be removed from streets designated as Class III bikeways.

Class III bikeways are probably appropriate primarily in single family residential neighbourhoods. They can be satisfactory only where cyclist traffic is of low volume, and motor vehicle traffic has low volume and mean speed, consisting essentially of passenger cars. Even in these circumstances, the advantages to be gained by defining a separate right-of-way for cyclists might, where sufficient width exists, well warrant the additional expense of establishing Class II bikeways with pavement stripes or markers.

Class III bikeways where cyclists share a single right-of-way with pedestrians are also in existence. In fact, considerable unsatisfactory experience has been reported from the United States.

> [On the university campus of Davis, California] bike paths are designated "for bicycles and pedestrians". What happens? Cyclists dominate the paths and pedestrians, fearful for their lives, walk in the mud. This happens at surprisingly low volumes--not just peak traffic hours.[52]

Since even a minimal number of cyclists would interfere significantly with pedestrian activity on a shared pedestrian-bicycle Class III facility, this type of bikeway can

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[51] Fisher, pp. 65, 67.

[52] Williams, "Bikeways: Another View," p. 4.

be satisfactory only where there is almost no pedestrian demand. Under such circumstances, designation of sidewalks as Class III bikeways has resulted in facilities which are virtually Class I.[53]

G. INTERSECTIONS

1. The Problem

Where bikeways are placed on streets or along street rights-of-way, intersections become a key design problem. Of all urban motor vehicle-bicycle accidents, a substantial share takes place at intersections, the percentage varying from 40 to 70 in various localities. The facts that in intersections bicycles and motor vehicles must mingle, tending to come into intense conflict, that motorists may not be aware of the presence of cyclists, and that cyclists execute a wide variety of movement patterns when attempting turns, all contribute to the safety problem at intersections.

The first prerequisite for safe intersections is that motor vehicle drivers and cyclists are aware of each other's presence. This means providing proper visibility clearances at all intersections, defining the presence of bikeways in an obvious way (pavement colouring, stripes, stencils and signing) and posting warning signs where motorists may not be aware that bikeways enter an intersection. Similarly, cyclists must be made aware of intersections with motor vehicle pathways in good time. At

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[53]Smith, pp. 18-20.

these intersections, rights-of-way, priorities of passage, and channelization for various turns must be made clear (and enforced) to avoid confusion and dangerous manoeuvres. Signal lights are as appropriate for bicycles at intersections as for motor vehicles and pedestrians. It should be remembered, however, that cyclists, anxious to conserve momentum, tend to treat STOP signs as YIELD signs.

2. Bicycle Left Turns

Making left turns is a hazardous manoeuvre for cyclists, and intersection design for bikeways should provide a safe and definite way to perform this manoeuvre. Figure 19 illustrates some typical ways in which cyclists execute left turns, and the conflict situations with autos that may arise. Path (a) is the left turn pattern most commonly prescribed by authorities, where there are no, or only simple on-street bikeways. It implicitly treats the bicycle as a low priority street vehicle (i.e. as a pedestrian), necessitates the cyclist's waiting for an extra signal phase (or for a gap in traffic across the whole width of the street), and requires a certain amount of dismounting and awkward manoeuvring. Nevertheless at signalized intersections with heavy traffic, it is probably the safest way to make a left turn, exposing the cyclist only to those conflicts and dangers involved in riding straight through two intersections. Path (b) is the same, except that the cyclist passes to the left of cars slowed

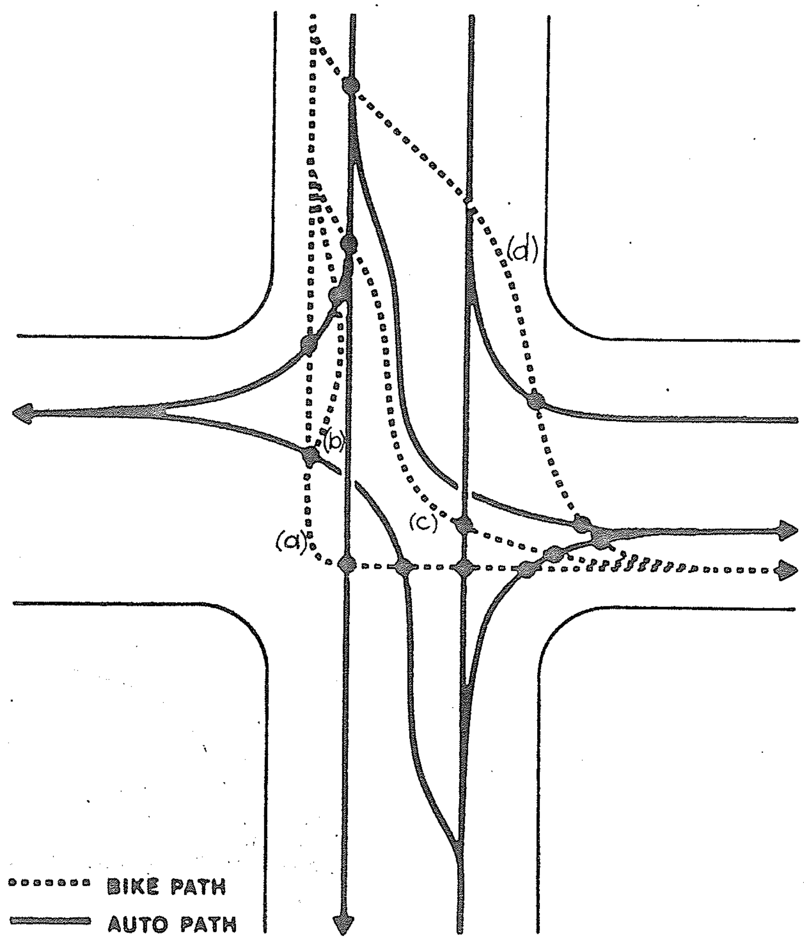

FIGURE 19. BICYCLE LEFT TURNS
SOURCE: SMITH, P. 44

down to make a right turn.

Path (c) is the way a bicycle behaving like a motor vehicle executes a left turn. The cyclist leaves the right edge of the street, moving into the left lane or turning pocket. This manoeuvre is easily performed on quiet streets, or when there are gaps in traffic. It exposes the cyclist to a number of conflict situations with motor vehicles travelling in the same direction, which are avoided by path (a). Furthermore, where a cyclist takes a position to the right than squarely in its centre (where his presence is apt to be resented by motorists) he is exposed to side-swipe danger.

Path (d) is the case where the cyclist approaching an intersection, being desirous of conserving momentum and avoiding delay, makes use of gaps in traffic to cross the street to the far left hand side. He rides wrong way to the intersection. There he makes his turn, crossing to the right side of the road either at once, or proceeding wrong way until a suitable crossing opportunity arises. This movement pattern exposes cyclists to a number of potentially very dangerous conflict situations.

The basic problem of the three left turn patterns other than (a) is the unpredictability with which they may be performed. Only a minority of cyclists signal lane changes or left turns and not all check behind them for oncoming traffic. Furthermore, the manoeuvring sometimes required is beyond the riding capabilities of many cyclists.

Finally, motorists tend to overlook cyclists and their intentions, and to show less courtesy towards them than to other motor vehicles.

3. Motor Vehicle Turns

Cyclists riding straight through intersections also face danger; they are liable to come into conflict with turning motor vehicles. Cars approaching from the opposite direction and making a left turn, are a significant cause of accidents. The drivers of such cars may not see cyclists approaching from the other direction, may underestimate their speed, or may be reluctant to yield right-of-way to an "inferior" vehicle.

Cyclists riding on the right side of a roadway, or on a bikeway to the right of motor traffic are exposed to conflict with right-turning motor vehicles. Accidents resulting from this situation are due to the fact that drivers often do not expect through traffic (other than slow-moving pedestrians) to their right. Car drivers may not see the cyclist, may misjudge his speed, or may expect him to yield to a "superior" vehicle. Cyclists may be unaware of the car's intensions, or may insist on their right of way. Right-turn-only lanes pose a special, aggravated version of this general problem to the cyclist, requiring him to perform manoeuvres similar to the execution of a left turn, often without benefit of the presence of an intersection or traffic controls.

4. Bikeway Intersection Design

The study of accidents at intersections suggests that the provision of clear and visible bikeways, delineating paths for all necessary movements, and defining priorities of passage are the basic requirements of good intersection design for bikeways.

In the United States bikeway markings are sometimes terminated (or marked with dashed rather than solid stripes) some distance before intersections. This is intended to allow the establishment of proper positional relationships between through and turning bicycles and cars, and to eliminate cyclists' expectations of protected bikeway status, which motorists may not respect at intersections.[54] What this bikeway intersection design (or non-design) does is to leave cyclists to fend for themselves at the most hazardous, conflict-ridden points of the street system.

A common European design, which also attempts to provide proper positional relationships between turning and through bicycle and motor traffic is illustrated in Figure 20-A. Its advantages over the null-alternative described above is that it

> provides positive definition by providing designated bike lane space for each of the turning and through cyclist movements positioned alongside motor vehicle lanes reserved for the same purposes respectively. This legitimizes and provides an established pattern for the through and left-turn manoeuvers many cyclists find preferable. Such a design shifts auto-bike interaction away from the area of intense activity at the intersection to its approaches.[55]

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[54] Smith, p. 46. [55] Ibid.

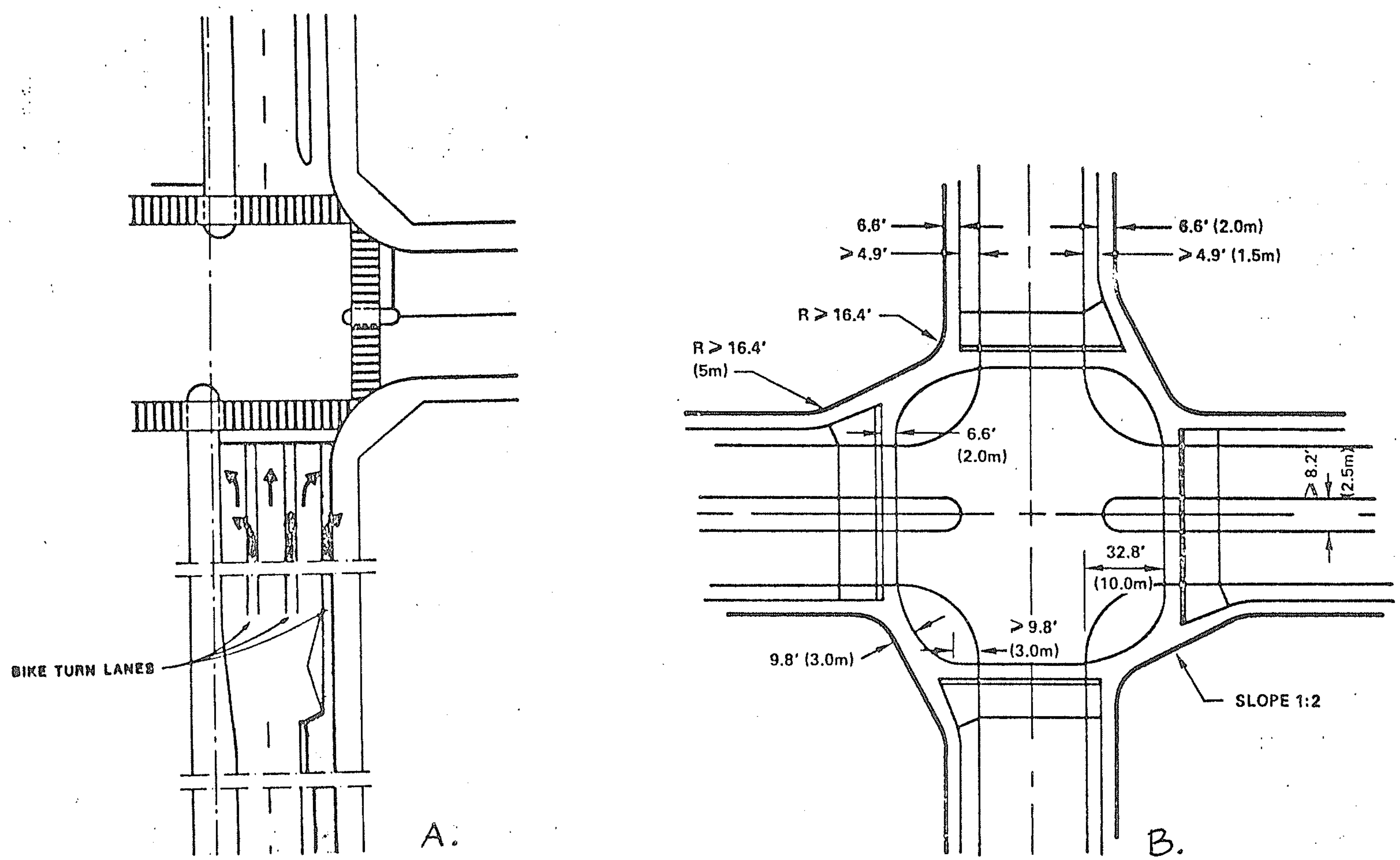

FIGURE 20. BIKEWAY INTERSECTION DESIGNS

SOURCE: SMITH, PP. 47, 48

Potentially dangerous lane changes across motor traffic lanes, with their many bicycle-auto conflict possibilities are still required, however, and may prove very difficult for unskilled cyclists, or where motorists are not sufficiently courteous. Furthermore, cyclists between two lanes of moving traffic tend to feel dangerously exposed, and in this design protection for cyclist rights-of-way is basically symbolic and may not be respected. The legitimization of necessary manoeuvres by cyclists, and the expectation of, and consideration for them by motorists which results is however a big advantage of this design. It is particularly appropriate, and indeed necessary to employ similar designs where right-turn-only lanes branch off from streets with bikeways.

Another type of common European intersection design for bikeways is illustrated in Figure 20-B. This places a bikeway loop around the motor vehicle intersection. Cyclists in this design are treated similarly to pedestrians and can be easily controlled by traffic signals. Paths for turns and through cycling are continuous and clear, and the specifics of the design can be dimensioned to force cyclists to reduce speed where necessary. The offset location of the bikeway crossings causes the meeting of cyclists and right-turning motor vehicles to occur at right angles. The location of bicycle traffic and the governing priorities of passage are clearly spelled out for motorists. Physical separation of bicycle and motor traffic can (and should be) simply achieved. Queuing space for bicycles can be provided to reduce conflicts between automobiles and waiting bicycles. A disadvantage of this design is the increased amount of intersection space required. This can be reduced through modification of the offset nature of the bikeways. Another disadvantage is the delay caused, in many instances, for left-turning cyclists who must wait through two signal phases. At busy intersections with no bikeway provisions, however, cyclists must often make left turns in a similar way, facing more hazards and manoeuvrings. All in all, this design (or one of its many possible modifications[56]) is the most suitable for handling intersections of Class II bikeways on street rights-of-way.

Class I bikeways must also occasionally cross motor vehicle roadways. Typically this occurs away from roadway intersections, at isolated locations. The effect of factors leading to accidents at intersections is therefore intensified.

Grade separation is the most positive way of ensuring safety at Class I bikeway intersections with roadways. The structures required are, however, expensive and occupy much space. Therefore grade separation is generally feasible only at extremely busy crossings, at crossings of high speed roadways, or where new development allows economical planning and implementation with initial construction.

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[56]see Fisher, pp. 101-107, for examples.

Where grade separation cannot be employed, provision of proper sight clearance zones, and prominent placement of crossing warning signs and markings for both motorists and cyclists, are important. Since cyclists tend to disregard STOP and YIELD signs to some extent, the use of physical constraints such as curves, fences, posts, berms and grades, to force slowing or stopping, is appropriate. Where motor traffic volumes are lower or equal to bicycle crossing volumes, STOP or YIELD controls should be placed on the roadway instead of, or as well as on the bikeway. Motor vehicle drivers tend to respect such signs more than cyclists.

H. BIKEWAY SIGNING

Existing recommendations for bikeway signing in the United States are summarized below:

1. Adequate signing is necessary at all decision points along the bikeway. These include:

(a) Signs informing the cyclist of upcoming directional changes.

(b) Confirmatory signs to ensure that route direction has been accurately comprehended.

2. Route or guide signing must be provided at regular intervals in order that:

(a) Newcomers to the route know that they are travelling on an officially designated bikeway.

(b) Cyclists already on the bikeway, especially in shared-facility bikeroutes, do not stray from it and lose their way.

3. Warning signs informing motorists that bikes

may be encountered should be positioned:

(a) Whenever a bikeway crosses the roadway.

(b) When a bikeway either begins or ends.

(c) At any other points where large numbers of bikes may be expected (e.g., parks, schools, recreational facilities).

4. In urban areas, motorist-directed warning signs should be positioned a minimum of one-half block before bikes may be encountered.

5. Warning signs informing bicyclists of potential hazards require the following specifications:

(a) Along bikelanes and bikeroutes, signs directed toward the motorist may also aid the cyclist. Little if any modification of existing procedures is necessary in such cases.

(b) Along bikepaths and for all hazardous conditions on bikelanes or bikeroutes for which there are no existing signs specific bicycle-directed warning signs should be erected. In order to provide sufficient response time, these should be positioned not less than 50 feet in advance of the condition toward which they are directed.

6. As an aid in uniformity, speed, and accuracy of comprehension, standard signs are recommended.

7. Stencilled pavement messages consisting of the standard "Bike Route" design are generally not recommended for use on restricted or shared bikeways, with the possible exception of bikelane sidewalk alternatives.[57]

Ideally the design of bikeways should be clear and obvious enough so that bikeway signs simply reinforce what is otherwise visible, and do not have to convey primary information. Bikeways might well be constructed of a speci-

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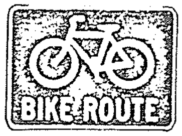
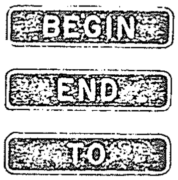
[57]James P. Hamill, Planning and Development of Bikeway Systems (Management Information Service, April 1973), p. 20.

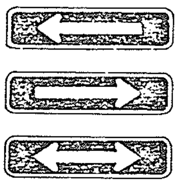
BIKE ROUTE DESIGNATION SIGNS (White on green Background)



Standard Route Sign



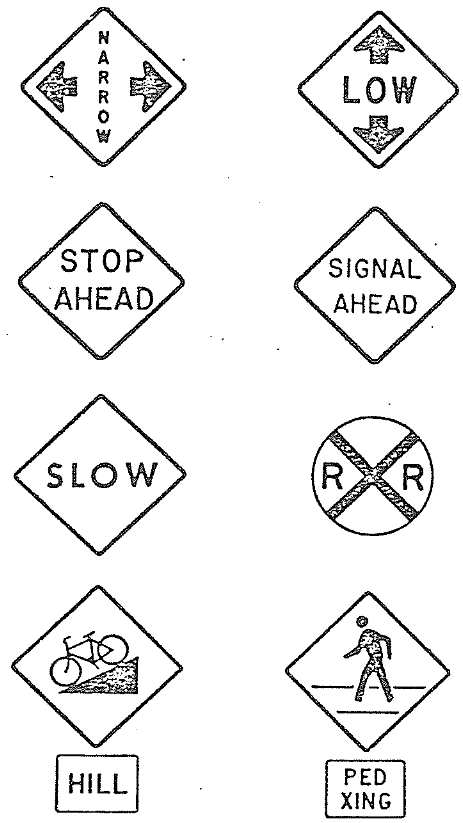
Message Plates
To be mounted above the official marker to designate the beginning and ending of the bike route, and to trailblaze to the bikeway.



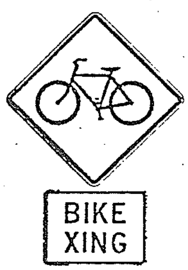
Directional Plates
To be mounted below the official marker to guide cyclists along the bikeway and to trailblaze to the bikeway.

Example destination signs for use at major decision points. The signs should be mounted below the official marker.

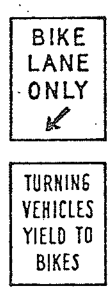
CYCLIST DIRECTED WARNING SIGNS
(Black on yellow Background)



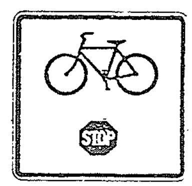
MOTOR VEHICLE DIRECTED AND WARNING SIGNS



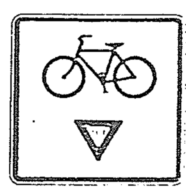
Black on yellow Background



Black on white Background



Used at connections of Class I and II bikeways with roadways and at roadway crossings where engineering studies find that they are required. Not generally used on Class III bikeways.



Used at roadway crossings of Class I and II bikeways when the crossing is located where automobiles are controlled by a stop sign. Not generally used on Class III bikeways.

Used at pedestrian crossings on Class I bikeways and at other locations where engineering studies find that they are required.

PAVEMENT MARKING

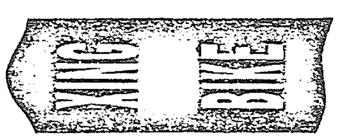


FIGURE 21. BIKEWAY SIGNING
SOURCE: OREGON STATE HIGHWAY DIVISION, PP. 24-30.

fic and distinctive pavement colour throughout an entire urban area. Asphalt coloured a dark cherry red (through either coloured mix or acrylic painting) has been recommended for the construction of all bikeways in Toronto[58] and is common in Germany and Holland. Otherwise bikeways must be indicated through distinctive pavement type, stencilling or striping. Proper sight clearances should always be provided so that motorists and cyclists are always expected and visible at possible points of conflict. Continuity of bikeways should be clearly maintained, and at decision points the choice of path available to cyclists should be clearly articulated.

With proper bikeway design fulfilling the above criteria, signs can then be used to emphasize the existence of a bikeway to warn motorists and cyclists of possible conflicts and hazards, and to direct cyclists to and along bikeways, informing them of destinations and emphasizing system continuity. A comprehensive United States example of bikeway signing is illustrated in Figure 21.

I. BICYCLE PARKING AND MIXED-MODE JOURNEYS

Even where no parking facilities are provided for bicycles, cyclists find opportunities. Bicycles are commonly seen chained to lamps and sign posts, fences and trees, or leaned against walls and windows. These are not, however, the best possible or safest spots for bicycles,

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[58]Strok, p. 78.

and where bicycle use is high, bicycles parked in inappropriate places may become a nuisance.

Bicycle parking facilities should be located at cyclist destinations, provide opportunity for locking and be in obvious public view or under supervision. Good standard bicycle rack and slotted pavement designs for parking are available. Lockers to fully enclose bicycles are becoming increasingly popular in large crime-plagued cities of the United States. Facilities can be provided partly by municipal authorities. Private firms and institutions should also be encouraged to provide bicycle parking. It must always be borne in mind that bicycle storage facilities are an integral component of any bikeway system.

Bicycle parking especially becomes a prime consideration when mixed-mode travel is considered. Mixed-mode journeys involving cycling have long been important in Europe. In Denmark, in the area around Copenhagen, cycling between home and the local regional railway station is a basic commuter pattern. In the United States too, the practice of providing bicycle parking racks at major stations of public transport systems has become widespread.[59] San Francisco's Bay Area Rapid Transit System provides lockers for commuters who cycle to the train.[60] Bicycles

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[59] Fisher, p. 150.

[60] Noel Grove, "Bicycles are Back--and Booming!" National Geographic, May 1973, p. 672.

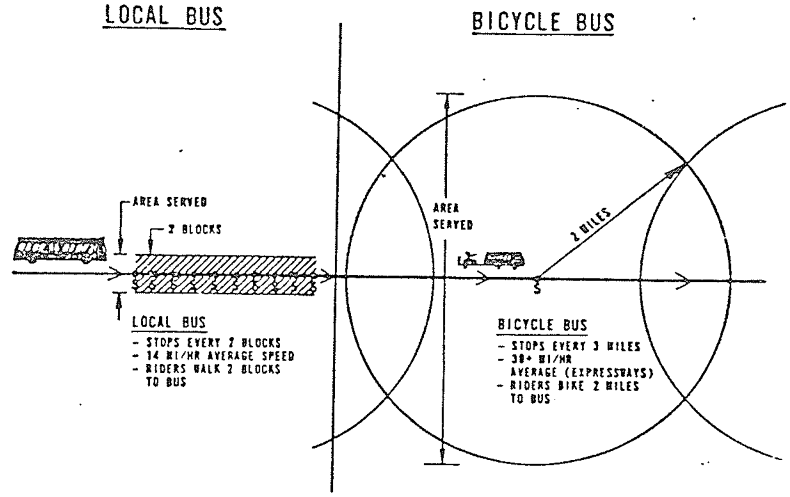
can provide an excellent feeder system for others forms of transportation. The "park and ride" concept is becoming an important part of North American public transport systems, and more and more large automobile parking facilities are provided at the peripheral stations of metropolitan areas. It is interesting to consider that one automobile parking spot can accommodate 16 bicycles.

Bicycles can also be transported by other vehicles. Bicycle carriers mounted on the rear of automobiles and folding bicycles are becoming increasingly common. Some fairly long-distance commuters transport their bicycles in automobiles, find free parking spots reasonably close to their place of work, and then cycle the rest of the way.

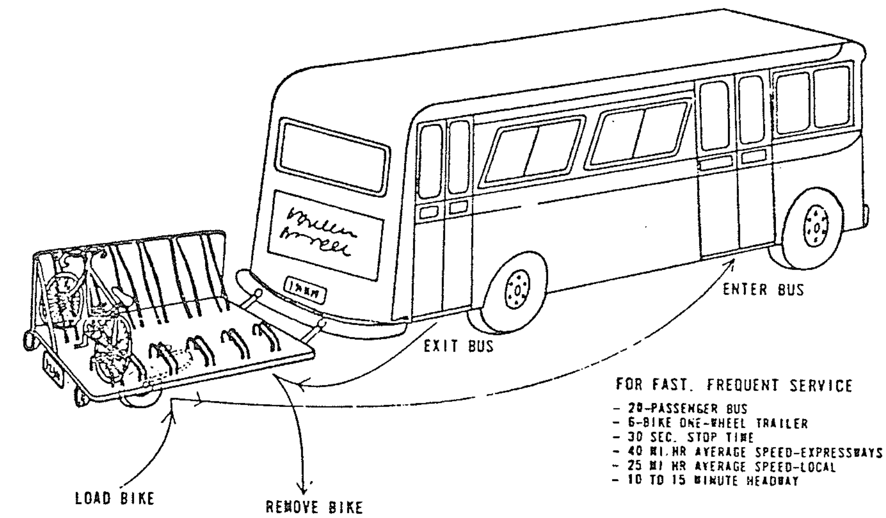
A bicycle-bus was initiated across the San Francisco Bay Bridge for a limited period of time to carry cyclists and their bicycles between Oakland and San Francisco.[61] This concept of the bicycle-bus has been developed in great detail, as is illustrated in Figure 22. It is argued that the transport of bicycles on public transportation promises the possibility of average trip speeds more competitive with automobiles.[62] This concept, however, appears suitable only for areas with mild climates all year round. In other localities, a bicycle-bus might perform a useful role

[61] The Bicycle Madness, "Life," July 30, 1971, p. 31.

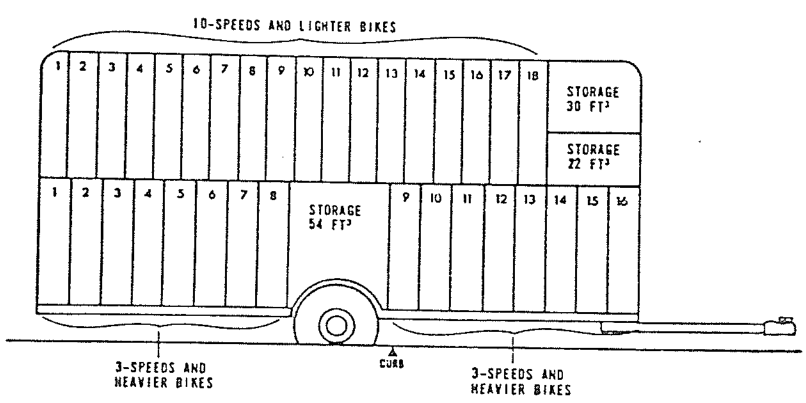
[62] David M. Eggleston, "Toward a Dual-Mode Bicycle Transportation System," M.A.U.D.E.P. Proceedings 1972, pp. 187-197.



Bicycle-bus — potential ridership.



20-Passenger bus plus 6-bike trailer.



34-bike trailer with baggage compartments.

FIGURE 22. THE BICYCLE BUS CONCEPT

SOURCE: EGGLESTON, PP. 192, 194, 195.

in serving outlying recreation areas during the summer, greatly increasing the potential recreational use of bicycles for urban dwellers.

It is possible to imagine that provision for mixed-mode journeys involving cycling could result in a shift of the transportation complex of downtown areas and central business districts. Increased automobile parking peripheral to downtown areas, or public transport systems feeding cyclists and bicycles into the downtown, could conceivably cause a sizable shift to bicycle usage within city centres. This might significantly relieve parking and traffic congestion there. In such limited areas, the enclosing of large complexes or paths to permit year-round cycling and walking, might even prove feasible.

It should be realized that the implications of mixed-mode journeys on bikeway concepts and planning might be considerable.

> That is to say, if mixed-mode usage becomes more prevalent than singular bicycle use, then a bikeway system network that criss-crosses an entire urban area may be less effective than a set of short length bikeways within, and radiating out from, employment or other trip generation centres to peripheral automobile parking facilities.[63]

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[63]Fisher, p. 151.

Chapter 3

IMPLEMENTATION

A. COSTS

Costs of bikeways will vary greatly. Nevertheless it is important to review the actual and estimated costs of various bikeway facilities recently constructed or planned in North America, so as to acquire some rough idea of the magnitude of expenditure per mile for different kinds of bikeways.

In California in 1972 the cost for a Class I independent bikeway was estimated at $8,000 per mile.[1] In Oregon in 1972 the average cost of 8 foot wide Class I bikeways was estimated as $36,000 excluding the cost of structures.[2] In Guelph the cost of construction of an 8 foot Class I bikeway in 1973 was $20,000 per mile ($8,400 for asphalt plus $11,600 for excavation and gravel), but was expected to drop to $15,800 per mile in the future.[3] In

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[1] Vincent R. Desimone, "Planning Criteria for Bikeways, "Proceedings of the Pedestrian/Bicycle Planning and Design Seminar, San Francisco, 1972, M.A.U.D.E.P. (Berkeley: Institute of Transportation and Traffic Engineering, July 1973), p. 174.

[2] James D. McClure, "Oregon Bikeway Program," M.A.U.D.E.P. Proceedings 1972, p. 212.

[3] Guelph Transportation Plan, Bicycleway Pilot Project: Interim Report No. 6 (Guelph: 1973), pp. 23-24.

Toronto in 1974 the cost for constructing an 8 foot wide Class I bikeway was estimated as $46,790 per mile; cost for a 6 foot bikeway was estimated as $38,880 per mile, and of a 3.5 foot bikeway as $36,580 per mile.[4] In Winnipeg in 1973 the cost of an 8 foot bikeway was estimated as $18,500 per mile, while two one-way paths of 5 feet each were estimated as costing $24,500 per mile.[5] The cost of an 8 foot wide Class I bikeway actually constructed in Winnipeg in 1975, however, was about $40,000 per mile.[6]

In Oregon in 1972 the average cost of constructing Class II bikeways was $16,000 per mile.[7] In California in 1972 the implementation of on-street Class II bikeways through signing and lane striping was estimated as costing $2,000 per mile.[8] In Guelph in 1973 this cost was estimated at $1,220 per mile with possibly an additional cost of $2,500 for the replacement of 25 catch basin covers per mile.[9]

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[4] W. Strok and Associates Limited, Bikeway System within Metropolitan Toronto (Municipality of Metropolitan Toronto, April 1974), pp. 78, 84.

[5] Winnipeg, City of, Transportation Division, Planning Division, Winnipeg Bicycle Route Study (Winnipeg: April, 1973), p. 19.

[6] Winnipeg, City of, Streets and Transportation Division.

[7] McClure, p. 212.

[8] Desimone, p. 174.

[9] Guelph, p. 24.

Implementation of Class III bikeways has been estimated as costing $1,500[10] or $720[11] per mile for signs and pavement markings at main road crossings.

Grade separations for 10 foot wide bikeways are estimated as costing $250 to $350 per linear foot for overcrossings, or $200 to $250 per linear foot for undercrossings or tunnels.[12] The cost of attaching a 10 foot wide cantilevered bikeway to an existing bridge is estimated at $155 per linear foot.[13]

For safety and security reasons lighting of independent Class I bikeways would be necessary if they were to be used at night. Cost would be comparable to that of lighting a residential roadway and might be as much as $63,360 per mile.[14] Experimental lighting of some independent bikeways, as well as research to establish the extent of increases in safety and after-dark use which results has been recommended in Toronto.

The cost of landscaping an average mile of Class I bikeway in Toronto in order to achieve a pleasing aesthetic environment was estimated as $5,280.[15]

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[10]Desimone, p. 174. [11]Guelph, p. 24.

[12]Desimone, p. 174.

[13]G. Fisher and others, Bikeway Planning Criteria and Guidelines (Los Angeles: Institute of Transportation and Traffic Engineering, University of California, 1972), p. A-3.

[14]Strok, p. 81

[15]Ibid.

The cost of maintenance for Class III and non-physically-separated Class II bikeways would be minimal, as implementation of such bikeways would not greatly increase total roadway maintenance costs already existing. The cost of maintaining physically separate Class II, as well as Class I bikeways has been estimated as being about $1,600 per mile per year.[16]

In Oregon some preliminary investigation has been done to determine the cost of bikeways per bicycle-user mile (analagous to the American highway cost of $0.02 per automobile-user mile). For bikeways costing $16,000 per mile and having an average daily traffic volume of 100 bicycles this cost per bicycle-user mile would be approximately $0.10. It is suggested that an anticipated average daily traffic volume of 100 bicycles would be the minimum that could warrant bikeway construction, but also expected that in most cases bikeway construction will so increase bicycle usage that this minimum will be far exceeded.[17]

If money is to be spent on a bikeway system for an urban area, some kind of cost-benefit analysis is necessary to establish the amount of expenditure which is warranted. This can be based on an estimate of the number of bicycle trips which would be made if facilities were provided, and on a "benefit value" set per bicycle trip. Such a study has been done for the Twin Cities of Minneapolis and St. Paul,

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[16]Ibid., p. 82. [17]McClure, p. 214.

Minnesota. An analysis of existing motor vehicle trips by length, purpose and character (such as flexibility of scheduling) was made, as summarized in Table 9. This led to the conclusion that during the six-month cycling season, almost 250,000 of the roughly 3,100,000 vehicular trips made daily could be made by bicycle if a comprehensive system of bicycling facilities were provided for the metropolitan region. A benefit value of $0.05 to $0.10 for each one of these bicycle trips could reasonably be set; this is considerably less than the benefit value implicitly accepted for the Twin Cities transit system--$0.40 (fare plus subsidy) per passenger. Using these criteria, an expenditure of $1,500,000 to $3,000,000 annually would be justified. This is in the order of 1 percent of the $176,000,000 of Twin Cities public funds spent on the automobile in 1969.[18] Other studies made in the United States also suggest that the expenditure of 1 percent of total transportation budgets on bicycle facilities can easily be justified.[19]

B. FINANCING

The desirability of providing facilities for bicycles

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[18] Carl E. Ohm, "Estimating Potential Bicycle Use and Public Investment," Proceedings of the Seminar on Bicycle/Pedestrian Planning and Design: December 1974, M.A.U.D.E.P. (New York: American Society of Civil Engineers, 1974), pp. 582-595.

[19] Richard C. Podolske, "Investing in Urban Bicycle Facilities: How Much? What Type? Where?," M.A.U.D.E.P. Proceedings 1974, pp. 596-613.

TABLE 9.

MINNEAPOLIS ST. PAUL POTENTIAL BICYCLE USE

VEHICULAR TRIPS THAT CAN BE ATTRACTED TO THE BICYCLE AS THE PRIMARY MODE

Trip Purpose	Percentage of Vehicular Trips Less Than Six Minutes in Duration	Total Number of Daily Home-based Vehicular Trips	Number of Vehicular Trips That Take Six Minutes or less to Complete	Percentage of Trips Six Minutes or Less in Duration That Will Be Made by Bicycle	Number of Vehicular Trips That Would Be Attracted to Bicycle Use if Proper Facilities Were Provided
School	20.1%	160,445	32,249	50%	16,124
Personal Business	40.5%	665,580	269,560	30%	80,868
Recreation	35.0% (approximation)	817,175	286,011	30%	85,803
Shopping	48.6%	565,809	274,983	20%	54,997
Work	18.9%	829,292	156,736	5%	7,837
Medical	14.0%	47,914	6,708	5%	335
Total					247,964

SOURCE: M.A.U.D.E.P. PROCEEDINGS 1974, P. 593.

in urban areas is clear. In comparison to other forms of transportation, however, the ability of the bicycle to produce revenue is severely limited, particularly in view of the present underdeveloped state of bicycle movement facilities. The automobile generates revenue through gasoline taxation, public transit through fares, but bicycles produce revenue only through licensing fees and general sales tax.

When bikeway systems are implemented in urban areas, municipal governments will bear prime responsibility. A relatively small proportion of the cost might reasonably be raised through compulsory bicycle licence or registration fees. The administrative costs of such programs are relatively high, but they are already in existence in many cities as a means of raising general revenue and of returning lost and stolen bicycles to their owners.

The least expensive, simplest and most practical source of funds for municipalities constructing bikeways will be general revenues, notably property taxes. This may be criticized as inequitable, since a bikeway system might be regarded as being of benefit to only a minority of the public. This is, however, true of almost all public expenditures. The benefits to society as a whole, of increased bicycle use for urban transportation are clear, and many authorities have agreed that the expenditure of 1 percent of a total transportation budget for bicycle facilities is entirely justifiable. Furthermore expenditures on certain kinds of bikeways can be made from recreation budgets. Examination of public expenditure per participant hour for bicycling versus other participant sports such as golfing, tennis and swimming can generally be expected to find bicycling comparatively neglected.[20]

In the United States, federal funds for bicycle facilities are available to the states and local governments. The Federal Highways Administration of the Department of Transportation will provide state highway departments with funds for bikeway construction. The Department of the Interior, through the Bureau of Outdoor Recreation, provides bikeway funding on a cost-sharing basis under the Legacy of Parks program and Land and Water Conservation Fund. Federal assistance is also available through grant programs under Department of Housing and Urban Development, Urban Renewal, Community Development, and Open Space Land Programs.[21]

On the state level, too, funds for bicycle facilities are being made available in the United States. Legislation in Oregon has made it mandatory to allocate a minimum of 1 percent of state highway funds to the development of bikeways.[22] New York, Maryland and Washington are among other

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[20]Ibid., p. 599.

[21]United States Department of Transportation, National Highway Traffic Safety Administration, Pedestrian and Bicycle Safety Study (Washington, D.C.: March 1975), pp. 90, 94.

[22]James P. Hamill, Planning and Development of Bikeway Systems (Management Information Service, April 1973), p. 2.

states also providing for the use of state Highway Trust Funds for bikeways.[23] In Massachusetts 1 percent of gas tax revenue is to go into a special fund for the constructinn and maintenance of bikeways for commuting purposes.[24]

In Canada, however, there has been no legislation providing specifically for federal or provincial funding of bicycle facilities. Provincial governments generally promote bicycle safety and fund some cyclist and motorist education programs. In Ontario, bicycle facility planning is recognized as a shareable cost in municipal transportation studies. Municipal expenditures for actually providing any bicycle facilities are not, however, eligible for any provincial subsidy.[25] It is interesting to note that on the basis of an estimated $4.00 in average sales tax per new bicycle sold, the provincial governments in Canada probably received a total of about $6,000,000 from retail sales tax on bicycles in 1973. This might reasonably be viewed as a possible source of bikeway funds.

C. PUBLIC PARTICIPATION

During the current bicycle boom in North America the first impetus for bikeways in most localities has come from

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[23] A. Trent Germano and others, "The Emerging Needs of Bicycle Transportation," Highway Research Record, Number 436 (1973), p. 11.

[24] Bicycling! March 1976, p. 16.

[25] Ontario Ministry of Transportation and Communications, A Review of the Ministry's Positinn with Respect to Bicycling (Route Projects Planning Office, October 1974), p. 3.

cycling enthusiasts demanding facilities. Pressure was applied by citizen activist groups, with city committees or city officials raising the bikeway concept as a political issue.[26] This strong history of community participation in the bikeway movement, which has ranged from simple lobbying efforts to the production of professional reports on the feasibility of bikeway systems, makes the general lack of community input during the bikeway planning process, after local governments have been aroused to act, particularly surprising.[27]

Usually, when the need for, or political desirability of providing bicycle facilities, has been accepted by local authorities, a planner has been assigned to develop a plan. Bikeway proponents have generally agreed that it is most desirable for bikeway planning to be done within the Transportation Department of a city, rather than by the Planning or Recreation Department. It is believed that transportation engineers will be most able to apply practical techniques most likely to result in useful and adequate bikeway systems. Planners in Planning Departments are regarded as dealing with less practical matters, and seen as likely to come up with elaborate, long-range bikeway development plans, which may or may not meet cyclists' needs, but which are un-

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[26] John M. Freiermuth, "Now That You Have One, What Have You Done For Your Bikeway Lately?," M.A.U.D.E.P. Proceedings 1974, pp. 151-154.

[27] Fisher, p. 147.

likely to be implemented.[28] Recreation Departments are expected to develop very one-sided bikeway proposals. In the United States, too many bikeways have been designed by park trails planners who have been more oriented to the needs of pedestrians, and by landscape architects more concerned with the visual aspects of a facility than its functional service qualities.[29]

The bikeway planner must approach his work seriously, basing his concepts and designs on adequate research of the needs and desires of cyclists, and the present and potential patterns of cycling activity. The importance of establishing a framework to provide for representations from all concerned bodies in the community at every stage of the planning process cannot be overemphasized. Similarly, participation of cyclists and cycling groups in formulating and evaluating the entire bikeway plan from its basic concepts to its finest details, is essential.

In some instances the task of planning bikeway facilities may be assigned to an appointed citizens' commission. In Portland, Oregon, for example, a Bicycle Path Task Force composed of bicycle advocates and members of the general public was appointed to develop bicycle facility plans.

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[28] John Williams, "Cycling and City Hall," Bike World, June 1975, pp. 36-39.

[29] Dan Smith, Bikeways: State of the Art 1974 (San Francisco: De Leuw Cather and Company, July 1974), p. 23.

This commission received aid from the appropriate city staff (parks, planning, traffic engineering, traffic safety, city engineer) and also used a plan prepared by a city engineer as a preliminary source of information. Public hearings provided another important source of facts, opinion and feeback to the commission.[30]

After a bikeway plan is drawn up it must be presented to the elected body of the local government to be adopted, perhaps as part of the community's development plan. If the bikeway plan is accepted, funds must be provided for implementation. Implementation has generally been in stages, with a first stage representing an experimental or test bikeway route, carefully chosen and then monitored after construction, to establish patterns of usage and reactions from cyclists and the general public.

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[30]Betty Barker, "Bike Freaks in City Hall: The Portland Experiment in Citizen Planning," M.A.U.D.E.P. Proceedings 1972, pp. 216-217.

PART TWO:

CASE STUDY: A BIKEWAY SYSTEM FOR WINNIPEG

Chapter 4

THE NEED FOR BIKEWAYS IN WINNIPEG

A. INCREASING BICYCLE USE

As in the rest of Canada, bicycle sales and use have increased dramatically in Winnipeg during the last few years. The use of bicycles for both commuting and recreational purposes, particularly among adults, has become increasingly obvious on the streets of the city. Very little has been done to document the extent of bicycle use, and data dealing with bicycles in Winnipeg is extremely scarce, perhaps because the bicycle is still regarded primarily as a children's toy, unworthy of serious consideration.

Bicycle use in Winnipeg declined from the end of the Second World War until 1970. In the Inner City (i.e. Old City of Winnipeg) for example, about 25,000 bicycles were registered just after the war, but from then on, the number of licenses issued annually declined steadily, reaching a low of 16,104 registrations in 1970. After 1970, however, bicycle registrations in both the inner city and the suburbs stopped decreasing, and began to increase dramatically.[1]

[1]Most of the old municipalities of Winnipeg which formerly issued bicycle licenses have no record of the number sold each year. Data was available only for the City of Winnipeg, Charleswood, West Kildonan and East Kildonan, from the License Branch, City of Winnipeg and the Community Offices.

In the last three years, over 60,000 bicycles were registered yearly in the City of Winnipeg:

1973	64,270
1974	68,289
1975	61,312

The decline in the number of licences issued during 1975 is not attributed to any decrease in bicycle use, but rather to a let-up in enforcement activity (search for and fining of unlicenced bicycles), particularly in the suburbs.[2]

The increase in ownership of adult bicycles during the 1970s in Manitoba is evident from the table below:

Table 10

Manitoba Households with Adult-Size Bicycles
(estimates in thousands)

Year	Total Households	Households with Adult-Size Bicycles	
		one or more	two or more
1972	287	91 (31.7%)	39 (13.6%)
1973	292	86 (29.5%)	37 (12.7%)
1974	306	102 (33.3%)	46 (15.0%)
1975	311	114 (36.7%)	49 (15.8%)

Information: Statistics Canada, Household Facilities and Equipment, Cat. 64-202, 1972, 1973, 1974, 1975.

[2]Interview with Mr. Barrie, Inspector of Licences, City of Winnipeg.

B. BICYCLE ACCIDENTS

Records dealing with traffic accidents involving bicycles are almost the only available source of data dealing with bicycle use in Winnipeg. This information is of great value for any attempt to increase bicycle safety, and can also be used to infer much concerning the patterns of bicycle use in Winnipeg.

1. The Increase in Bicycle Accidents

Reflecting increased bicycle use, the number of bicycle accidents in Winnipeg has risen rapidly in the last few years. Table 11 below shows how the number of bicycle deaths and injuries has doubled in urban Manitoba (i.e. within the city limits of Winnipeg and Brandon) within the 5 years from 1969 to 1974.

Table 11

Bicycle Accidents in Urban Manitoba (Winnipeg and Brandon)

	Deaths	Injuries
1969	1	129
1970	1	138
1971	1	146
1972	4	212
1973	3	219
1974	2	259

Information: Motor Vehicle Branch, Manitoba Department of Highways.

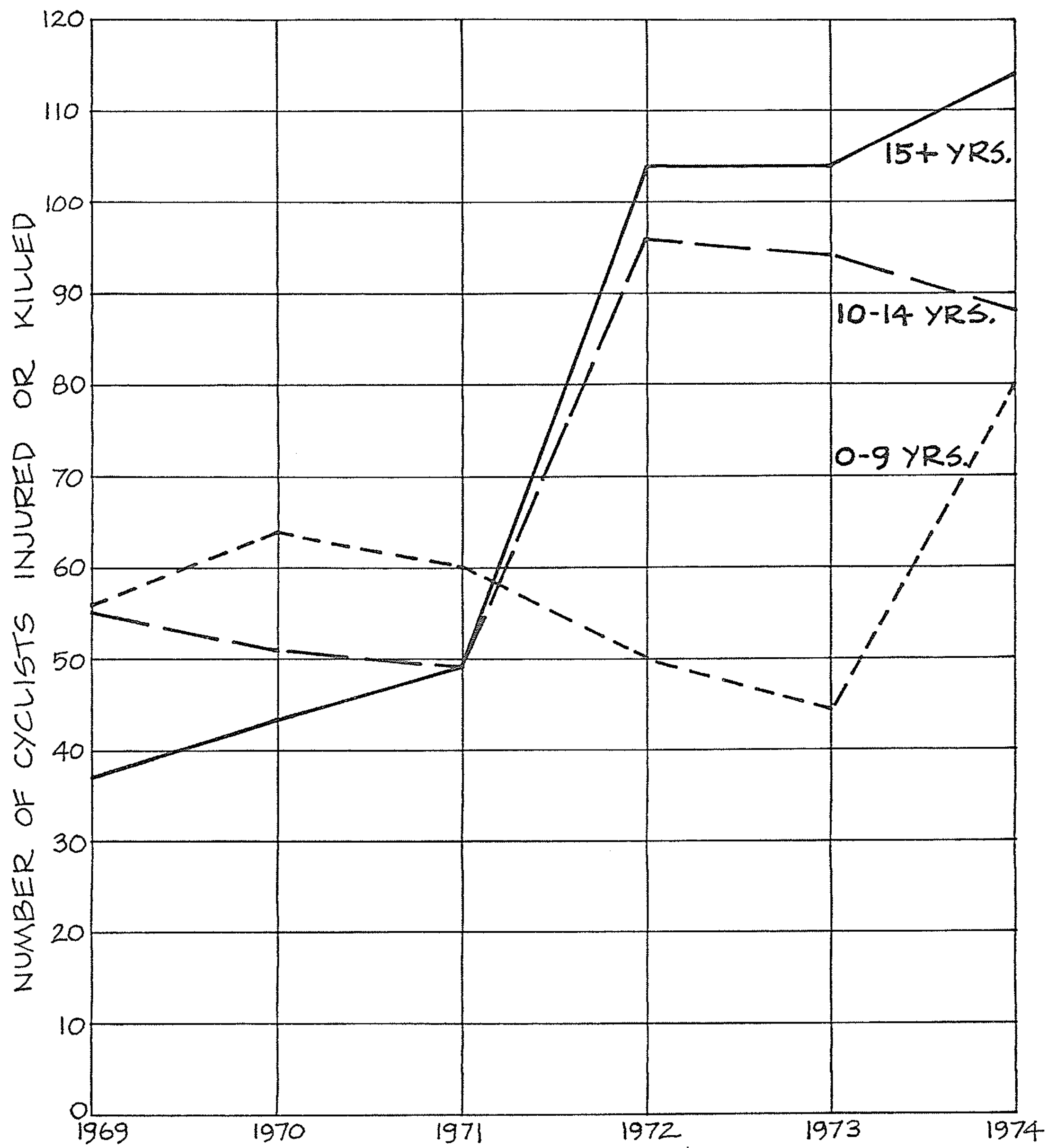

FIGURE 23. MANITOBA CYCLIST INJURIES AND FATALITIES BY AGE GROUP

INFORMATION : MANITOBA MOTOR VEHICLE BRANCH

The accident statistics also reflect the increasing use of bicycles by adults. Figure 23 shows the dramatic rise in injuries and fatalities among cyclists aged 15 years and over.

To gain a perspective regarding the number of bicycle accidents in Winnipeg it is of interest to compare the number of bicycle accidents annually with the number of pedestrian and motor vehicle accidents. In recent years in Winnipeg about 200 accidents involving bicycles were reported to police each year, while there were about 600 involving pedestrians and a total of some 23,000 involving motor vehicles.[3]

It should be noted that a large number of bicycle accidents (and near accidents) are not reported to the police. In general only bicycle accidents involving collisions with motor vehicles are reported, and then only where they result in personal injuries. Such accidents tend to be serious, and of the accidents reported in the last three years, 20 percent resulted in personal injuries severe enough to require hospitalization.[4]

2. Locations of Bicycle Accidents

Figure 24 shows the locations of the more than 600 bicycle accidents reported to the police during the three

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[3]Winnipeg, City of, Streets and Traffic Branch, Accidents by Collision Type, Control Type, Vehicle Type and Vehicle Movement (Winnipeg: 1973, 1974, 1975).

[4]Ibid.

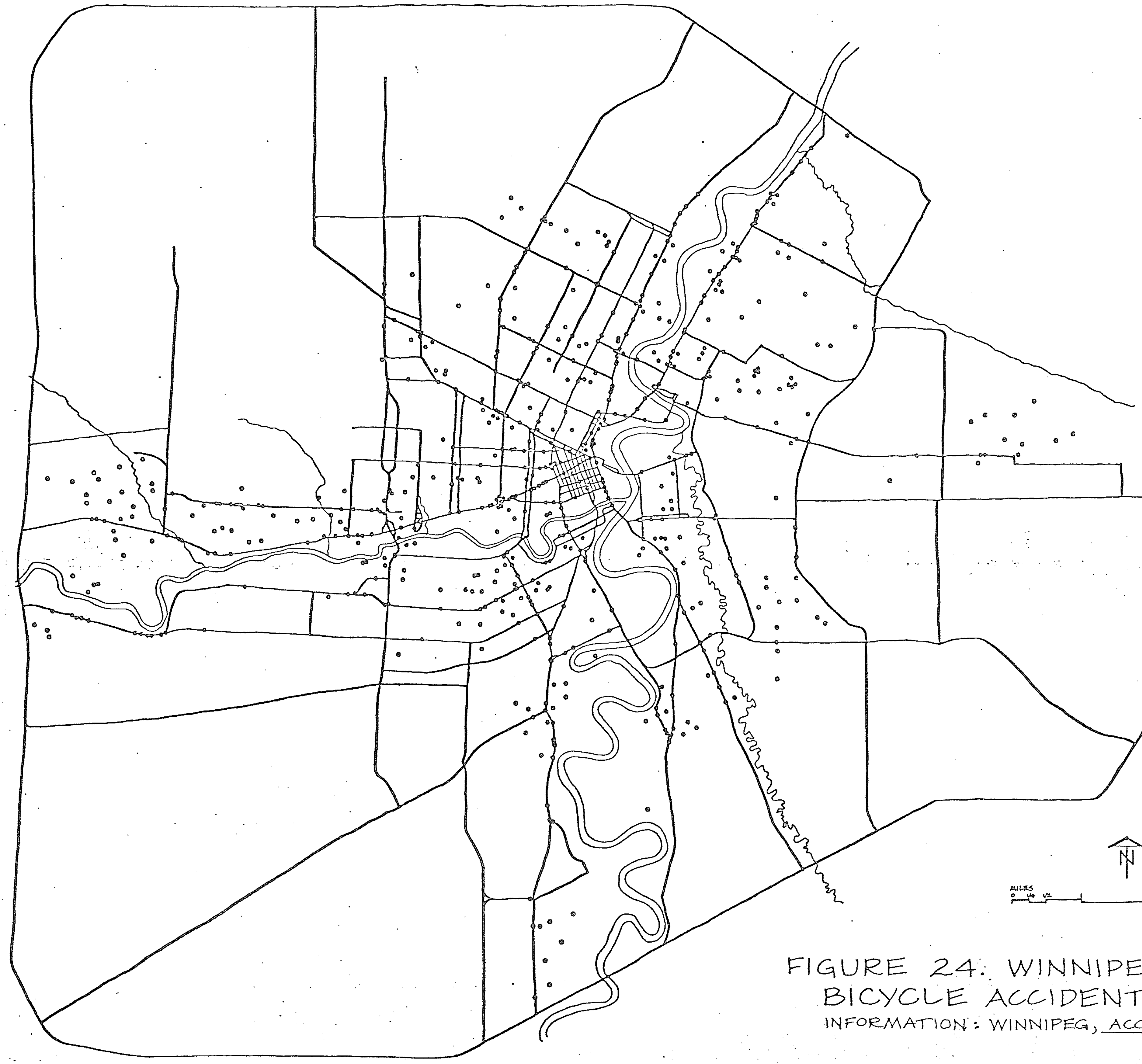

FIGURE 24: WINNIPEG:
BICYCLE ACCIDENT LOCATIONS
INFORMATION: WINNIPEG, ACCIDENTS.

years from 1973 to 1975.. The accident locations might seem to be spread randomly over the built-up areas of the city. The incidence of accidents can, however, be seen to be relatively higher in certain areas of the city (in the north and west as compared to the south, for example), and there is a clustering along major arterial routes.

The table below classifies the bicycle accident locations (1973 to 1975) according to two important criteria: major or minor street, and intersection or non-intersection.[5]

	Intersection		Mid-block		Total	
Major Streets	244	(38%)	150	(24%)	394	(62%)
Minor Streets	100	(16%)	143	(22%)	243	(38%)
Total	344	(54%)	293	(46%)	637	(100%)

A majority of accidents (6.2 percent) occurs on major streets. Slightly more than half of bicycle accidents occur at street intersectinns. These are concentrated, however, on intersections with major streets; on minor streets there are more mid-block than intersection accidents.

The pattern of bicycle accident locations in Winnipeg is not unlike that of other North American cities. Some conclusions regarding bicycle use and the need for bicycle facilities in Winnipeg can be drawn from this information. The distribution of bicycle accidents reflects two basic factors: the distribution of cycling activity, and the

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[5]Ibid.; major streets are defined as those appearing on the map in Figure 24.

danger cyclists are exposed to in various locations throughout the city. Thus the distribution of bicycle accidents can indicate areas where there is the greatest need for bicycle facilities, and where their implementation will result in the greatest benefits. The high incidence of bicycle accidents along major arterial routes suggests that a significant proportion of cycling in Winnipeg might well be destination-oriented, and that any system of bikeways for the city should, to some extent, provide for utility bicycle trips. Finally, the high incidence (46 percent) of bicycle accidents on streets between intersections indicates that establishment of bikeways along critical routes could result in significant increases in bicycle safety.

3. Types of Bicycle Accidents

Study of the ways in which bicycle accidents occur provides an important guide to planners attempting to improve bicycle safety. The following listing, summarizing a total of 635 bicycle accidents which occurred in Manitoba (500 or 79 percent of them in Winnipeg) in the 3 years from 1973 to 1975, indicates the most significant types of bicycle accidents.

149 cyclists (23%) failed to yield right-of-way to motor vehicles and collided with them.

89 cyclists (14%) were hit by oncoming motor vehicles which made left turns into their paths.

74 cyclists (12%) were struck by motor vehicles which

failed to yield right-of-way.

71 cyclists (11%) were struck from behind by approaching motor vehicles.

48 cyclists (8%) attempted to change lanes or swerved to the left and collided with passing motor vehicles.

37 cyclists (6%) were cut off by motor vehicles travelling in the same direction making right turns across their paths.

35 cyclists (6%) made left turns into the path of oncoming vehicles.

32 cyclists (5%) struck the opening doors of parked motor vehicles.

30 cyclists (5%) ran into the rear of stopped motor vehicles.

15 cyclists (2%) on the wrong side of the road collided with oncoming motor vehicles.

14 cyclists (2%) were side-swiped or squeezed into the curb by motor vehicles passing in the same lane.

14 cyclists (2%) made left turns from the curb lane and were struck by vehicles approaching from the rear.[6]

This analysis indicates that the pattern of bicycle accidents in Winnipeg is similar to that in other North American cities. To increase bicycle safety it would most of all be necessary to educate both cyclists and motorists

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[6]Manitoba, Province of, Department of Highways, Motor Vehicle Branch, An Analysis of Bicycle/Motor Vehicle Collisions Reported in Manitoba (Winnipeg, 1973, 1974, 1975).

to obey traffic regulations, and to become more aware of each other's presence and rights. Education programs directed towards increasing bicycle safety presently concentrate only on cyclists. The importance of also educating motorists in regard to their obligation towards cyclists is obvious from the fact that in the last three years, motorists rather than cyclists were judged at fault in 60 percent of the bicycle accidents reported to the Winnipeg police.[7]

The types of bicycle accidents occurring in Winnipeg also indicates that the establishment of bikeways in appropriate locations could do much to increase bicycle safety by providing separate rights-of-way for bicycle traffic, by prescribing safe patterns of movement through intersections, and by increasing motorists' awareness of cyclists.

4. Times of Bicycle Accidents

Some conclusions as to patterns of bicycle use can be drawn from Figure 25, which depicts the frequency of bicycle accidents at the various hours of the day. Accidents occurring on weekdays are plotted separately from those on holidays and weekends. The distinctly different pattern of accident occurrence on weekdays, and in particular the accidents occurring between 6:00 and 9:00 A.M., suggest that there may be a significant amount of bicycle commuting in

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[7] Winnipeg, Accidents.

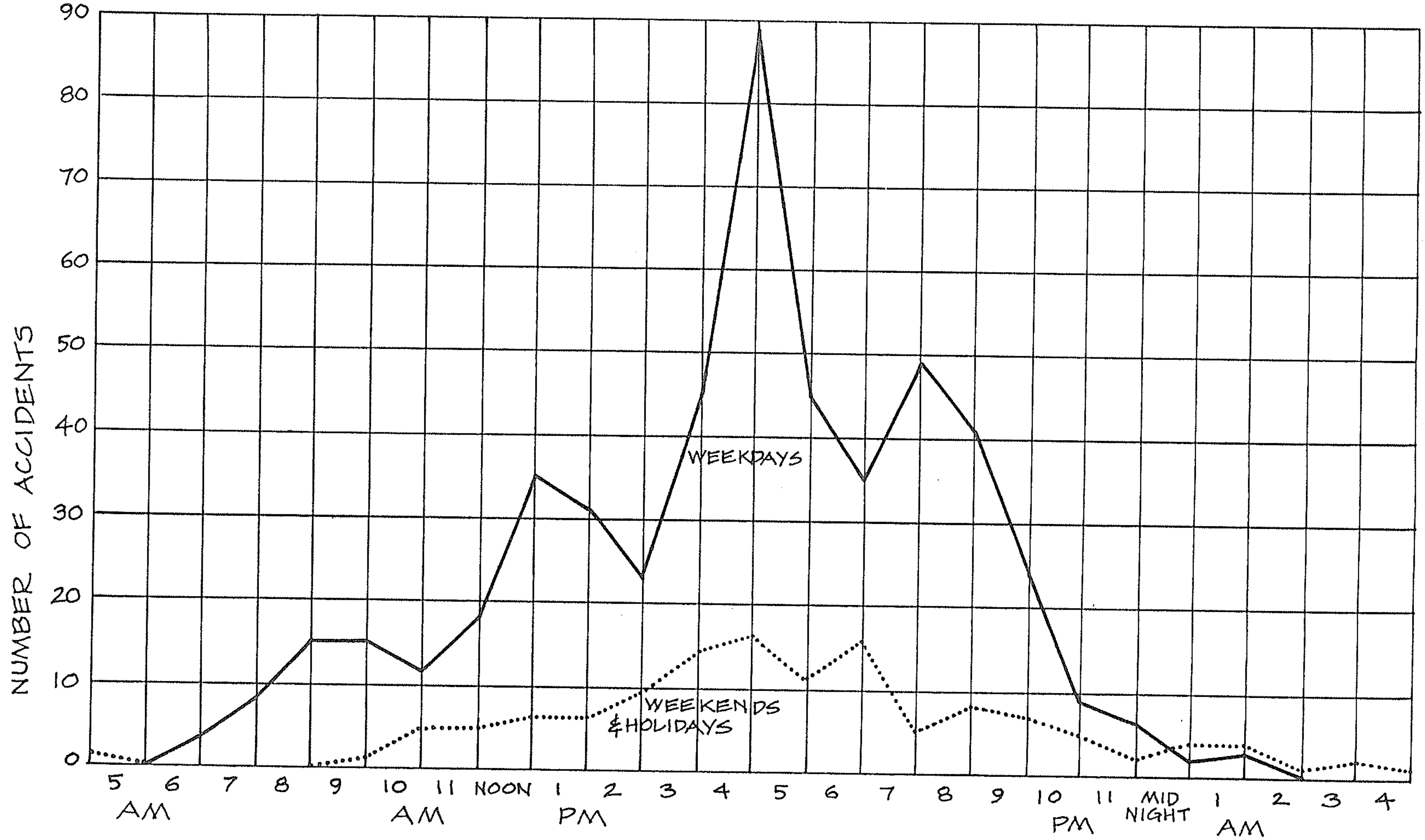

FIGURE 25. WINNIPEG BICYCLE ACCIDENT TIMES: WEEKDAYS AND HOLIDAYS

INFORMATION: WINNIPEG, ACCIDENTS.

Winnipeg. The peak in bicycle accidents occurring between 4:00 and 5:00 P.M. probably represents "after-school" cycling by school children as well as commuter and other utility cycling during the dangerous evening rush hour. The surprisingly high number of bicycle accidents in the very late evening and early morning hours may also be expected to involve destination-oriented rather than purely recreational cycling.

The accidents occurring on weekend and holiday afternoons and during the "after-supper" hours on weekdays represent primarily recreational cycling. There are more bicycle accidents per weekday than per Saturday, Sunday or holiday. Only 20 percent of bicycle accidents during the last three years in Winnipeg occurred on weekends and holidays. This is significantly less than the 31 percent which would have been expected if occurrence of accidents was constant throughout the week. The heavier, more dangerous motor traffic on weekdays is probably the cause of this. No conclusions can be drawn concerning whether bicycle use is heavier on weekdays or on weekends and holidays.

It is, however, safe to assume from this data that a fairly high proportion of bicycle accidents in Winnipeg involves cyclists making destination-oriented trips and that a useful bikeway system must meet the needs of such cyclists, as well as providing for recreational cycling.

During the last 3 years, 46 bicycle accidents (or some 9 percent) of those occurring in Winnipeg, happened during the hours of darkness. The majority of bicycles involved were not properly equipped with lights.[8]

The distribution of bicycle accidents throughout the year can be used to determine the months during which cycling activity takes place in Winnipeg.

	Accidents (1973-1975)[9]
January	0
February	3
March	14
April	47
May	102
June	145
July	126
August	106
September	62
October	31
November	4
December	0
Total	640

A small number of enthusiasts does continue cycling throughout the winter, and there have been bicycle accidents in ten of the twelve months. Almost 97 percent of all accidents, however, occurred in the seven months from April to

[8] Manitoba Motor Vehicle Branch, An Analysis of Bicycle/Motor Vehicle Collisions.

[9] Winnipeg, Accidents.

October.

C. EXISTING AND PRESENTLY PROPOSED BICYCLE FACILITIES

Very few facilities have been provided for cyclists in Winnipeg. In fact, there was no consideration of bicycle traffic and provision for it in the Metropolitan Winnipeg Development Plan, the Winnipeg Area Transportation Study, and in the urban renewal studies made for the city. In response to the increasing numbers of cyclists on city streets, however, the City of Winnipeg in 1973 prepared the Winnipeg Bicycle Route Study. This report has become the basis for the provision of bicycle facilities in Winnipeg. In summary, it recommended:

(1) A system of bicycle routes be developed in Winnipeg consisting of:

(i) Bicycle Paths - which are ribbons of pavement specifically designed for bicycles located in areas where it is possible to prohibit motor vehicle traffic, and

(ii) Bikeways - which are well identified, suggested cycling routes, utilizing existing vehicular roadways (preferably minor streets) where cyclists would share the roadway with other types of traffic.

(2) In the immediate future, bicycle routes be constructed mainly for recreational purposes, although their use for other purposes such as commuting to and from work may be attractive to some cyclists.

(3) A network of bicycle routes be adopted in principle as a guide for future planning purposes.

(4) A first stage circuit, in the vicinity of Assiniboine Park, be considered for implementation as soon as is practical.

(5) The Community Committees be asked to review the suggested routes within their areas and submit

their comments and suggestions for improvements to the system within their boundaries.

(6) The local cycling associations be given the opportunity to comment on, and actively participate in, the planning of these routes.

(7) The Provincial Government be urged to develop the Greater Winnipeg Floodway and Birds Hill Park for cyclists and to provide connections between these two areas and the suggested Winnipeg network.[10]

It further suggested that the bikeway system "should consist of a series of interconnected loops of varying lengths" each bearing an appropriate name used in signing the routes. Loops were considered desirable in that "they allow the user to come and go via different routes adding to the interest of the outing". These routes, which would all be primarily recreational in nature, "should link residential areas (the origin of most cycling trips) with shopping centres, recreational areas, schools, playgrounds and aesthetically pleasing areas such as our parks and riverbanks."[11]

The reasons for concentrating on bikeways for recreational cycling were given as follows:

System Concept:

From observation of existing bicycle usage it appears that a large number of recent enthusiasts are using this mode of travel for social and recreational

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[10]Winnipeg, City of, Transportation Division, Planning Division, Winnipeg Bicycle Route Study (Winnipeg: April 1973), pp. 3-4.

[11]Ibid., p. 6.

> purposes and a relatively small number are commuters. Much of the reason for this low commuter trip usage can be attributed to the relatively hazardous cycling conditions which exist on the heavily travelled major streets during the peak periods of the day. Among factors contributing to these conditions for all cyclists are the high travel speed of automobiles relative to bicycles and the weaving manoeuvers necessitated by automobiles parked in the curb lane or by debris which tends to collect in the gutter along the curb. These conditions are further aggravated by the difficulty motorists have in distinguishing cyclists in the traffic stream. Recognizing the physical constraints of the existing streets and right-of-ways and the problems inherent in mixing motor vehicles and bicycles, it is our opinion that little can be done to alleviate these conditions for the commuting cyclist and it appears that planning emphasis should be placed on the development of bicycle routes oriented towards recreational use.[12]

Some bicycle facilities in accordance with these proposals have already been provided in Winnipeg. In 1973 a long portion of Wellington Crescent leading to Assiniboine Park (as shown in Figure 26) was designated as a bikeway, with all but local motor traffic prohibited on Sundays. This bikeway proved very popular. On August 26, 1973, a Sunday shortly after implementation of the bikeway, 1,108 bicycles were observed to enter Assiniboine Park via Wellington Crescent, while 841 exited between 11:00 AM and 4:00 PM.[13]

In 1975 a 4.2 mile bikeway route within Assiniboine Park was constructed at a cost of $130,000. As shown in Figure 27 the circuit consists of 3.2 miles of separate

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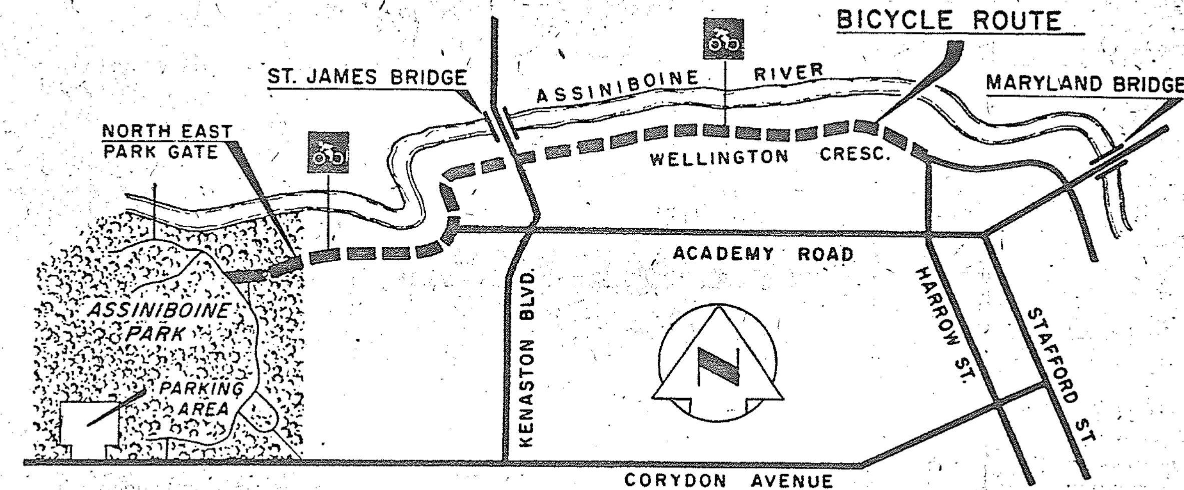
[12]Ibid., p. 5.

[13]Winnipeg, Streets and Transportation Division.

CITY OF WINNIPEG
Works and Operations Department
Streets and Transportation Division

WELLINGTON CRESCENT BICYCLE ROUTE



On each Sunday throughout the summer, beginning on April 18, 1976, Wellington Crescent between Harrow Street and the northeast gate of Assiniboine Park will be designated as a bicycle route between 11:00 A.M. and 5:00 P.M. During this time, only local access will be available for motor vehicle traffic on this portion of Wellington Crescent. With the exception of bicycles, no traffic will be allowed to use the Assiniboine Park gate at Wellington Crescent and Park Boulevard. **Motorists wishing to enter Assiniboine Park are advised to use the entrances along Corydon Avenue, including the new Zoo parking lots.**

Cyclists wishing to use the bicycle route should follow the bicycle route signs posted for this purpose. Care should be used along the route since motor vehicle traffic will still be present.

N. W. DIAKIW, P. Eng.,
Commissioner of Works and Operations

FIGURE 26. WELLINGTON CRESCENT BIKEWAY
SOURCE: WINNIPEG FREE PRESS, APRIL 17, 1976.

Class I bikeway and 1 mile of Class III bikeway (park roadway designated for joint cycle/motor vehicle use). There are some faults in this bikeway. It is a circuit which does not go anywhere; it merely circles the park. The straight portions along the golf course fences, moreover, are boring for cyclists. The bikeway is not always clearly signed, and there is confusion as to how it continues at several points. A portion of the Class III bikeway proceeds "wrong way" along a one-way road, and many motorists are unaware of the road's designation as a bikeway. The high volumes of traffic cause the combined pedestrian/bicycle pathways to function poorly, with pedestrians and cyclists causing much interference for each other. The width of the bikeway and volume of traffic also preclude side-by-side cycling (highly desirable for social-recreational cycling) at most times.

Nevertheless the Assiniboine Park bikeway has proved enormously popular, and is used to full capacity on Sundays. Its implementation has doubtless done much to promote recreational cycling in Winnipeg. During 1975, Sunday bicycle volumes in the Park between 11:00 AM and 5:00 PM averaged about 2,500.[14]

A few other, minor bicycle facilities existing in Winnipeg can be seen in Figure 30. There is a narrow gravel Class I bikeway in Churchill Drive Park. This is

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[14]Ibid.

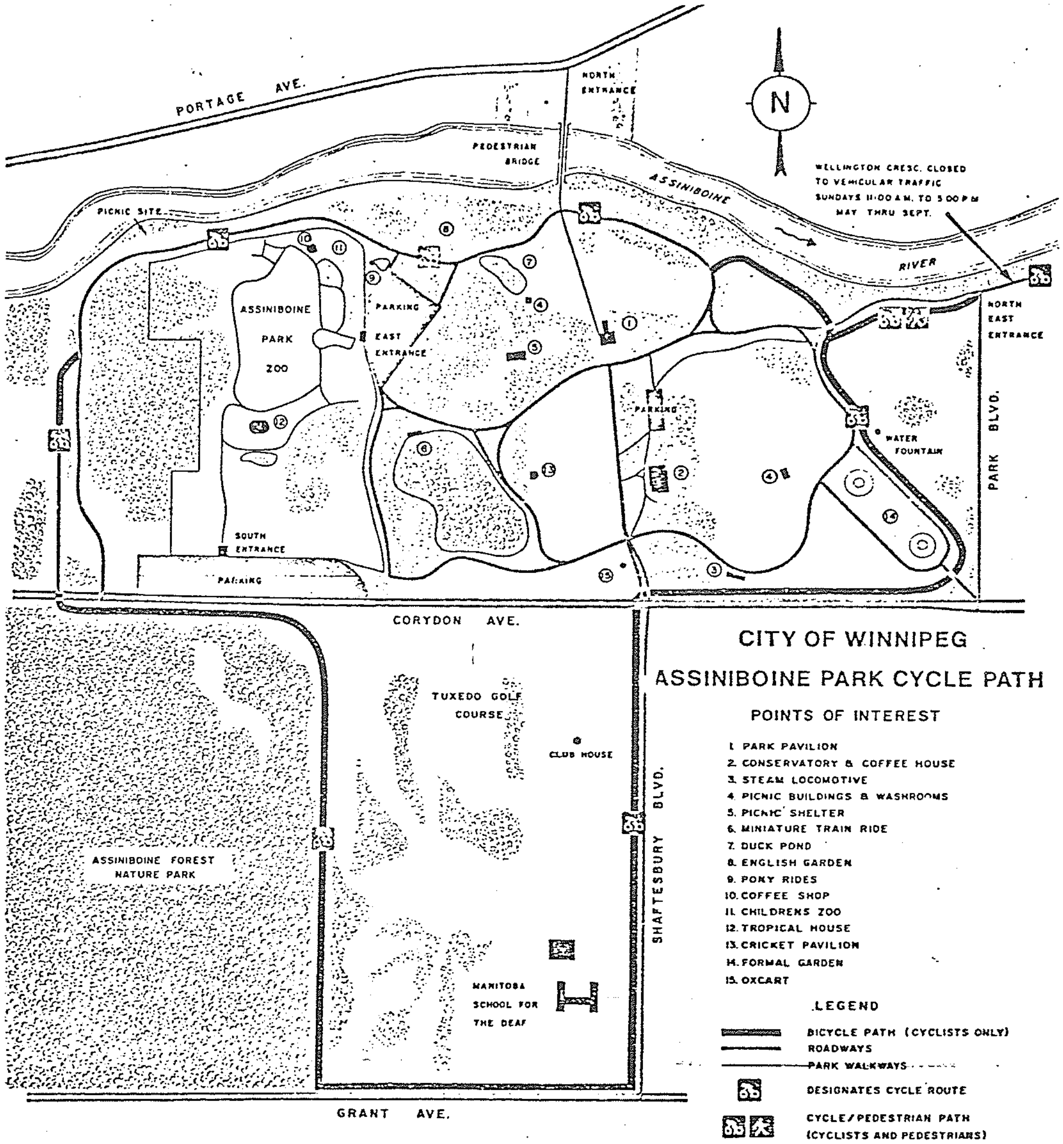

FIGURE 27. ASSINIBOINE PARK BIKEWAY
SOURCE: CITY OF WINNIPEG

close to the Elm Park Bridge which now serves only pedestrian and bicycle traffic. These two facilities are unfortunately connected only by a busy street, Jubilee Avenue. The paved shoulders of Henderson Highway, leading to Lockport, have been designated bikeways through signing. A railway bridge over the Assiniboine River incorporates a cantilevered pedestrian/bicycle crossing connecting Wellington Crescent with Portage Avenue near Polo Park. Construction of a bikeway north of the Trans-Canada Highway East, joining the end of Des Meurons Street at the Windsor Park Golf Course with the Bonvital Swimming Pool on Archibald, is planned for 1976.[15]

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[15] Ibid.

Chapter 5

DESIGN OF A BIKEWAY SYSTEM FOR WINNIPEG

Stress has been laid on the necessity of public participation in the bikeway planning process. In this section it is proposed to develop a conceptual and schematic plan of a bikeway system for Winnipeg, based on preliminary investigation into the nature of cycling activity in Winnipeg. This will provide an illustration of considerations that are essential in the bikeway planning process, demonstrating the application of basic general principles presented in Part One to a specific case. The resulting preliminary design of a bikeway system might serve as a point of departure for a bikeway planning process involving extensive public participation, and perhaps resulting in a somewhat different final bikeway plan.

A. SYSTEM OBJECTIVES AND CONCEPT

The plan under which bikeways are presently being provided in Winnipeg is oriented primarily to recreational cycling. An investigation into the nature of cycling activity in the city, based on the limited information available, has however revealed that a significant proportion of cycling is for transportation, and destination-oriented in nature. The fact that it may be rather difficult to provide a bikeway system useful for utility cycling in Winnipeg, is no valid reason for not attempting to develop one.

The benefits to be derived from a shift to commuter cycling have been enumerated. In the climate of Winnipeg, it must be recognized that the role of bicycles and bikeways as an element of the city's total transportation system will be seasonal, limited to seven months of the year for most people. Some benefits to the city during the winter also might, however, result from a tendency of cyclists to shift to public transport rather than private automobiles during the non-cycling season. It may also be possible to use certain Class I bikeways for snowmobile and cross-country ski trails during the winter. Nevertheless most bikeways will be used mainly during seven months of the year, and a cycling season of this length adequately warrants the provision of a bikeway system. Although summer in Winnipeg is short, it is treasured, and advantage of it is taken to the full. This is evidenced by the golf courses and outdoor swimming pools of the city, which are useful for a shorter season than bicycles.

The main objective a bikeway system for Winnipeg should serve can be expressed simply as to provide safe, convenient and pleasant connections between the origins and destinations of bicycle trips. This expresses the function of a bikeway system primarily from the transportation point of view. Pleasant, well-designed bikeways, if they are independent or on minor streets, however can serve a recreational function as well as leading to destinations for utility cycling. Recreational cycling can furthermore be combined with other purposes, and is often, in itself, destination-oriented (towards parks, for example).

Continuity must be an important element of all bikeway routes. Large or small obstacles should not exist along their length. The continuation of each route and where it is going should always be clear to the cyclist. Bikeway routes having distinct and important bicycle trip attractors at each end, as well as along their length, would be highly desirable. Besides serving the transportation function, this would simplify signing and naming routes, attracting trips to them. Most importantly, stressing particular goals at the ends of bikeway routes and along their length, will enhance the imageability of a bikeway system, enabling cyclists to develop and retain clear conceptual plans of the system in their minds.

The bikeway system should form a sort of clear arterial route system into which residential streets (the origin or destination of almost all bicycle trips, and relatively safe for careful cycling) would feed. Bikeways should be located to alleviate bottlenecks and permit the crossing of barriers within the urban fabric. Bridges and underpasses are the most serious forms of bottlenecks presently existing in Winnipeg. Separate lanes for bicycles should be provided in many existing structures as parts of specific bikeway routes, and should be included as part of almost all new construction.

Where possible bikeways should be Class I, existing on their own rights-of-way, as part of continuous linear, green systems, which should also incorporate major urban facilities. The provision of such open spaces in a linear continuous pattern, with schools, community, recreation and shopping facilities located on them, should be an element of all new development in the city. The significance of such open space "seams" linking a community together goes far beyond the convenient provision of bikeways. These would merely be one element of the system.

Where it is impossible to provide Class I bikeways coinciding with cyclists' travel desires, minor streets should be designated Class III bikeways, with measures taken to ensure route continuity on all levels. Where only major streets coincide with the travel desire line, Class II bikeways should be implemented.

B. A PROPOSED BIKEWAY SYSTEM

Trip making patterns by all the modes of vehicular traffic are to some extent similar in Winnipeg. Vehicular traffic volumes representing primarily passenger automobiles are illustrated in Figure 28. Bus passenger volume distribution is very similar. Many bicycle trips will also reflect desire lines similar to those resulting in these patterns, but the effects of certain trip attractors on bicycle trip generation differ significantly from their effect on motorized trip generation. It has been shown

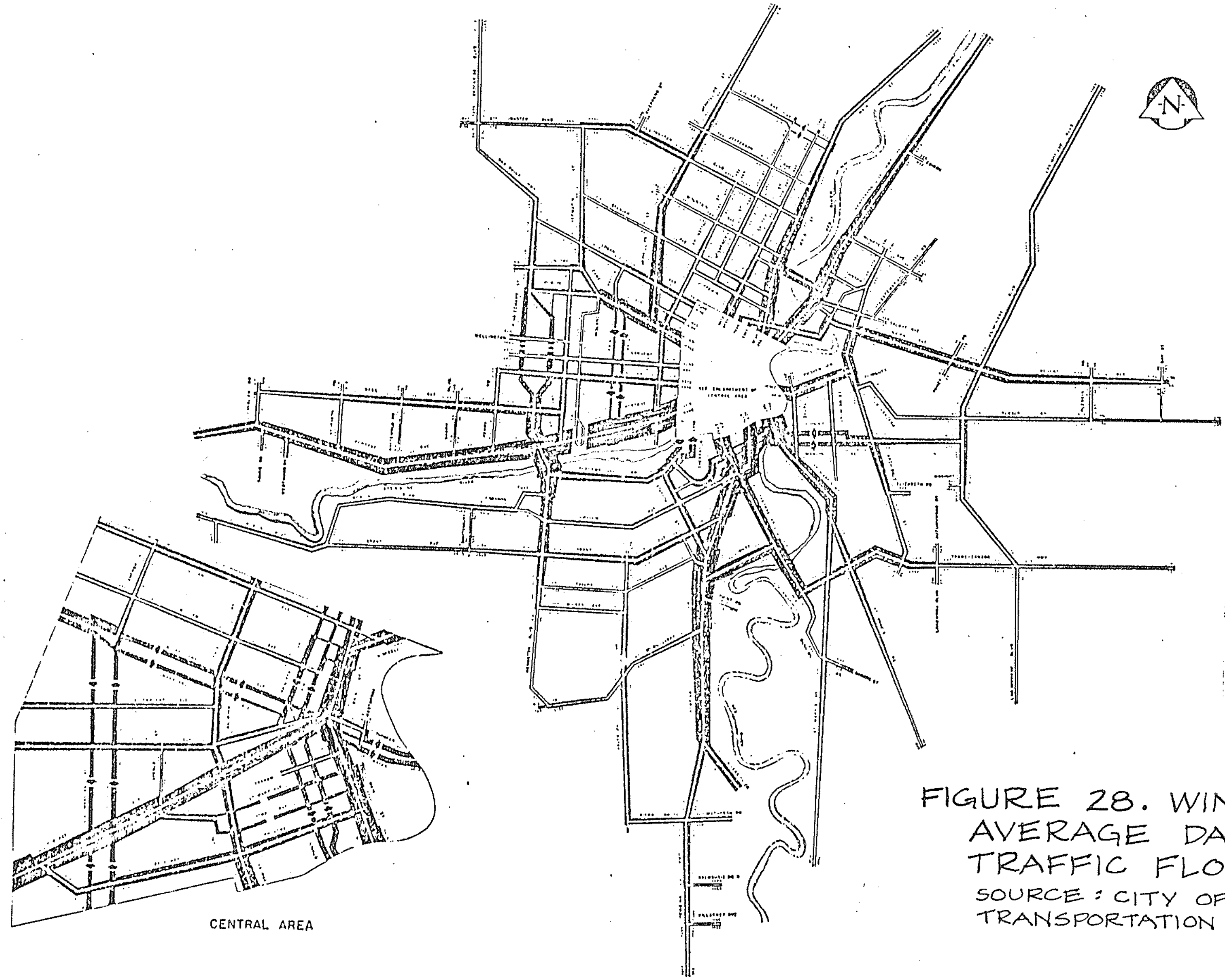

FIGURE 28. WINNIPEG AVERAGE DAILY TRAFFIC FLOW 1973

SOURCE: CITY OF WINNIPEG TRANSPORTATION DIVISION that parks, schools, sports areas, and commercial facilities are the major bicycle trip attractors. The location of these facilities in Winnipeg is shown in Figure 29.

A system of bikeway routes must be designed to connect residential areas with trip attractors, with emphasis on the penetration of existing barriers. Such barriers are rivers, major arterial roads, railway lines and yards and hydro rights-of-way. At the same time, some of these barriers, notably hydro and railway rights-of-way, public riverbanks, and buffer strips along certain major arterial roads, may provide opportunities for the construction of independent bikeways. Class I bikeways might also be constructed in other open spaces within the city, in parks and along golf courses or cemeteries. All these elements of the urban fabric of Winnipeg, both bicycle traffic barriers and bikeway construction opportunities are shown in Figure 30.

Based on this information, a preliminary plan of bikeway routes for Winnipeg was developed, and is illustrated in Figure 31. This plan is presented as a possible point of departure for a planning process involving extensive public participation, as well as ongoing research into the nature and volume of bicycling in Winnipeg.

In an overall plan of an urban bikeway system such as this, suggestions can be made as to the class of bikeway to be implemented for each segment of the system. To determine final locations and physical design, detailed in-

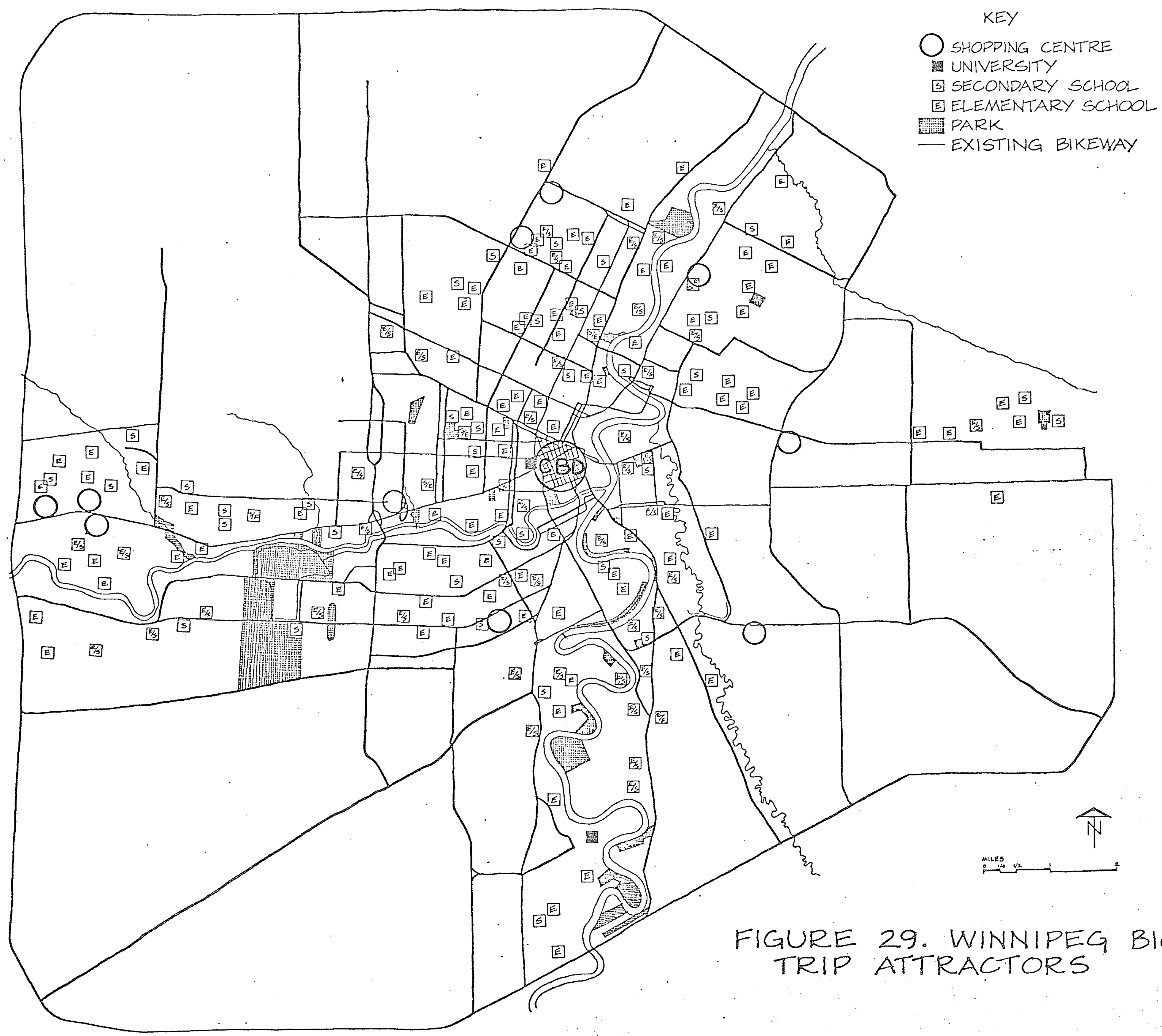

FIGURE 29. WINNIPEG BICYCLE TRIP ATTRACTORS

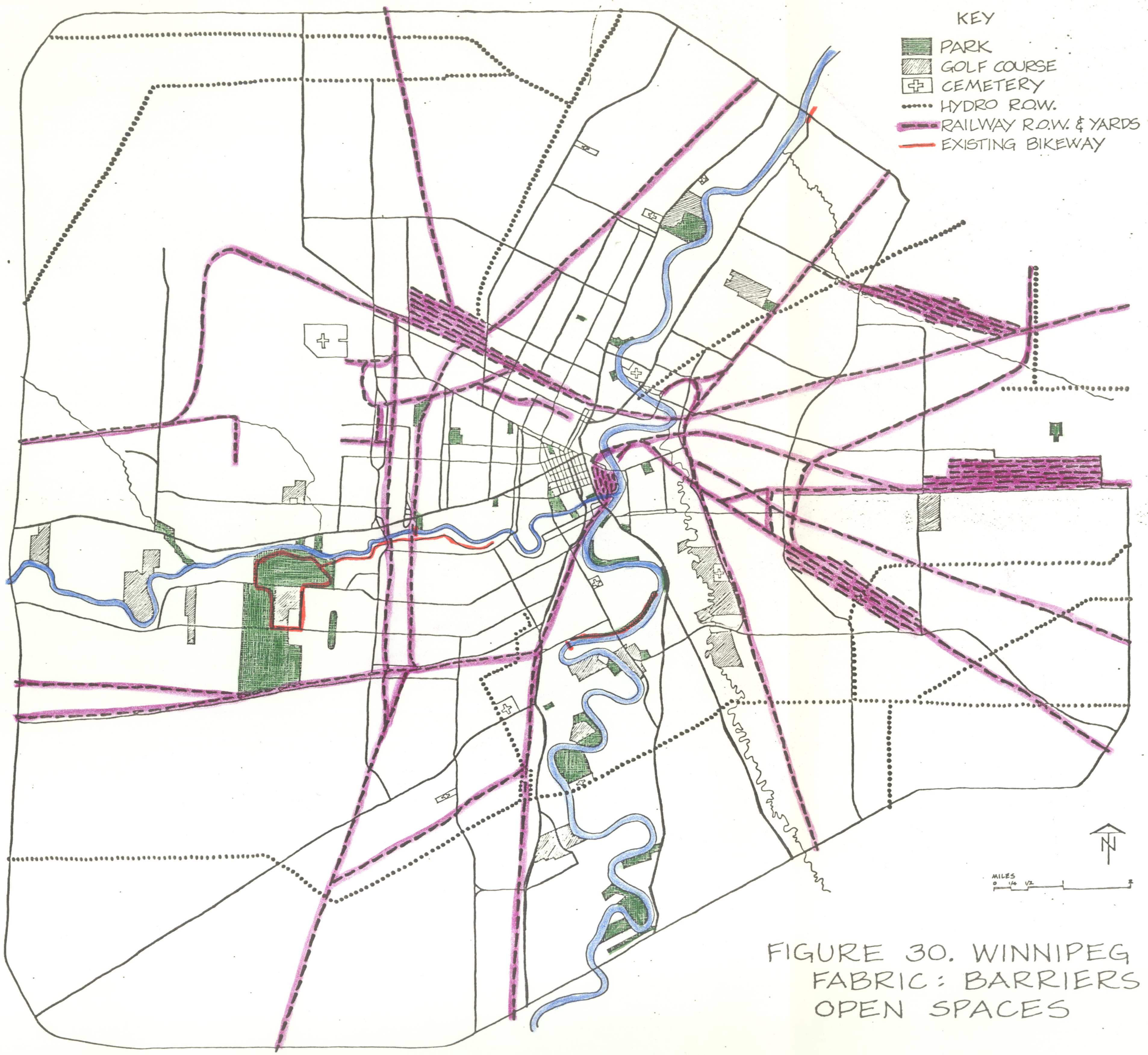

FIGURE 30. WINNIPEG URBAN FABRIC: BARRIERS AND OPEN SPACES

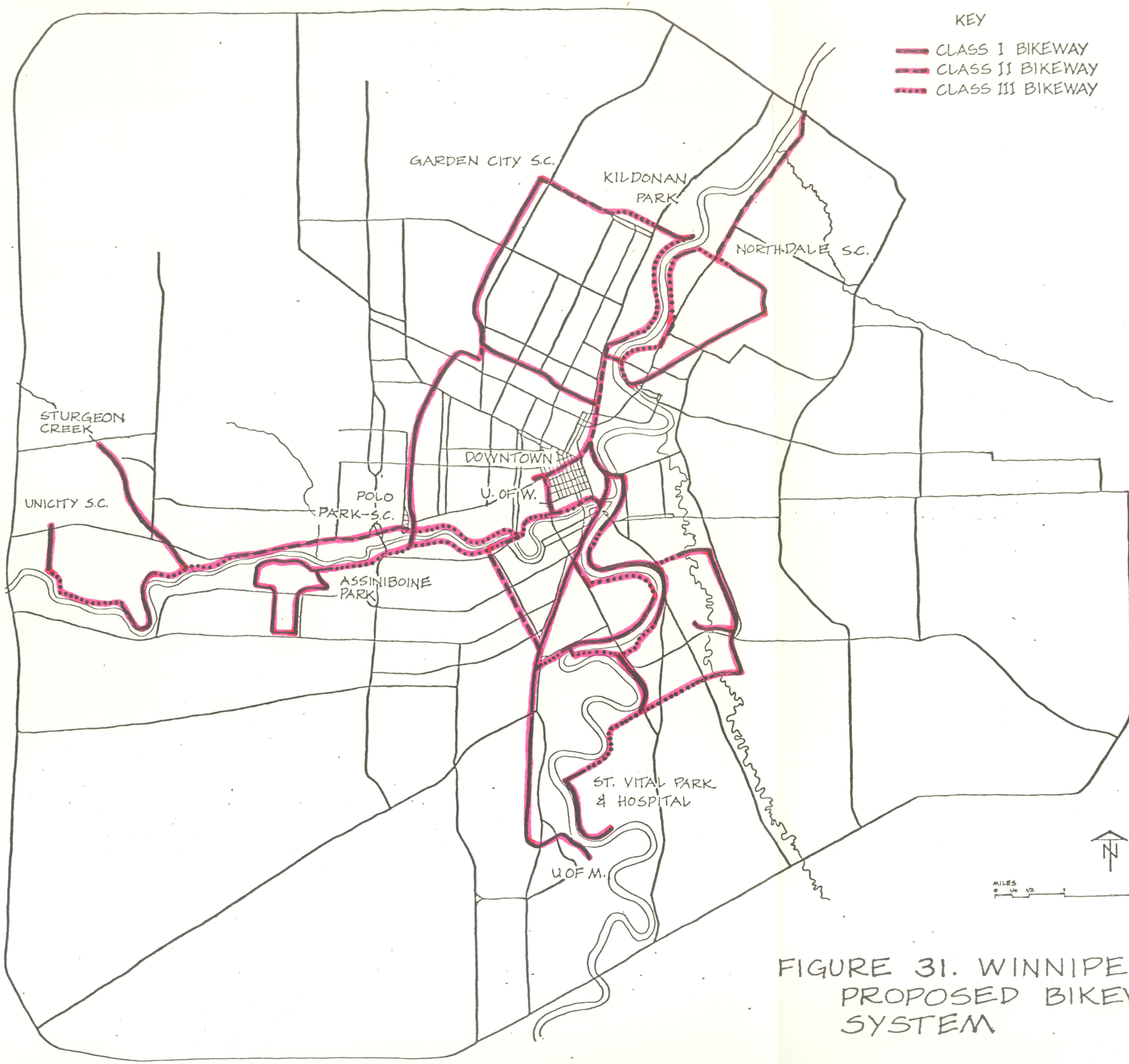

FIGURE 31. WINNIPEG PROPOSED BIKEWAY SYSTEM

vestigation is necessary for each bikeway section. The basic criteria to be applied during this process have been outlined in Chapter 2.

C. STAGING

The first stage of the bikeway system to be built should strongly reflect the basic concepts of the entire system, so that these are tested. After construction, careful monitoring of this first bikeway should be used to establish patterns of bikeway usage and reactions from both cyclists and the general public.

The first bikeway route should preferably be a radial route feeding into the downtown area from a strong destination (a major park if possible) near the periphery of the city. This would be a route suitable for both utility-oriented and recreational cycling, and the extent to which it was used for each could be determined. The effect of the provision of the bikeway on bicycle usage and safety could also be measured. The route should incorporate segments of different classes and types of bikeway.

If possible the first stage of the bikeway system should be built in an area of the city now relatively ill-provided with cycling and open space facilities, and where the pattern of accident locations (Figure 24, page 139) suggests that a maximum benefit could be derived from bikeway provision.

Balancing all these criteria, it would seem that the bikeway route extending from Kildonan Park, parallel to Main Street, and then through the downtown area to the University of Winnipeg (as shown in Figure 31) would be a reasonable first stage.

Chapter 6

IMPLEMENTATION

A. COST AND FINANCING

The proposed bikeway system illustrated in Figure 31 consists of about 38 miles of Class I bikeway, 13 miles of Class II bikeway, and some 22 miles of Class III bikeway. Average costs of construction per mile of bikeway might be estimated as roughly $40,000 for Class I, $15,000 for Class II, and $1,000 for Class III. The total cost of the bikeway system would thus be about $1.73 million.

The cost of maintenance for Class I and Class II bikeways might be estimated at $1,600 per mile annually. This would amount to $81,600 per year.

Assuming a 20 year life for any bikeway facilities constructed, interest rates of 10 percent per annum, and maintenance costs as calculated above, the cost to the City of Winnipeg of the entire bikeway system outlined in Figure 31 would be in the order of $340,000 annually.

This bikeway system was developed as a preliminary design to represent a modest response to the need for bicycle facilities in Winnipeg, without explicit cost criteria. It is now necessary to compare this system's cost with the amount Winnipeg might reasonably be expected to spend on bikeway facilities. The expenditure of 1 percent of a city's total transportation budget on bicycle facilities has been justified in parts of the United States. In Winnipeg in 1975 some $34 million of public expenditures were for transportation, over 20 percent of this going to subsidize public transportation.[1] Very surprisingly, the estimated annual cost of the proposed bikeway system is exactly 1 percent of Winnipeg's total transportation budget.

In Minneapolis-St. Paul, it was estimated that with a comprehensive bikeway system, 8 percent of the total number of daily home-based vehicular trips made during the cycling season could be attracted to bicycles (see page 126). Winnipeg is perhaps not directly comparable to the Minneapolis-St. Paul metropolitan area; although climate and topography are similar, Winnipeg is smaller in area, and has better public transportation. Nevertheless it is of interest to apply the proportion 8 percent to the total of 1,000,500 home-based vehicular person trips made daily in Winnipeg.[2] 80,040 bicycle trips might be expected daily for some six months of the year. If a benefit value of $0.05 to $0.10 per trip is accepted, an annual expenditure of roughly $500,000 to $1,000,000 on bikeways could be

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[1]Winnipeg, City of, <u>1976 Current Estimates</u> (Winnipeg: April 15, 1976).

[2]Winnipeg, Streets and Transportation Division, 1971 Origin-Destination Survey.

justified. This is considerably more than the estimated cost of the proposed bikeway system.

Bikeway funding should come out of the general revenues of the City of Winnipeg. Nevertheless it is interesting to compare the estimated cost of the proposed bikeway system with the revenue currently being generated by bicycle use. In 1975 61,312 bicycle licences were sold in Winnipeg for $1.50 each, raising $91,968. The sale of some 900 lost and stolen bicycles which could not be returned to their owners (of a total 1700 bicycles recovered by police) added some $16,000 more to the general revenues of the City.[3] Lastly, it was estimated that in Canada as a whole perhaps $6 million was raised through bicycles sold in 1973 (page 129). Winnipeg, accounting for 2.5 percent of Canada's population, may have accounted for some $150,000 of this revenue. Thus it can be seen that the revenues bicycle use in Winnipeg raises in these ways amounts to about 75 percent of the bikeway system proposed for Winnipeg. With implementation of a bikeway system increasing bicycle use these revenues can also be expected to increase.

B. PUBLIC PARTICIPATION

The importance of public participation in the bikeway planning process has been emphasized. The proposed

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[3]Mr. Barrie, Licence Department, City of Winnipeg.

bikeway system for Winnipeg developed in Chapter 5 is presented merely as a basis for such a planning process.

Planning might occur within the Streets and Transportation Division of the City of Winnipeg if a framework for the participation of cyclists, cycling groups and the general public in formulating and evaluating the entire bikeway plan from its basic concepts to its finest details, is established.

Alternatively, planning might be done by a committee drawing on the expert assistance of the professional staff of the City of Winnipeg, as well as on public input.

In either case the importance of serious investigation to establish patterns of bicycle use both before and after commencement of bikeway provision cannot be overemphasized. This has been neglected in the past.

BIBLIOGRAPHY

Abrams, H. Toward a Metropolitan Toronto Bicycle Route System. Municipality of Metropolitan Toronto: Roads and Traffic Department, May 1973.

Baird, George, and others. On Building Downtown: Design Guidelines for the Core Area. Toronto: City of Toronto Planning Board, September 1974.

De Leuw, Cather, and Company. Bicycle Circulation and Safety Study. City of Davis, California: August 1972.

Fay, Mike. Bicycle Paths and Bikeways: A Systems Planning Approach. Winnipeg: Municipal Planning Branch, November 1974.

Fisher, G., and others. Bikeway Planning Criteria and Guidelines. Los Angeles: Institute of Transportation and Traffic Engineering, University of California, 1972.

Forschungsgesellschaft für das Strassenwesen (Highway Research Board). Vorläufige Richtlinien für Radverkehrsanlagen (Guidelines for Bicycle Traffic Facilities). Cologne, Germany: August 1963.

Germano, A. Trent, and others. "The Emerging Needs of Bicycle Transportation," Highway Research Record, Number 436, pp. 8-18.

Ginzton, Artemas A. "The Bicycle Boulevard (or Bikeway Arterial) Concept." Paper presented to the National Highway Safety Advisory Committee, Washington, D.C., April 1974.

Grove, Noel. "Bicycles are Back--and Booming!" National Geographic, May 1973, pp. 671-681.

Guelph Transportation Plan. Bicycleway Pilot Project: Interim Report No. 6. Guelph: 1973.

Hamill, James P. Planning and Development of Bikeway Systems. Management Information Service, April 1973.

Hirst, Eric. "Cycling for Energy Conservation," Bicycling! June 1974, pp. 48-29.

Koninklijke Nederlandsche Toeristenbond. Fietspaden en Oversteckplaatsen (Bicycle Paths and Cycle Crossings) 2d rev. ed. Amsterdam, Netherlands: Verkiersafdeling van de ANWB (Traffic Division of the Algemene Nederlandse Wielrijders Bond), December 1967.

"The Bicycle Madness," Life, July 30, 1971, p. 31.

Manitoba Department of Highways, Motor Vehicle Branch. An Analysis of Bicycle/Motor Vehicle Collisions Reported in Manitoba. Winnipeg: 1973, 1974, 1975.

Metropolitan Association of Urban Designers and Environmental Planners, Inc. Proceedings of the Pedestrian/Bicycle Planning and Design Seminar, San Francisco, 1972. Berkeley: Institute of Transportation and Traffic Engineering, University of California, July 1973.

________. Proceedings of the Seminar on Bicycle/Pedestrian Planning and Design, December 1974, Florida. New York: American Society of Civil Engineers, 1974.

National Asphalt Paving Association. "Effective Design for Bicycle Paths," Paving Forum, April 1966, p. 7.

Ontario Bikeway Coalition. Windsor Bikeways. Windsor: April 1973.

Ontario Department of Transport. An Investigation of Rider, Bicycle and Environmental Variables in Urban Bicycle Collisions. Technical Bulletin 70-01. Toronto: October 1970.

Ontario Ministry of Transportation and Communications. A Review of the Ministry's Position with Respect to Bicycling. Toronto: Route Projects Planning Office, October 1974.

Oregon Department of Transportation, Highway Division, Location Section. Oregon Footpaths and Bikeways Progress Report. Salem: Oregon State Highway Division, April 1975.

Oregon State Highway Division. Bikeway Design. Salem: January 1974.

"Point of View: An Anti-Bikeway Movement," Bicycling! June 1974, pp. 77-80.

Popish, L. N., and R. B. Lytel. A Study of Bicycle-Motor Vehicle Accidents. Santa Barbara, California: June 1973.

Rådet for Trafiksikkerhedsforskning. Cykelstiers Betydning for Faerdselssikkerheden, Rapport 1. Copenhagen, Denmark: Statens Trykningskontor, 1969.

Russak, Sid. "Bikeways: The Way They Are," Bicycling! September 1975, p. 32.

Seypka, R. The Scarborough Bicycle Pathway System. Scarborough: Pollution Probe Scarborough, 1972.

Shanteau, Robert M. "Bicycle Bottlenecks: Bicycle Planning from a Bicyclist's Point of View." Paper presented at the conference of the Metropolitan Association of Urban Designers and Environmental Planners, San Diego, December 1974.

Skrabak, Darryl. "Bike Law," Bicycling! February 1976, pp. 51-52.

________. "The Bikeway Backlash," Bicycling! September 1975, pp. 25-28.

________. "N.C.U.T.L.O. Spells 'Power'," Bicycling! December 1975, pp. 55-59.

________. "Wisconsin Bikers Watch Out!" Bicycling! March 1976, p. 84.

Smith, Dan. Bikeways: State of the Art 1974. San Francisco: De Leuw Cather and Company, July 1974.

Statewide Bicycle Committee. Final Report. Sacramento: California Department of Transportation, February 1975.

Statistics Canada. Household Facilities and Equipment. Catalogue: 64-202. Ottawa: 1972 to 1975.

________. Motor Vehicle Traffic Accidents. Ottawa: 1956 to 1973.

Strok, W., and Associates Limited. Bikeway System Within Metropolitan Toronto. Municipality of Metropolitan Toronto: April 1974.

Tebeau, W. H. "Evaluation of the Oregon Bikeway Program." Salem: 1976. (Mimeographed.)

U.S. Department of Transportation, National Highway Traffic Safety Administration. Pedestrian and Bicycle Safety Study Washington, D.C.: March 1975.

Williams, John E. "Bikeways: Another View." (Mimeographed.)

________. "Cycling and City Hall," Bike World, June 1975, pp. 36-39.

________. "Mama, I've Got Them Demand Survey Blues," C.T. Quick Paper No. 1. (Mimeographed.)

________. "Separate ≠ Equal," C.T. Quick Paper No. 2. (Mimeographed.)

Winnipeg, City of. 1976 Current Estimates. Winnipeg: April 15, 1976.

Winnipeg, City of, Streets and Traffic Branch. Accidents by Collision Type, Control Type, Vehicle Type and Vehicle Movement. Winnipeg: 1973, 1974, 1975.

Winnipeg, City of, Transportation Division, Planning Division. Winnipeg Bicycle Route Study. Winnipeg: April 1973.