Final Research Report
Research Project T9903, Task 19
Bicycle Facilities Improvements

BICYCLE FACILITIES AND USE

by

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16. ABSTRACT

Interest is increasing in realizing the transportation potential of the bicycle for purposes other than recreation. At the same time, information is lacking about the relationship between facilities and use. This project addressed this lack of information in four tasks. The first task synthesized the elements required to create a cycling-friendly environment, which is characterized by five elements: coherence, directness, safety, attractiveness, and comfort. Cyclist classification schemes were investigated, along with several important operational characteristics of the bicycle and rider that affect facility design. The second task developed a comprehensive list of bicycle facilities, including 23 major categories with 55 subdivisions. Third, methods for measuring bicycle use were investigated, along with the results from various surveys and counts. The fourth task was the creation of a framework for selecting facilities improvements with the goal of identifying the geographical areas most likely to benefit from such improvements. The framework is a two-step process that looks first at demographic and land-use issues and then focuses on facility and access deficiencies. A case study demonstrated the change in use that resulted from filling in a 'missing link' in a regional trail near Seattle. A set of appendices to the report provide extensive information on facilities, sample survey forms, and detailed results obtained from 3000 user of the Burke-Gilman Trail/Sammamish River Trail system in Seattle and King County.

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EXECUTIVE SUMMARY

This report describes the results of a project designed to identify bicycle facility improvements that would encourage more people to use a bicycle for commuting and other utilitarian purposes. Specific tasks included 1) synthesis of the elements required to create a cycling-friendly environment; 2) development of a comprehensive list of bicycle facilities; 3) review of measures to assess bicycle use with results from various surveys; and 4) creation of a framework for selecting facility improvements. Such an effort is particularly timely as we seek to provide cost-effective alternatives to the increasing use of automobiles and the problems that result therefrom.

The types of users and the operating characteristics of their vehicles as they relate to facility design considerations were surveyed. This led to the following Key Findings:

#1: Specific attention must be paid to the types of cyclists who may want to use whatever facilities are being considered. Cyclists can be classified into four groups: avid, regular, young regular, and beginning. While their needs and capabilities may vary, they share a common desire to use their bicycles for transportation. A high quality cycling environment will encourage the less frequent and less skilled to cycle more and thus to progress to a higher level of cycling.

#2: Facility designs must be compatible with the operating characteristics and limitations of the bicycle. Smooth, clean riding surfaces free from hazards are essential for the safe operation of bicycles within the transportation system.

#3. Designers must be aware of the characteristics, capabilities, and limitations of the bicycle and its operator. This is, of course, no different than the design of facilities for automobiles. We just have less knowledge and awareness of the needs of the cyclists and their bicycles.

A comprehensive approach is necessary in order to increase utilitarian cycling. The goal is stated in the following Key Finding:

#4: Consideration should be given to developing a cycling-friendly environment that encourages the use of the bicycle for transportation purposes. Such an environment would provide a coherent system that would be easy to use and would offer a choice of direct routes that were safe, attractive, and comfortable.

Adequate bicycle facilities are critical to achieving a major increase in utilitarian cycling. Thus another major goal of this research was the development of a list of facilities to support such cycling. A total of 23 major facility categories with 55 subdivisions were identified and described in detail.

#5: A comprehensive list of facilities necessary to fully support utilitarian cycling has been developed. While not all of the facilities listed are necessary, their existence would promote increased cycling and enhance the cycling experience of those who do.

Measuring bicycle use is quite difficult. Various methods to gather this information were reviewed, including surveys and traffic counts. The report provides information on the following survey options: telephone, in-person interview, mail back, travel diaries, and verbal and observational. Traffic count options discussed include manual counts, video recordings, and automated counters.

#6: A variety of methods are available for measuring bicycle use, including primarily surveys and traffic counts. Care must be exercised in the design and execution of such methods in order to yield reliable and useful data.

The results of several surveys and counts, some of which represented original work, are presented in the report. Demographic profiles of cyclists in general and bike commuters in particular were developed, along with specific information about the nature of their trips.

#7: The tens of millions of people who ride bikes represent a huge potential group of utilitarian cyclists. Safe and attractive facilities providing efficient connections will encourage greater use of cycling, especially for short trips.

Since funding for bicycle facilities is quite limited, funding agencies are interested in identifying the facilities that might yield the greatest 'return on investment' in terms of increased cycling. No such tools exist, and data are virtually nonexistent on the impact of any specific facility addition or improvement with respect to increased cycling. It is also clear that answering such a question is quite complex because the question involves such issues as land use, population density and demographics, the availability of alternatives, and of course the distance to desired destinations.

#8: There are no objective models or tools to help determine where additional bicycle facilities should be built or which facilities will lead to the greatest increase in utilitarian cycling. More research is clearly needed.

A two-part framework for selecting facility improvements has been developed. It was not possible within the scope of this project to test this approach, but it is offered as a starting point for additional research.

#9: A framework for selecting facility improvements has been developed. The first step involves locating areas more likely to benefit from such improvements. Step 2 focuses attention on the infrastruc-

ture and operational changes that might be most appropriate.

Finally, the report presents a Case Study wherein bicycle use on a popular multi-use trail in the Seattle area was monitored before and after a critical 'missing link' was filled in. The results showed a substantial increase in use with a significant fraction of cyclists using the facility for commuting.

INTRODUCTION

Research Objectives

This project sought to identify bicycle facility improvements that would encourage more people to use a bicycle for commuting and other utilitarian purposes. Specific tasks included 1) synthesis of the elements required to create a cycling-friendly environment; 2) development of a comprehensive list of bicycle facilities; 3) review of measures to assess bicycle use with results from various surveys; and 4) creation of a framework for selecting facility improvements.

Background

Society's increasing reliance on the automobile to meet the vast majority of its personal travel needs is well documented, as are the problems that accompany such a mode choice: congestion, air, water and noise pollution, increased time spent traveling, escalating infrastructure needs, and an over-dependence on foreign energy sources. We have spent the past 50 years suburbanizing our landscape while largely prohibiting the co-location of jobs, residences, and services.

Against this backdrop the bicycle stands out as a transportation vehicle with largely unrealized potential. Bicycles are relatively inexpensive to purchase and easy to maintain. They are non-polluting. They provide personal transportation that features door-to-door service. Not to be overlooked are the public health benefits of the aerobic exercise one gets while cycling.

National numbers indicate that almost half (48.8%) of daily trips are under 5 km, and 62% are 8.3 or fewer Km. (Zeeger 1994) Such trips can easily be made by most people on a bicycle. Indeed, bikes can often "beat" cars on urban trips of 10 km or less. Short automobile trips are also the most polluting since automotive emission control systems work most effectively when the engine is warm.

Figure 1 illustrates the distribution of daily trips by purpose for all travel modes and for bicycle trips. A large fraction (42%) of total trips are taken for personal/family business (e.g. shopping) while only 20% of bicycle trips are for this purpose. While on a national basis only 0.7% of all trips were made by bike, such trips total approximately 1.7 BILLION annually. (Zeeger 1994)

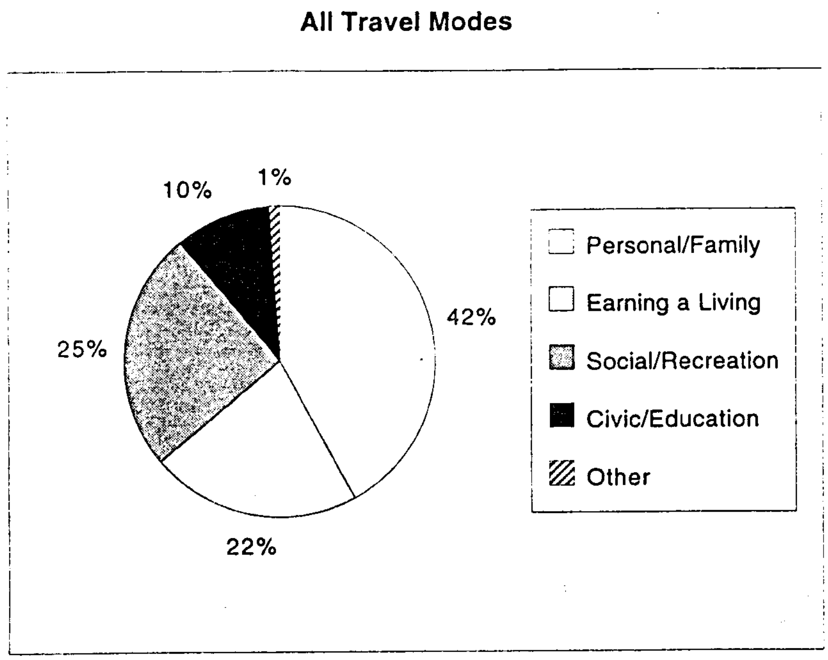
Increasing the number of commute and utilitarian trips made by bicycle will require addressing several interrelated issues. Figure 2 breaks the issues into three major components that might be thought of as sequential in nature. (Adapted from Goldsmith 1992) 'PERSONAL CONSIDERATIONS' involve issues that might affect an individual's willingness to consider using a bike for transportation.

'TRIP FEATURES' confront those willing to bike. The availability of direct, safe routes on bicycle-friendly facilities is often cited in surveys of potential bike commuters as a necessary condition in order to be able to bike.

Finally, 'DESTINATION BARRIERS' can prevent those willing and able from using their bike for transportation. The key elements here are secure bicycle parking along with showers and clothes lockers. Employer and co-worker attitudes can also play a role in encouraging and supporting bicycle commuting.

Meanwhile, as part of the Washington State Transportation Policy Plan (WSTPP), Washington has adopted a Bicycle Transportation Policy that seeks to support the increased use of bicycles. The policy identifies four major areas that need attention: Facilities, Safety Education, Promotion, and Funding. (Washington State Transportation Commission, 1992) State laws such as the Commute Trip Reduction Act and the Growth Management Act, along with both federal and state Clean Air Acts, further support the increased use of bicycles as transportation vehicles. Facilities are the necessary, if not sufficient, element if we are to begin to realize the potential of the bike.

DAILY TRIP PURPOSES



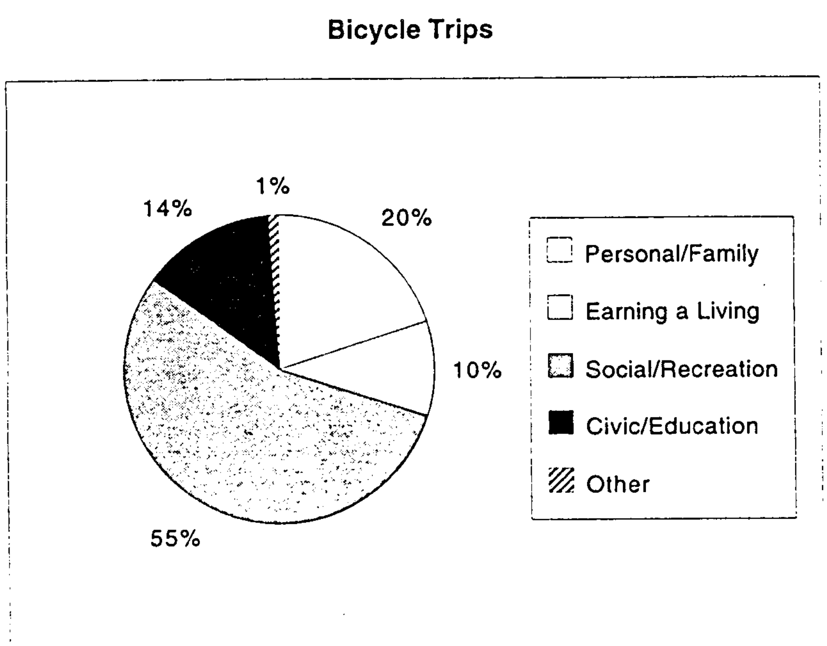


Figure 1. Comparison of trip purposes by all modes and by bicycle (Zeeger 1994).

TO BIKE TO WORK OR NOT?

First, a potential bicycle commuter must deal with:

PERSONAL CONSIDERATIONS

- O Being open to consider an alternative to the car.
- O Proper attitude - a bicycle is a transportation vehicle.
- O Realistic assessment of safety issues.
- O Physical ability to cycle.
- O Equipment/training/experience to use a bike for transportation.
- O Family responsibilities (e.g. child care).
- O Need for a car at work.

Next, the willing must confront:

TRIP FEATURES

- O Reasonable travel time and distance.
- O Direct routes with minimal delays.
- O Appropriate roadway facilities (e.g. bike lanes, bridge crossings).
- O Well maintained facilities (e.g. lack of glass and debris).
- O Reasonable traffic volumes.
- O Negotiable terrain.
- O Acceptable weather conditions or knowledge to deal with same.

Finally, those willing and able with acceptable trip features must overcome:

DESTINATION BARRIERS

- O Secure bicycle parking (e.g. lockers, supervised).
- O Clothes lockers to store work clothes.
- O Showers and changing facilities on-site or near by.
- O Employer/co-worker attitudes:
  - -> Flex-time
  - -> Relaxed dress codes
  - -> Encouragement (facilities, cash incentives, recognition)

Only when an individual can accept and deal with these issues will they try utilitarian cycling.

Figure 2. Factors affecting the decision to bicycle commute.
(Adapted from Goldsmith 1992)

RESEARCH APPROACH

The current low level of utilitarian cycling is due, at least in part, to the absence of a cycling-friendly environment in most of our communities, as well as to inadequate knowledge about cycling and those who ride bikes. Cyclists were classified and the essential features of the bicycle were described, along with some important points about bicycle riding that can have implications for facility design and maintenance. Finally, a cycling-friendly environment was described in relation to five key features.

The development of a comprehensive list of facilities to support utilitarian cycling required the review of a number of design manuals and guides. A table was created to integrate this information into a comprehensive list of such facilities. A brief description of each item is presented along with cross-references to the original sources where they exist.

Measuring bicycle use is quite difficult. Various methods to gather this information were reviewed, as were several studies and surveys that have attempted to assess use. A demographic profile of current cyclists was developed, along with information on their use patterns.

Finally, an attempt was made to develop a framework for assessing which facilities might yield the greatest 'return on investment' in terms of increased cycling. Since no documented studies exist, this latter exercise was of necessity somewhat speculative. A Case Study is presented that showed increased bicycle use in response to a facility improvement.

FINDINGS

Task 1. The Cyclist, The Vehicle, and The Environment

Before one attempts to design facilities to create a cycling-friendly environment, the capabilities and limitations of the intended users and their vehicles must be understood.

A. Classifying Cyclists

Various schemes have been developed to classify or characterize cyclists. Most use cycling experience or skill level as the distinguishing characteristic. Three such schemes are presented in Table 1.

Table 1. Schemes to classify cyclists.

Source	Classification	Characteristics
Wilkinson 1994	Group A - Advanced	Experienced - desires direct access to destinations and is comfortable using existing streets and highways.
	Group B - Basic	Casual, novice, occasional - desires comfortable access to destinations and prefers some separation from motor vehicles.
	Group C - Children	Pre-teen - residential areas with low volume traffic or physically separated facilities.
Forester 1994	Vehicular Cyclist	All cyclists should be considered drivers of vehicles with no special accommodations.
Davis (City of Davis 1993)	Avid	Uses all roads comfortably.
	Regular	Uses roads and appreciates bike lanes and paths when they provide direct routes.
	Young regular	Mostly junior or senior high school students using bikes for social or personal business.
	Beginning riders	Those who lack the skill and experience to handle traffic. Includes children.

Wilkinson suggests combining Groups B and C together, since their needs are similar. However, such a combination lumps together cyclists with a wide range of skills, experience, and needs. Children under the age of 15 may represent 40% (with 25% age 10 or less) of bike riders in the U.S. Forester fails to recognize that the vast majority of cyclists lack the training and experience necessary to ride safely and comfortably in traffic.

While arguments can be made for and against each of these classification schemes, the important point is that cyclists are not a homogeneous group. Facilities designed for cyclists must take into account the different needs and capabilities of those who will use them. The Davis approach seems the most reasonable because it individually acknowledges the major user groups.

KEY FINDING #1: Specific attention must be paid to the types of cyclists who may want to use whatever facilities are being considered. Cyclists can be classified into four groups: avid, regular, young regular, and beginning. While their needs and capabilities may vary, they share a common desire to use their bicycles for transportation. A high quality cycling environment will encourage the less frequent and less skilled to cycle more and thus to progress to a higher level of cycling.

B. The Bicycle

The bicycle is the most energy efficient form of land transportation ever devised. However, it has certain characteristics that must be appreciated when bicycle facilities are designed. These are presented in Table 2.

Table 2. Bicycle characteristics that influence facility design.

Characteristic	Consequence
Instability	Requires continuous steering adjustments and weight shifting to keep the bike upright. A major contributor to the most frequent bicycle accident type: falls. A minimum speed must be maintained and as speed decreases maneuvering room increases.
No suspension / High pressure tires	The pavement provided on bicycle facilities must be smooth and free of potholes, cracks, raised pavement markers, and bumps.
No operator protection or crumple-zone.	Collisions with fixed objects or vehicles can cause the rider to be thrown from the bike, as well as result in serious damage to the bicycle.
Effected by side-winds	Whether winds are naturally caused or the result of passing high-speed vehicles (particularly large trucks), extra lateral space or buffers should be provided.
Physical security	Unattended bicycles and their attached components may be subject to vandalism or theft unless secure parking is provided.
Highly maneuverable	Allows the cyclist to steer out of trouble and stop in a very short distance (assuming dry conditions and clean pavement).

KEY FINDING #2: Facility designs must be compatible with the operating characteristics and limitations of the bicycle. Smooth, clean riding surfaces free from hazards are essential for the safe operation of bicycles within the transportation system.

C. *The Cyclist/Bicycle System*

Several additional points regarding the cyclist/bicycle system that will influence facility design should be kept in mind. Table 3 lists five of them with an explanatory comment.

Table 3. Cyclist/bicycle system features.

Point	Comment
Speeds attainable	Muscle power limits the speed that a cyclist can sustain. On flat terrain most people can achieve 15 to 25 km-per-hour (KPH) while trained cyclists reach 40 KPH. During descents, speeds in excess of 75 KPH are possible.
Minimize wasted energy	Facility design and operational characteristics should keep energy losses to a minimum. Frequent stops waste energy, increase the amount of unstable, slow speed riding, and discourage cycling.
Cycling is social	Cyclists are social beings and facilities should be designed to permit side-by-side riding whenever possible.
Information gathering	A cyclist can acquire information about the traffic environment through hearing as well as sight.
Minimum operating volume	A cyclist requires a minimum "operating volume" that is approximately 1.25 m wide by 2.0 m long by 2.5 m high. The natural tendency of people to 'shy' away from nearby objects such as walls and other fixed objects requires additional width beyond the actual length of the handlebars. The height of overhead structures should be no less than 3.5 m.

KEY FINDING #3. Designers must be aware of the characteristics, capabilities, and limitations of the bicycle and its operator. This is, of course, no different than the design of facilities for automobiles. We just have less knowledge and awareness of the needs of the cyclists and their bicycles.

D. The Five Elements of a Cycling-Friendly Environment

The provision of a few bicycle lanes or paths will not be sufficient to induce most people to ride to work or use their bikes for errands. Rather, the goal should be the creation of a comprehensive, cycling-friendly environment. Such an environment, of course, includes physical facilities but also addresses the major reasons why people do not bike for utilitarian purposes.

The Dutch have published a comprehensive bicycle facility design manual that starts with the cycle/cyclist's characteristics and limitations, accepts the premise that bicycles should be considered an integral and legitimate part of the transportation system, and seeks to create a truly cycling-friendly environment. (CROW 1993) Five complementary characteristics define such an environment and are listed in Table 4. (AASHTO 1991, pages 8-9, presents a similar view although less compact.)

Table 4. Five elements of a cycling-friendly environment (summary).

Element	Key Characteristics
Coherence	All origins and destinations are linked with a choice of routes that are easy to locate, complete, and of consistent quality.
Directness	Cycling routes are as direct as possible, with minimal delays.
Safety	Facilities minimize the chance of accidents among all users of the transportation system and provide for the safety and security of cyclists and their vehicles.
Attractiveness	The surroundings are pleasant and inviting.
Comfort	Cyclists travel efficiently over smooth, well maintained surfaces along routes where delays are kept to a minimum.

Appendix A illustrates how these five features can be related to various elements of the transportation system.

KEY FINDING #4: Consideration should be given to developing a cycling-friendly environment that encourages the use of the bicycle for transportation purposes. Such an environment would provide a coherent system that would be easy to use and would offer a choice of direct routes that were safe, attractive, and comfortable.

Task 2. A Comprehensive List of Bicycle Facilities

The lack of "bicycle facilities" is often cited in studies and surveys as a major impediment to the greater use of bicycles. A national Louis Harris survey found "safe bike lanes" and "showers and storage at work" as two of the top three changes needed to increase bike commuting. (*Bicycling* 1991) Responses to the "Bicycle Washington" survey conducted as part of the WSTPP confirmed the importance of good bicycle facilities for both utilitarian and recreational cycling. (Subcommittee on Bicycle Transportation 1991)

Unfortunately, the term "bicycle facilities" is not very specific and means different things to different people. If the average cyclist-on-the-street were to define the term "bicycle facilities," he or she would probably answer "bike paths" and maybe mention "bike lanes and streets." Those who used their bikes for more than recreation might add "secure bike parking" and perhaps "showers and lockers" at work if they were bike commuters. While certainly essential elements, these represent only a small fraction of the facilities that should be present to fully support the widespread use of the bicycle for transportation.

A major goal of this research was to identify the full range of physical facilities that would characterize a truly cycling-friendly environment. The literature was consulted, with particular attention given to existing bicycle facility design and planning manuals. Table 5 presents the resulting list in alphabetical order.

While the length of the list may at first seem intimidating, one should note that the author is unaware of any city or region in which all of the items listed are adequately addressed. Rather, the reader should consider that we have already created virtually all of these or comparable facilities, which are largely taken for granted, to support our use of the automobile. Indeed, many of those same facilities perhaps with some modifications can be used for cycling transportation.

Table 5. Comprehensive list of bicycle facilities. (See Appendix B for details.)

1.	***Airports***	
	A.	Access
	B.	Parking
	C.	Tourist services
2.	***Bicycle Parking***	
	A.	Attended
	B.	Automated
	C.	Lockers
	D.	Racks
3.	***Bridges/Overpasses***	
	A.	Bike only or shared with peds
	B.	Railings
	C.	Shared with motor vehicles
4.	***Cattle Guards***	
5.	***Construction Zones***	
	A.	Detours
	B.	Temporary paved surfaces
	C.	Use of steel plates
6.	***Curbs - extruded***	
7.	***Drainage/Utility Covers***	
8.	***Fences/Railings***	
9.	***Ferries***	
	A.	Automobile/passenger
	B.	Passenger only
	C.	Terminals/parking
10.	***Intersections***	
	A.	Road/driveway
	B.	Road/road
	C.	Road/path
11.	***Lighting***	
12.	***Maintenance***	
13.	***On-Road Facilities***	
	A.	Arterials - major/minor
	B.	Bicycle boulevards
	C.	Collectors / local streets
	D.	Freeways
	E.	Hybrid bike lane
	F.	Stripped bike lane
	G.	Wide curb lanes/shoulders
14.	***On-Street Parking***	
	A.	Diagonal
	B.	Parallel
	C.	Parking and bike lanes
	D.	Perpendicular
15.	***Pavement Structures***	
16.	***Railroads***	
	A.	At-grade crossings
	B.	Cars
	C.	Terminals/platforms
17.	***Separated Facilities***	
	A.	Bike only
	B.	Mixed use
	C.	Rail trails
	D.	Related facilities
18.	***Sidewalks/Ramps***	
19.	***Traffic Control Devices***	
	A.	Bollards
	B.	Expanded bike streaming lane
	C.	Paint
	D.	Raised pavement markers
	E.	Refuges
	F.	Signals
	G.	Signs
	H.	Speed Bumps/traffic diverters
20.	***Transit/Light Rail***	
	A.	Buses
	B.	Roadway conflicts
	C.	Trains (light)
	D.	Terminals/platforms
21.	***Tunnels/Underpasses***	
	A.	Bike only or shared with peds
	B.	Shared with motor vehicles
22.	***Vegetation - Adjacent***	
	A.	Obstructing
	B.	Surface problems
23.	***Workplace Facilities***	
	A.	Clothes lockers
	B.	Showers

Such a list of facilities (Table 5) can not convey many of the issues involved as they relate to cycling. In addition, references to available guidelines and manuals can provide more detailed information about facility design. Thus, an annotated version of Table 5 appears in Appendix B, where each entry has a brief description or explanation along with references, where they exist, to several guidelines and manuals. In some cases the references present inconsistent information, while in others no mention of a particular facility appears.

Obviously not all facilities are needed or appropriate for all locales. However, they all should be carefully considered from the perspectives of both the current utilitarian cyclists and those who might be induced to use their bikes more. A coherent, direct, safe, attractive, and comfortable environment that provides most or all of these facilities will result in increased use.

KEY FINDING #5: A comprehensive list of facilities necessary to fully support utilitarian cycling has been developed. While not all of the facilities listed are necessary, their existence would promote increased cycling and enhance the cycling experience of those who do.

Task 3. Bicycle Use: Methods and Selected Results

Various techniques have been developed to measure automobile travel including the decennial Census, the National Personal Transportation Survey, analysis of gasoline sales and records of car mileage. It is much more difficult to assess the amount of bicycling especially for utilitarian purposes. The availability of better use measures would provide a clearer picture of the type and extent of cycling being done, as well as help assess the impact of various facility improvements.

National travel surveys have shown that cycling represents only a very small fraction of reported trips. While there is no question that cycling, at present, is not a major form of transportation in the U.S., it is also highly likely that the extent of cycling has been seriously under-counted. Both the timing of these surveys (typically in late winter or early spring) and the way questions have been phrased ("for the predominant mode of transportation used for the last trip") have contributed to this result. Recreation or short utilitarian trips - the very type of trips for which the bike is most often used and for which it is most appropriate - may not have been counted at all.

On the other hand, surveys designed to uncover cycling behavior in this country have found it. Sizable fractions of the population own and use bikes and represent a large pool of potential utilitarian riders. They already own the basic equipment and have at least a rudimentary skill level to use this travel option.

The two principal techniques available are **surveys** and **traffic counts**. Surveys can be done in various ways and offer the opportunity to gather information about travelers (e.g. demographic and socioeconomic) and details about their travel habits and experiences, while surveys can also gauge their preferences for various options. Thus, surveys can be helpful in planning facilities that, if the responses are representative of the community, should better serve the travelers' needs. Surveys require careful design, can be labor intensive, and usually involve sophisticated analysis which can further increase their cost. Using surveys to gauge changes in travel habits that result from a particular facility change requires identifying and contacting affected users both before and after the change, which can be quite difficult.

Average daily traffic counts are the time-honored way to monitor roadway use and most jurisdictions have a database showing average daily motor vehicle volumes on their major roadways. Unfortunately, very little data exist on bicycle traffic volumes along roads or even on dedicated bicycle facilities. Such data gathered over time could be used to assess the effectiveness of facility improvements, as well as to provide exposure data to better analyze accident information.

A complete discussion of how to design, carry out, and analyze travel surveys and traffic counts is beyond the scope of this research. However, some examples of survey and counting methods appropriate to assessing bicycle use are given below followed by specific results from several sources.

A. *Bicycle Use Surveys.*

Designing a good survey should start with a clear and well considered set of objectives. Questions must be carefully worded to ensure that they are clear to the respondents and will elicit the correct response. If possible, the survey should be tested on a representative sample of respondents before being used on the larger target audience. Shorter surveys are more likely to be answered than longer ones. The methods used to distribute and collect the surveys can also affect the response. In general, better responses will be obtained for those surveys that provide a convenient, no-cost way to reply.

Random surveys, in which every Nth person is contacted, will generally yield the most statistically robust results (assuming a large enough sample). Such surveys can be used across an entire population (e.g. all residents of a city) or some sub-set thereof (e.g. those using a bike path).

Alternatively, all members of the target group (e.g. members of a bicycle club) may be surveyed. It is important to recognize that in either case (random or blanket), only those with some interest in the subject of the survey are likely to respond. Thus, all such responses will carry certain biases that may be hard to unravel. The key is to carefully describe the methodology used so that any reader of the results will understand how the survey was done and can then properly interpret them.

1. **Telephone surveys** require access to the telephone numbers of the target population, as well as properly trained surveyors. Those called may be reluc-

tant to answer certain questions (e.g. regarding household income or ethnicity) because it is obvious that their responses can be linked to them directly. Many people also consider phone surveys an intrusion into their privacy as well. Such surveys are also labor intensive to conduct. Thus they are often short and highly focused. The City of Seattle, using volunteers, has used this technique to gather information on walking and cycling patterns, and it is the standard method used by the national polling organizations.

2. **In-person interviews** are similar to telephone surveys but usually require even more highly trained individuals. At the same time, they are severely limited in terms of the geographical area that can be covered. The results obtained rely heavily on the skill of the interviewer.

3. **Mail back surveys** can be longer than those done over the phone and often include a self-addressed, postage-paid reply envelope. They may be mailed or handed out directly to the target group. Appendix C contains samples of two mail surveys. In one case the goal was to determine the usage of a particular multi-use trail system (the Burke-Gilman/Sammamish River Trails), and the surveys were distributed to all trail users who would accept them. The other survey is more extensive and was derived from one used by Kaplan (1975) to measure bicycle use of regular riders who were members of the League of American Wheelmen. The results of several mail surveys are summarized below in Task 3, Section C.

4. **Travel diaries** are designed to gather specific trip information (e.g. time-of-day, origin, destination, mode, and travel distance or time) over periods ranging from one day to perhaps a week. Collecting accurate data using

diaries is obviously dependent on having cooperative and accurate subjects. If properly completed, such information provides a detailed trip making picture of those surveyed. Appendix C contains a sample travel diary.

5. **Verbal and observational surveys** can be used to gather some types of use information. For example, in the Case Study described below, helmet use (observational) and trip purpose (verbal) information was gathered while a traffic count was conducted on a multi-use trail. Having the observers in close proximity to the trail and alerting the trail users through signage to announce their trip purpose made this possible.

B. Bicycle Traffic Counts

Some of the established techniques for counting motor vehicles (e.g. hand tallies, pneumatic tubes, induction loops, and most recently, video techniques) can be used to count bike traffic. Hand tallies are the most commonly used approach but also the most labor intensive. Applying the mechanical or electronic counting methods requires special care to eliminate false counts caused by motor vehicle traffic on roads. Using these automatic techniques on bike paths can also present challenges, given the lack of well defined travel lanes and the wide range of speeds observed on such paths.

1. **Manual counts** can be used to record bike traffic along road or trail segments or at intersections where turning movements can also be observed. Little training is required, but the counter must be conscientious or the results will be unreliable. Expense often limits such counts to a few days or even a few hours, thus providing only a snap-shot of the overall picture. If personnel are available, a cordon count can be conducted in which all traffic

moving into a given area is monitored. Using approximately 25 volunteers, Seattle was able to count bicycle traffic into the central business district during one morning commute. All such infrequent bicycle counts are subject to great variability. The temperature, precipitation, darkness, seasons, even day of the week are variables that can cause dramatic changes in the results. Thus longitudinal studies (monitoring use over months or years) must be done with care.

2. **Video recording** is a way to more frequently monitor a particular location at low operational cost. While a standard video cassette recorder (VCR) is limited to 6 to 8 hours of recording on a single tape, time-lapse VCRs are available that can record for up to 40 full days of images on a single cassette. The problem then becomes one of analyzing such tapes - a potentially boring and time consuming task. If traffic is light, it is possible to play the tapes at fast-forward and review the images at perhaps 10 to 20 times real time. (Bike counts in the Seattle I-90 bicycle/pedestrian tunnel acquired by using this technique are reported below.) Such high-speed analysis can not be used when traffic volumes are high because too much traffic makes it impossible to distinguish the items of interest with sufficient reliability. Automated video image analysis systems have the potential to identify bikes in a mixed traffic scene, but so far the technology has not been used for this purpose. Such a capability would greatly reduce the data reduction task and provide a way to more easily gather bicycle use data.

3. **Automated counters** such as induction loops and pneumatic tube counters can be used to counts bikes in special situations (e.g. bike lanes and paths). If automated counters are used on streets, care must be taken to ensure that

car and truck traffic does not generate false counts. The positioning of such devices to capture all the bicycle traffic is sometimes impossible, since some cyclists choose to travel in the same lanes as the motor vehicles. "Automated trail counters" are sometimes promoted as being able to count bikes. However, this is more difficult than it first might appear. A simple system that shines a light across the trail and counts interruptions of the beam may count a single bike as up to 10 users as the wheels, fork, frame tubes, and legs successively break the beam. More sophisticated approaches pulse the beam and then only record objects that break three or more successive pulses. These work well for walkers, large animals and snowmobiles because of either their slow speed or large cross-section. However, bikes traveling in excess of about 5 KPH will not be counted by such systems.

KEY FINDING #6: A variety of methods are available for measuring bicycle use, including primarily surveys and traffic counts. Care must be exercised in the design and execution of such methods in order to yield reliable and useful data.

C. *Selected Use Survey and Count Results*

Several surveys were analyzed to characterize current cyclists and the types of riding they engage in. Of particular interest were those who commute by bicycle. Two surveys, one for the U.S. Consumer Product Safety Commission (CPSC) and the other for Rodale Press (both presented in Rodgers 1994), provided a national perspective. Both the published report and the raw data from an origin/destination survey from Boulder County, Colorado, were analyzed to reveal the bicycle commuting habits in Boulder Valley, an area known nationally for its support of cycling. (Denver Regional Council of Governments 1992) Finally, responses from a survey of more than 3000 users (including a sample of almost 500 bicycle commuters) of the Burke-Gilman Trail/Sammamish River Trail (BGT/SRT) provided a snap-shot of local cycling patterns. A complete summary of that survey is reported in Appendix D.

1. **Who rides bikes?**

Nationally, an estimated 67 million people age 5 and above ride a bike at least once a year, while close to 100 million bikes are available to be ridden. Almost 40% of the riding was reported by children under 15 years old while nearly 20% was reported by people between the ages of 31 and 40. For adult cyclists the average age is between 35 and 38 years. Males make up slightly more than half of all riders (52%) although the more regular male riders outnumber the females about 2 to 1. Cyclists tend to have higher educational and income levels than the national averages. Professional or managerial jobs were reported most often by the adult cyclists (28 to 41%) followed by clerical and administrative (19 to 23%). (Rodgers 1994) The data from Boulder and Seattle were similar except that the Boulder cyclists were younger (average age was 28 versus 35).

2. **How much and where do they ride?**

The mean number of hours of cycling estimated by all respondents to the CPSC national survey was 236.2 per year (median = 105 hours). Meanwhile, the Rodale survey of adult cyclists revealed that almost 26% reported riding 2 to 3 times per week, while another 23% claimed a frequency of 2 to 3 times per month and 14% reported once per week. Low traffic volume streets are the most common places to ride, as most people avoid major arterials and highways. Sidewalks and playgrounds represent the second most likely venue for cycling, particularly for children.

3. Why do they ride?

Table 6A shows the trip purposes reported by the adult Rodale cyclists. Fitness and exercise were reported by more than three-quarters of the respondents. Slightly over 10% listed commuting as a reason to bike. About 8.7% of the riders reported spending all or most of their time either commuting to work or going to school. This accounts for 12.6% of all hours ridden. From this one can infer that commuters ride their bikes for longer periods than non-commuters.

Table 6.A. Bicycle trip purpose.

RODALE (All Riders)	
Multiple Responses	%
Fitness/Exercise	77.4%
Family Activity	48.1%
Visiting Friends/Relatives	20.7%
Commuting	10.1%
Fast Recreational Rides	9.0%
Mt. Bike Recreational Riding	5.2%
Day-long Tours	3.4%
Weekend Tours	1.9%
Triathlon/Biathlon Event	1.1%
Century Rides	1.0%
Road Racing	1.0%
Mountain Bike Racing	0.7%
Week-long Tours	0.6%
Commercial Bike Tours	0.4%
Unknown	3.2%

Table 6.B. Reasons to bike more.

RODALE (Adults)	
Multiple Responses	%
Person to Ride With	46.4%
Safer Places to Ride	34.7%
More Comfortable Seat	34.0%
More Scenic Riding Places	28.6%
Better Physical Condition	26.8%
Ability to Ride to Work	14.0%
Gears Easier to Shift	10.9%
Access to Riding Events	4.1%
Training Course	1.5%
Unknown	9.1%

(Source: Rodgers 1994)

4. Reasons to bike more.

The Rodale survey asked the question: What would cause you to ride more? Table 6B shows the responses, which confirmed the social nature of cycling, as the most frequent response was having a person to ride with (46.4%). Second were safer places to ride (34.7%), followed by more scenic riding (28.6%). Also mentioned was the "ability to ride to work" (10.9%) but without any indication of what would be needed to provide that "ability."

5. Bike Commuters - Boulder vs. Seattle

The Boulder and Burke-Gilman Trail/Sammamish River Trail (BGT/SRT) data provided an opportunity to develop a picture of the types of people who commute to work or school by bike and to characterize the type of riding that they do. The methodologies used to collect the data were different for each of these sources. Boulder data came from an origin/destination survey conducted using a travel diary. The BGT/SRT data come from a mail-back survey handed to trail users. Thus care should be used in comparing the results.

Table 7 compares all Boulder and Seattle cyclists with the subset that commute by bicycle with respect to age, gender, income, and, for Seattle, also occupation. Just over 50% of the Boulder cyclists reported commuting trips in their travel diaries, while 57% of those returning BGT/SRT surveys on a Tuesday listed work or school as their trip purpose. Boulder cyclists were a bit younger than those in Seattle, but the gender split (2 to 1 male-female) was virtually identical. Seattle commuters appeared to have lower incomes.

Thirty-four percent of Boulder bike trips involved commuting between home and work or school. Bicycles accounted for 7% of the commute trips, while transit's share was 4% and single-occupancy vehicles made 71% of such trips. Travel times rather than trip distances were reported for the Boulder bike trips. The average bicycle trip times and estimated distances (based on 20 KPH average speed) were as follows:

Home-Work	16.8 minutes	5.6 km
Home-School	11.0 minutes	3.7 km

Meanwhile, commuting cyclists using the BGT/SRT reported using the trails an average of almost 200 times per year. Reported total commute distances averaged 10.7 km, of which trail travel accounted for 7.2 km on average. See Appendix D for additional details on the BGT/SRT commuters.

Table 7. Demographic data on bicycle commuters - Boulder vs. Seattle

SURVEY:		BOULDER		BGT/SRT		
	GROUP/SUBSET	All Cyclists	Bike Commuters	Saturday Cyclists	All Tuesday Cyclists	Tuesday Bike Commuters
	SAMPLE SIZE	497	253	1431	832	475
AGE:	Average	27.8	28.7	35.5	34.9	34.1
	10 or less	9.1%	4.7%	0.8%	0.1%	0.0%
	11-14			1.2%	0.1%	0.0%
	10-19	16.5%	13.4%			
	15-20			3.6%	2.9%	1.9%
	21-30	27.2%	34.0%	29.9%	36.1%	40.4%
	31-40	29.2%	30.8%	33.1%	35.3%	35.6%
	41-50	15.5%	14.6%	19.4%	14.5%	13.5%
	51+	2.6%	2.4%	9.5%	8.5%	6.3%
	Unknown			2.7%	2.4%	2.3%
GENDER:	Female	34.2%	31.0%	36.5%	29.1%	28.0%
	Male	65.8%	69.0%	63.0%	70.2%	70.9%
	Unknown			0.4%	0.7%	1.1%
OCCUPATION:	Clerical/Administrative	NA	NA	3.5%	3.6%	2.5%
	General Laborer	NA	NA	1.6%	1.8%	1.7%
	Homekeeper	NA	NA	2.6%	2.0%	0.8%
	Professional/Manager	NA	NA	62.9%	50.6%	48.2%
	Skilled Labor	NA	NA	5.7%	4.7%	3.6%
	Student	NA	NA	16.6%	28.4%	38.3%
	Other/Unemployed	NA	NA	5.7%	6.6%	2.9%
	Unreported	NA	NA	1.4%	2.3%	1.9%
HOUSEHOLD INCOME	<$15K	10.1%	13.6%	17.8%	26.1%	31.6%
	$15K<$30K	16.8%	20.6%	25.4%	29.7%	32.4%
	$30K<$45K	28.9%	27.2%	23.6%	20.1%	16.3%
	$45K<$60K	23.3%	20.2%	12.6%	10.9%	9.8%
	>=$60K	20.8%	18.4%	15.0%	9.5%	7.6%
	Unreported			5.7%	3.7%	2.3%

Sources: DRCOG, 1992; Original data from 1990 Burke-Gilman/Sammamish River Trail Survey by Cascade Bicycle Club, King County, and City of Seattle.

6. I-90 Tunnel Bicycle Traffic

The I-90 Bicycle/Pedestrian Tunnel through the Mt. Baker Ridge in Seattle provides an important connection between Bellevue and Mercer Island and downtown Seattle. The tunnel is fitted with four video cameras which permit monitoring activity in the tunnel. With the assistance of personnel at the WSDOT Northwest Region Office, a VCR was used to record bicycle traffic during the morning (0600-0900) and afternoon (1600-1900) prime commute times.

Tapes for several days in August and October 1994 were acquired and analyzed, providing the results shown in Table 8. Generally, a 6-hour tape could be analyzed in about 30 minutes by playing the tape in "shuttle search" mode.

Table 8. I-90 Bicycle tunnel traffic - AM/PM rush hours.

BICYCLE TRAFFIC - I90 Tunnel						REPORTED WEATHER			
Date	Day of	AM (0600-0900)		PM (1600-1900)		Temperature		Rain	Sky
1994	Week	East	West	East	West	Low	High	(cm)	
8/18	Th	--	--	69	40	14	26	0	PC
8/19	F	10	58	58	24	15	24	0	S
8/24	M	16	51	--	--	12	24	0	PC
10/10	M	--	--	31	8	9	16	Trace	C
10/11	T	10	39	58	24	7	15	0	PC
10/12	W	10	27	--	--	5	15	0	PC
10/13	Th	9	34	33	11	6	13	0.94	C/R
10/14	F	4	16	--	--	8	13	0.05	PC/R
10/18	T	--	--	36	12	8	13	0	C
10/19	W	8	25	35	17	7	14	0.33	C/R
10/20	Th	7	27	28	3	11	13	0.15	C/R
10/21	F	--	--	29	16	8	15	0	C
10/24	M	14	30	--	--	6	18	0	PC
10/26	W	--	--	14	5	11	14	2.67	C/R
1995									
1/20	F	--	--	27	18	9	14	0	PC
1/23	M	14	21	25	13	6	13	0	C
1/24	T	11	27	--	--	4	14	0	C
1/25	W	11	18	23	22	6	12	Trace	C
1/26	Th	9	19	21	13	6	14	Trace	C
1/27	F	7	21	--	--	4	13	0	PC
2/13	M	--	--	9	3	-3	3	0	Snow/S
2/14	T	8	9	10	11	-6	3	Trace	C
2/15	W	2	3	10	9	1	7	0.99	C/R
2/16	Th	6	20	19	4	4	9	0.60	C/R
2/17	F	3	10	--	--	7	11	0.76	C/R
3/10	F	--	--	21	13	9	13	1.47	C/R
3/13	M	12	19	20	14	8	15	0.66	C/R
3/14	T	6	15	--	--	8	17	0.86	C/R
3/15	W	--	--	30	19	6	12	0	PC
3/16	Th	19	32	51	30	2	15	0	PC
3/17	F	16	32	39	30	7	18	0.30	C/R
3/20	M	5	17	--	--	8	13	0.48	C/R
3/21	T	--	--	20	13	2	9	0.03	C/R
3/22	W	14	25	--	--	2	11	0.05	C/R

NOTES: '--' indicates data not taken. Weather data as reported in the Seattle TIMES.
Temperatures degress C. SKY: C = Cloudy, PC = Partly Cloudy, R = Rainy, S = Sunny.

KEY FINDING #7: The tens of millions of people who ride bikes represent a huge potential group of utilitarian cyclists. Safe and attractive facilities providing efficient connections will encourage greater use of cycling, especially for short trips.

Task 4. Facility Improvements to Increase Bicycle Use

With limited resources one should ask: Which types of bicycle facilities will result in the greatest increase in use? Unfortunately, answering such a question is very difficult. As noted in the Introduction, individual travelers must consider several factors before deciding to cycle rather than to use another form of transportation. Clearly, adequate facilities are a necessary but not sufficient requirement.

Beyond the individual, the decision to build a particular facility must also consider a host of other issues, including the demographics of the area (including population density); land-use patterns in the area; distances between homes, shopping opportunities, and work sites; the presence of barriers to utilitarian cycling; the attractiveness of alternatives (e.g. congestion-free roads or very efficient transit); and the presence of cycling-trip generators. Such generators may include schools and universities, work sites with large fractions of younger workers and perhaps with relaxed dress-codes, and recreational areas featuring bicycle-friendly features.

No studies have provided objective criteria or formulas that can provide the basis for selecting one area over another to receive cycling facilities improvements nor have any studies indicated which improvements will yield the greatest return on investment. Indeed the need for more research to provide just such tools is one of the major conclusions of this research project.

Note that several authors have recently proposed methods that purportedly will evaluate a particular road segment and suggest either specific facilities or evaluate the friendliness or safety from a cyclist's perspective. Wilkinson (1994) uses traffic volumes and speeds in various environments to develop a set of graphs intended to suggest various road treatments (e.g. bike lanes, wide curb lanes). Sorton and Walsh (1994) have developed a "bicycle stress level" index based on traffic volume, curb lane width, and traffic speed as primary variables. Secondary variables include the number of commercial driveways per mile, parking turnover, and the percentage of heavy vehicles. Finally, Epperson (1994) has summarized efforts to create a "cycling level of service standard (LOS)." Unfortunately, none of these methods can answer the central question: What facilities are needed and what impact will they have?

KEY FINDING #8: There are no objective models or tools to help determine where additional bicycle facilities should be built or which facilities will lead to the greatest increase in utilitarian cycling. More research is clearly needed.

A. *A Framework for Selecting Facilities Improvements*

The preceding having been said, it is possible to propose at least a structure within which to approach this problem and to provide guidance until better tools are available. The following framework (Table 9) presents a two-step process designed to help narrow the choices of where to direct resources.

Step 1 identifies six key factors that can be used to locate geographic areas with appropriate populations, land-use patterns, and the basic infrastructure to support increased cycling without massive changes. Investing in improved bicycle facilities in the absence of these factors is not likely to result in a significant payoff.

Once likely areas have been identified, Step 2 can be used to assess various infrastructure and operational features that might benefit from improved facilities. Some changes might have a dramatic impact if they removed a major barrier or resulted in a major reduction in travel time by bicycle between two significant generators. Other changes would be more incremental.

The overall goal should be the creation of a comprehensive, cycling-friendly environment that makes cycling an attractive option as travelers are making their mode choices.

KEY FINDING #9: A framework for selecting facility improvements has been developed. The first step involves locating areas more likely to benefit from such improvements. Step 2 focuses attention on the infrastructure and operational changes that might be most appropriate.

Table 9. A framework for selecting bicycle facility improvements.

Goal: Creation of a cycling-friendly environment.

STEP 1. LOCATE AREAS LIKELY TO BENEFIT	
Feature	*Examples*
A. Favorable Demographics	1. Large numbers of children
	2. Majority age 50 or less
	3. Interest in fitness
B. Compatible Land Use	1. Medium to high population density
	2. Mixed land uses
	3. Presence of cycling generators (e.g.: university)
C. Reasonable Trip Distances and Times	1. Jobs/schools within 30 minutes by bike
	2. Shopping/services within 10-15 minutes by bike
	3. Most destinations within 10 km
D. Supportive Social Environment	1. Perception of safety
	2. Presence of people activity
	3. Employer support/tolerance for cycle commuting
E Functional Infrastructure	1. Basic road system adequate for cycling
	2. No major barriers
	3. Reasonable topography
F. Suitable Traffic Conditions	1. Speeds/volumes reasonable
	2. Congestion may be good
	3. Lack of heavy commercial traffic

STEP 2. ASSESS FACILITIES AND OPERATIONAL DEFICIENCIES	
Feature	*Examples*
A. On-road Facilities	1. Inadequate lane widths
	2. Incomplete bike (lane) system
	3. Dangerous intersections
B. Route Structure	1. Barriers/gaps/missing links
	2. Routes difficult to find and follow
	3. Bike routes not direct
C. Operational Features	1. Frequent STOP signs on bike routes
	2. Signals fail to detect bikes
	3. Signal timing incompatible with continuous bicycle travel
D. Quality	1. Rough riding surfaces
	2. Glass and debris in cycle tracks
	3. Presence of dangerous drain grates and utility access covers
E Destination Facilities	1. Unsafe access to work or shopping sites
	2. Inadequate bicycle parking
	3. No showers or lockers at work
F. Safety*	1. Travel through high crime areas
	2. Unwillingness of motorists to share the road
	3. Inadequate traffic law enforcement on all users

NOTE: * Safety as used here is not a "facilities" issue per se, but inattention to these features will be a serious detriment to all types of cycling and thus deserves mention here.

B. *Case Study: Change In Use Following A Facility Improvement*

A "Missing Link" Closed.

When the Sammamish River and Burke-Gilman Trails were built in the '70s a 5 km gap existed between Kenmore and Bothell, known as the "Missing Link." Half of the gap could be traversed using a heavily traveled, four-lane state highway (SR 522) with inadequate and poorly maintained shoulders. A two-lane street (NE 175th) that serves a heavy industrial area with lumber yards, a concrete plant, sea-plane base, and marina was the other half of the link. In addition, a very busy arterial had to be crossed.

In 1988 a trail was completed in the eastern half of this section, thereby eliminating the need to ride on the state highway. The 1990 trail counts described in Appendix D were thus done after completion of this portion. The remaining 2.5-km segment was completed in June 1993, when a tunnel was installed under a busy arterial. (See Figure 3.) The result was an uninterrupted mixed-use trail stretching 42 km from north of downtown Seattle to Redmond.

New Counts

Traffic counts had been taken on both sides of the Missing Link in 1990 (Kenmore and Sheridan Beach). This provided an excellent opportunity to evaluate changes in use as a result of this new facility. Three new counts comparable to those taken in 1990 were conducted in 1994 at the same two locations on one Saturday and two Tuesdays in May. The second Tuesday was added to provide additional information on bike commuting on the facility.

While the basic objective remained the same - count users going through each station - several changes were made in the process for 1994. First, some data were taken before and after the 0700 to 1900 period. On each Tuesday counts were

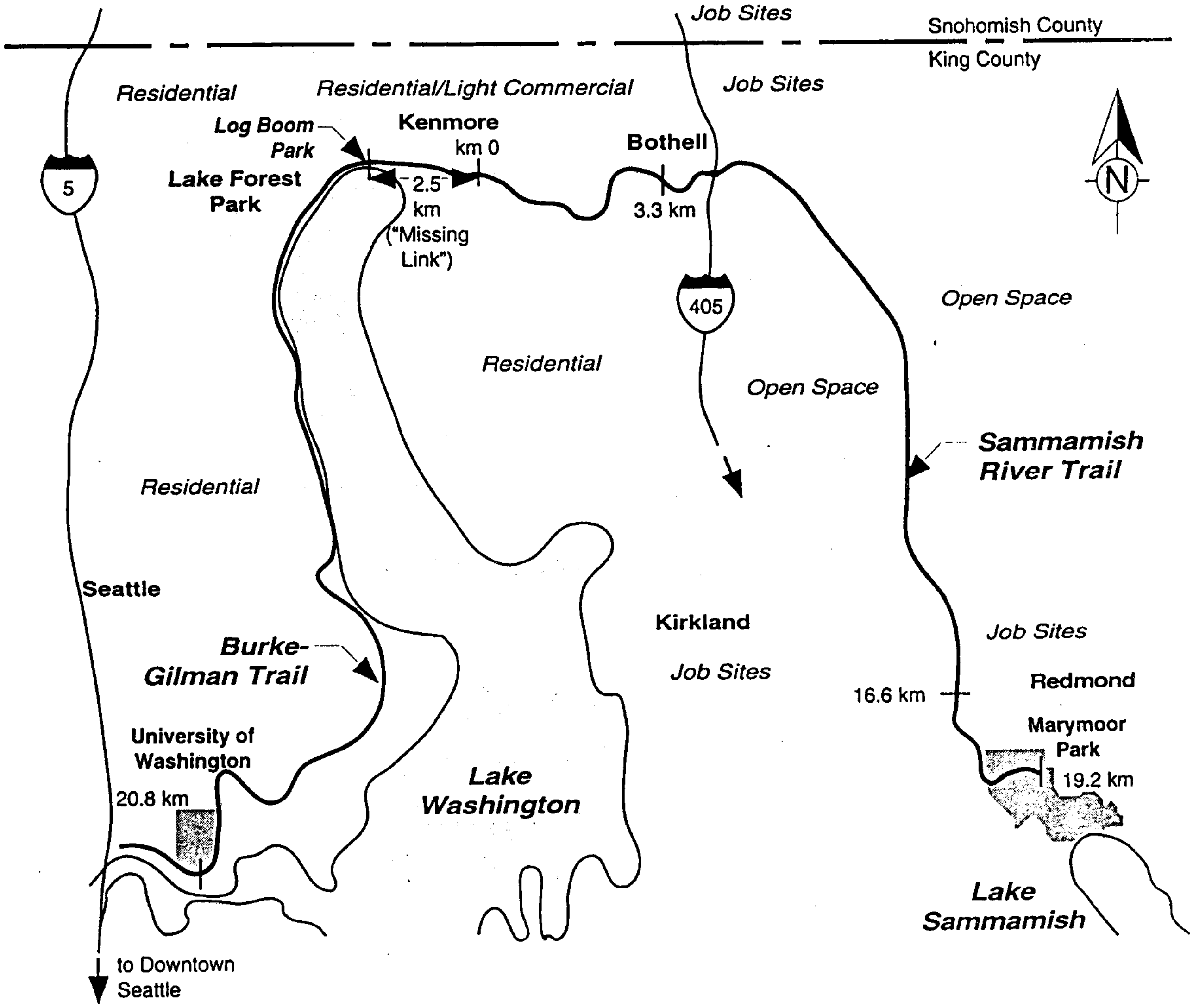


Figure 3. Vicinity map of the "Missing Link."

taken starting at 0600. This was done because bicycle commuters heading in either direction from this area might be 15 or more kilometers from their destinations and thus might well be gone before 0700. Since several hundred cyclists had used the trail between 1800 and 1900 in 1990, an extra hour was added at one station (Kenmore) to obtain counts from 1900 to 2000.

Second, in place of hand-out cards, an oral survey of trip purpose was conducted. Signs with the following messages were placed in advance of each station (in both directions): TRAIL SURVEY AHEAD, TELL US TRIP PURPOSE, COMMUTING/RECREATION/TRAINING. The counters were instructed to ask all users for their trip purpose if they did not volunteer it. Well over 90% of the users cooperated in telling us the purpose of their trips.

Third, while the 1990 survey had been conducted using mostly local bicycle club volunteers, the health occupations club of the local high schools was hired to conduct the 1994 counts. Two people staffed each station throughout the counting periods.

Fourth, in 1993 King County passed a mandatory bicycle helmet law. The counters were instructed to record helmet wearing by each cyclist and classify the rider as either a child (through age 12), a teenager (13-19) or an adult (over 20).

Dramatic Increase in Use

As shown in Table 10, bicycle traffic for comparable 12-hour periods increased substantially from 1990 to 1994, particularly at Kenmore. Note that on the 1994 Saturday, clouds moved in about noon, and around 1500 a drizzle began that lasted for 2 hours. It is likely that this inclement weather reduced the number of riders and led to the slight decrease shown at Sheridan Beach.

Table 10. Twelve hour bicycle counts BGT/SRT - 1990 vs. 1994

	KENMORE			SHERIDAN BEACH		
	1990	1994	% Change	1990	1994	% Change
Tuesday	330	1118	239%	617	1216	97%
	330	1040	215%	617	1057	71%
Saturday	1803	2548	41%	2485	2260	-9%

The hourly counts at each station are shown in Figure 4. As can be seen, use in 1994 was greater throughout each day except after noon on Saturday when the weather changed. Note also that on Tuesdays a large number of cyclists continued to use the trail between 1800 and 1900.

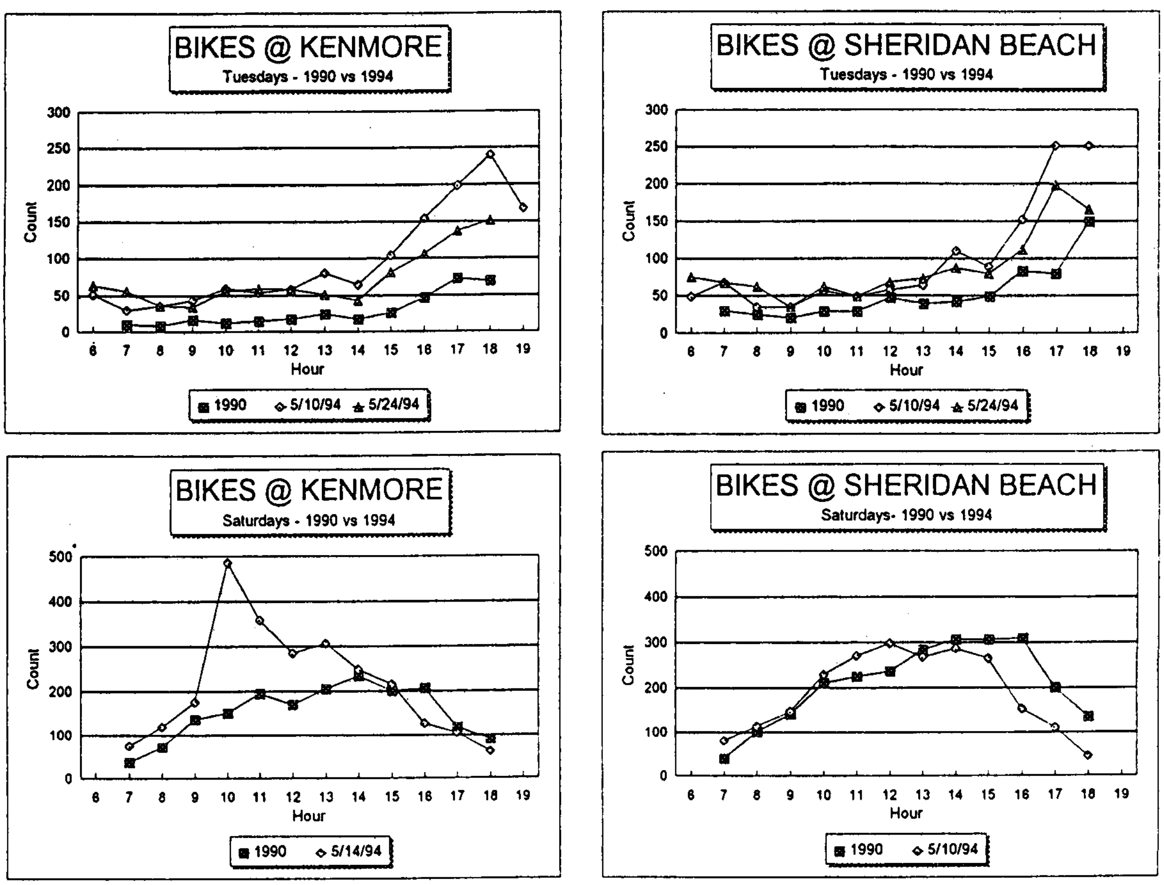


Figure 4. Hourly bicycle counts BGT/SRT - 1990 vs. 1994.

Trip Purpose

As was expected, the commuters use of the facility was heaviest in the morning (0600 to 0900) and again in the afternoon (1600 to 1900). Figure 5 shows reported trip purpose as a function of time at each site for both Tuesdays. Sheridan Beach had more commuters, as expected, since it is closer to the University of Washington (about 16 km from Sheridan Beach) and Seattle job sites.

The fraction of total users who reported commuting as their purpose ranged from 18.6% to 28.3% for the 13-hour Tuesday counts. Table 11 summarizes the commuter counts during the AM and PM peaks. These numbers are especially significant given the distance to any major concentrations of jobs. The land use along most of the trail in Seattle is residential, while in Kenmore there are both industrial and commercial (retail) areas. Further east (8 to 10 km) in Bothell, there are some employment sites in the North Creek Valley and along the Sammamish River to Redmond (22 km). However, much of the eastern portion of the trail is located in open space. Given the distance to job sites, one can safely speculate that many of these commuters were traveling between 12 and 25 km to their jobs. Anecdotal evidence suggests that many of these bicycle commuters would not be doing so in the absence of the trail.

Helmet Use

Table 12 shows the bicycle helmet use rates by age group aggregated over the three days of observation. Given the relatively short distance between the stations, it is likely that some cyclists were counted multiple times. There was some variability in the data for each age group during the three days and even at the two sites. The high and low percentages for each age group on any given day were as follows: children: 68% to 100%; teenagers: 40% to 100%; and adults: 86% to 94%.

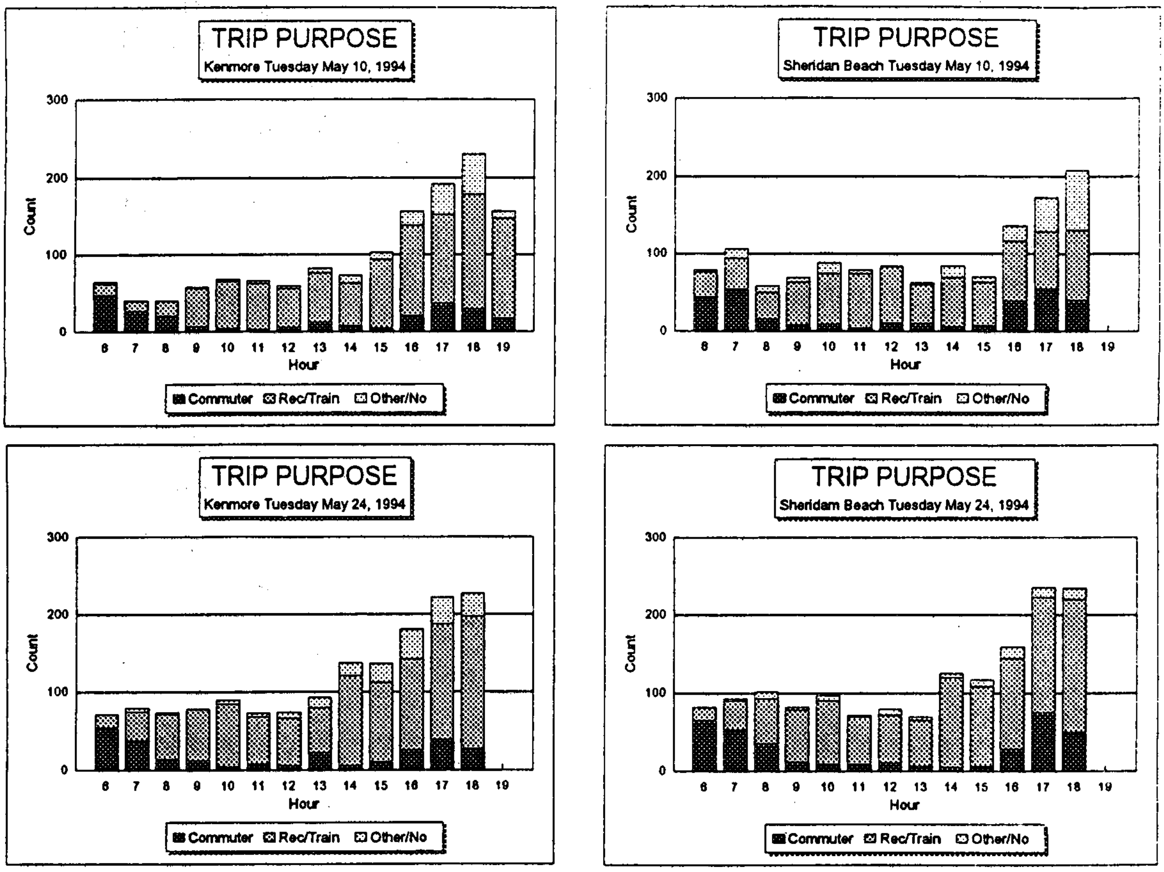


Figure 5. Trip purpose for Tuesdays at Kenmore and Sheridan Beach.

Table 11. Bicycle commuters during prime time.

PRIME COMMUTING TIME STATISTICS - 1994

DATES/ HOURS	KENMORE			SHERIDAN BEACH		
	COM	TOTAL	% COM	COM	TOTAL	% COM
May 10						
AM 6-9	96	144	66.7%	114	247	46.2%
PM 16-19	87	577	15.1%	134	710	18.9%
PRIME TOTALS	183	721	25.4%	248	957	25.9%
13 HR TOTALS	229	1230	18.6%	303	1602	18.9%
% PRIME	79.9%	58.6%		81.8%	59.7%	
May 24						
AM 6-9	107	221	48.4%	153	227	67.4%
PM 16-19	92	436	21.1%	153	463	33.0%
PRIME TOTALS	199	657	30.3%	306	690	44.3%
13 HR TOTALS	268	1229	21.8%	366	1295	28.3%
% PRIME	74.3%	53.3%		83.6%	53.3%	

Table 12. Observed helmet use.

OBSERVED HELMET USE			
	Yes	No	% Yes
Children	265	23	92.0%
Teenager	245	65	79.0%
Adults	8101	896	90.0%
TOTALS	8611	984	89.7%

CONCLUSIONS

Bicycles offer many advantages as a transportation vehicle, yet at the present time they are used primarily for recreation. The keys to substantially increasing their use for commuting and personal business purposes lie in understanding the capabilities and limitations of the mode while adopting a comprehensive approach to the provision of appropriate facilities. The goal should be the creation of a cycling-friendly environment that provides a coherent system that is easy to use and offers a choice of direct routes that are safe, attractive, and comfortable.

This research produced a comprehensive list of bicycle facilities encompassing 23 major categories with 55 subdivisions along with cross-references to six design manuals and guides. While not all of the identified facilities will be needed in every case, the list is intended to convey the notion that cyclists require more than the occasional bike lane or path.

While this research identified various methods for measuring bicycle use, it also revealed the virtual lack of objective data on how facilities affect such use. "Before and after" studies are difficult to perform and have simply not been done.

Data from Boulder and Seattle indicated that if cycling is supported through facilities development and encouragement, a significant mode shift can occur. Removing a single barrier in a critical location can have a dramatic effect on use.

Finally, a framework for identifying areas likely to benefit from facility improvements was developed. The two-step process, while requiring validation, may offer a method for selecting high-return facility improvements.

RECOMMENDATIONS/APPLICATION/IMPLEMENTATION

The five elements of a cycle-friendly environment and the bicycle facility matrix should be disseminated to government officials and the public. Doing so may enhance the appreciation for the breadth of the issues involved in increasing cycling for transportation.

Clearly additional research into the connection between the provision of bicycle facilities and use are urgently needed. There is a great deal of interest in and funding for such facilities in response to the opportunities provided by the Intermodal Surface Transportation Efficiency Act (ISTEA). Applying the use measures identified in this research to gather baseline data and then conducting similar studies after construction may yield valuable information.

Application of the proposed framework for selecting specific neighborhoods and transportation corridors for facilities improvements would help refine and validate the concept. Additional surveys seeking specific information on facilities needs would also be helpful.

ACKNOWLEDGEMENTS

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APPENDIX A

Five Elements of a Cycling-Friendly Environment

The Dutch bicycle facilities design manual "Sign up for the bike" (CROW 1993) lists the five essential requirements for a cycling friendly environment as 1. Coherence, 2. Directness, 3. Safety, 4. Attractiveness, and 5. Comfort. (The AASHTO 1991 bicycle facility guide uses similar language but is less concise.) In the U.S. these terms are not commonly used to describe bicycle facilities. However, they do present a useful paradigm because they succinctly capture all the elements that should be present if the goal is to provide a high quality cycling environment that will attract substantially more cyclists to using their bikes for more than recreation.

In the table (A.1) on the following pages, each of these elements is expanded into several criteria upon which to judge how well a particular element is meeting the needs of cyclists, along with specific parameters for each criterion. Limiting factors or goals have then been proposed where possible for various types of facilities (both on-street and off). Note that "Network" is also included to further emphasize the need to think holistically about the entire **system.**

Note that while the Dutch provided the framework for this table, it has been substantially altered with the goal of making the concepts more useful to U.S. readers. Further, many of the specific entries (e.g., COMFORT/Chance of stop/Arterial of only once every 4 km) are provided as values requiring further validation. Those wishing to substitute their own values are of course welcome to do so.

Table A.1. Five elements of a cycling-friendly environment with details.

FIVE ELEMENTS OF A CYCLING-FRIENDLY ENVIRONMENT

Requirement	*Criterion*	*Parameter*	*Limiting Factors*				
			Network	On-Street			Off-Street
				Arterial	*Collector*	*Local*	*Paths/Trails*
1. COHERENCE	Ease of route finding	Road signs					Cross Streets Marked Destinations/Distances
		Area plans/maps	Available for each area	Bike routes on map	Access routes shown		Trail/path system maps
		Readability of signs	All readable while cycling	Major bike routes signed			
	Consistency of quality	Cycling km's of the highest quality		70%	50%		100%
		Number of quality changes/km		Minimal			None
	Freedom of route choice	Number of alt routes of equal distance	Min. of 2, one socially safe	Min. of 2, one socially safe	Min. of 2, one socially safe	100-150 m between parallel routes of equal length.	Parallel on-road alternative available.
	Completeness	Number of connected origins/destinations	100%				
2. DIRECTNESS	Actual cycling speed	Design Speed	Maximize	40 kph	35 kph	30 kph	30 kph
	Delay (time)	Average waiting time loss per km	Minimize	15 sec/km	20 sec/km	20 sec/km	
	Detour Distance	Detour factor (extra distance required)	Minimize	1.2 times direct	1.3 times direct	1.4 times direct	

Conituned

Adapted from CROW 1993

Table A.1. Five elements of a cycling-friendly environment with details.

FIVE ELEMENTS OF A CYCLING-FRIENDLY ENVIRONMENT							
Requirement	*Criterion*	*Parameter*	*Limiting Factors*				
			Network	On-Street			Off-Street
				Arterial	*Collector*	*Local*	*Paths/Trails*
3. SAFETY	Traffic accident victims	Number of fatalities	50% reduction	All fatal accidents should be investigated to determine role played by facilities.			
		Number of injured	40% reduction	Effort should concentrate on locations with highest incidence. Need a good reporting system			
	Chance of conflict w/motor vehicle.		Minimize	Careful design selection based on conditions. (Shoulders/lanes/paths)			Road crossings critical - careful design required
	Complexity of riding task	(Unknown)	Ability of cyclist	Reduce number of intersecting traffic lanes/directions			Separate different uses in high use areas
	Subjective safety complaints	Number of complaints per type per location	Minimize				
	Social Safety	Bike thefts/vandalize	Minimize				
		% victims of theft	Max. 5%				
		Presence of residential buildings		50% of length	50% of length	75% of length	Varies with facility
4. ATTRACTIVENES	Visibility	Horizontal lighting strength		7 lux/sq.m.	7 lux/sq.m.		
	View	Type/placement of vegetation		Good sight lines, min. places to hide, Visibility to surrounding areas			
	Experience of surroundings	Varied visual experience					"Park-like" in some situations
Conitnued							Adapted from CROW 1993

Table A.1. Five elements of a cycling-friendly environment with details.

FIVE ELEMENTS OF A CYCLING-FRIENDLY ENVIRONMENT							
Requirement	*Criterion*	*Parameter*	*Limiting Factors*				
			Network	On-Street			Off-Street
				Arterial	*Collector*	*Local*	*Paths/Trails*
5. COMFORT	Smoothness	Texture/longitudinal smoothness		"Bicycle-smooth"			
	Hilliness	Number of hills with grades > 5%		Minimize to the extent practical			
	Traffic obstruction	Interruption in cyclist's trip by other users	Minimize				
	Chance of stop	Number of times stop req'd (avg. per km)		0.25	0.75	1.5	0.1
	Impediment due to weather	Wind impediment		Where possible, provide wind breaks.			
		Snow impediment		Plow all bike facilities. Remove ice promptly			

Adapted from CROW 1993

APPENDIX B

Bicycle Facilities Matrix

The following matrix Table (B.1) lists each of the bicycle facilities presented in Table 5, along with a short narrative describing each item. The "Source Documents" columns provide references to seven of the facilities design manuals and guides that were consulted as part of this research. They are identified below, with full citations appearing in the References list.

It is important to point out that this matrix is not intended to serve as a detailed design manual. Rather, the matrix is intended to convey the breadth of facilities that should be considered in the development of a cycling-friendly community and to direct the reader to more detailed information.

NOTES on table entries:

1. Page (marked "p") and chapter (marked "C") references are given.
2. A reference adjacent to a major category (e.g., **2. Bicycle Parking**) may contain information on the subheadings under that item (e.g., **D. Racks**).
3. A page reference may refer to the first of several pages containing relevant information.

SOURCES:

A - AASHTO 1991 (Guide for the Development of Bicycle Facilities)

W - WSDOT 1989 (WSDOT Design Manual, Sectuion 1010, Facilities for Nonmotorized Transportation)

V - Velo Quebec 1992 (Technical Handbook of Bikeway Design)

N - NCDOT 1994 (North Carolina Bicycle Facilities Planning and Design Guidelines)

S - NBWS-CS#24 1994 (National Bicycling and Walking Study, Case Study #24)

C - CROW 1993 (Dutch design manual)

Table B.1. Bicycle facilities matrix.

		Source Documents						
BICYCLE FACILITIES MATRIX								
Types of Facilities	Description and Comments	A	W	O	V	N	S	C
1. Airports	Airports serve as major employment sites as well as gateways to metropolitan areas. Making them bike-friendly will not only facilitate commuting but also encourage tourists to bring their bikes.							
A. Access	Large airports are often served by limited access roadways not open to cyclists. It is essential that safe and direct access to all airports be provided. Maps and route signing should be provided to assist visitors.							
B. Parking	Secure bicycle parking for airport employees should be provided. Multiday bicycle storage should be available to travelers who will be returning to the airport.							
C. Tourist services	A repair stand (perhaps with tools for loan) should be provided to assist tourists in assembling their bikes upon arrival. Low cost storage for bicycle shipping boxes should also be provided.							
2. Bicycle Parking	High quality bicycle parking at all destinations is an essential element of a bicycle friendly infrastructure. Fear of bike theft inhibits many potential riders from using their bikes for utilitarian trips. Bike parking should be at least as convenient as any auto parking provided. Weather protection should be provided.	p38	p4	p31	C11	C8	p59	C9
A. Attended	Attended, checked bicycle parking (perhaps in a parking structure) offers good protection from theft but requires an attendant. Such an approach might be appropriate at a business with a security guard.							
B. Automated	Japan and Germany have installed automated bike parking structures, often at train stations. The cyclist loads his bike into the machine and receives a claim check while the bike is stored internally. Upon presentation of the claim check the bike is automatically retrieved and returned to its owner. Such systems are expensive but can store a large number of bikes while occupying a relatively small amount of land. They are, however, several stories high and so only suitable for urban settings.							
C. Lockers	Fully enclosed lockers offer excellent protection from theft, vandalism, and the weather. They are most appropriate for long term parking when the bike will be left for several hours. They are usually leased for a month or more but some agencies have experimented with coin-operated lockers.							
D. Racks	Bicycle rack designs have evolved over the years leaving many unsatisfactory racks still in use. A good rack is robust and securely anchored to the ground while providing a convenient means to lock the frame and both wheels while making it difficult to tamper with the lock. Some racks also provide secure storage for small items (e.g.: helmets, tools, lights) that might be easily stolen.							

Continued

Page B.1 lists source documents

Table B.1. Bicycle facilities matrix.

BICYCLE FACILITIES MATRIX

Types of Facilities	Description and Comments	Source Documents A	W	O	V	N	S	C
3. Bridges/Overpasses	Lack of bicycle access across bridges and overpasses often creates a major obstacle to bicycle travel. Detours are often lengthy and frequently unsafe. All new and reconstructed bridges and overpasses should be designed to accommodate bicycles. Attention should be paid to the possibility of severe side winds or, in the case of floating bridges, waves breaking over the side.	p33	p3		C9	p21 54	p43 52	P121
A. Bike only or shared with peds	A bridge designed solely for two-way bicycle use should have a minimum 3 m clear width with 4.25 m preferred. If also used by pedestrians the minimum width should be 4 m with 4.8 m recommended if heavy mixed use is expected. Grades should not exceed 5%.							
B. Railings	All railings should be at least 1.5 m high relative to the adjacent riding surface. Where possible a shy distance of 0.5 m should be provided. One rub rail at the height of the handlebars and another at shoulder height should be provided. Vertical railing members can easily snag hands or parts of the bicycle and cause a fall. Chain link and similar fencing should not be used in place of railings.		p13	p28	p24, C6	p22		
C. Shared with motor vehicles	Several treatments possible: A striped bike lane; a wide curb lane; or a bike lane separated by a physical barrier. If a sidewalk is considered special care is required to provide sufficient width to minimize conflicts with peds as well as protect nonmotorized users from falling into the traffic lanes. Light standards and other poles should not obstruct the traveled way.							
4. Cattle Guards	In rural areas cattle guards can be extremely dangerous for cyclists. Bicycle friendly designs should be used and they must be well marked sufficiently in advance.		p4				p45	
Continued		Page B.1 lists source documents						

BICYCLE FACILITIES MATRIX

Types of Facilities	Description and Comments	Source Documents: A	W	O	V	N	S	C
5. Construction Zones	It is critical that the needs of cyclists be considered when it is necessary to perform construction or maintenance on or near bicycle facilities. No bicycle facility should be closed unless an adequate alternative is provided. All barricades and dangerous areas must be lighted at night.							C10
A. Detours	When necessary to re-route bicycle traffic, a good detour must be provided (as would be done for motor vehicles). It should be as direct as possible and well signed in both directions. If possible such closures should be announced well in advance so that alternate routes might be explored.							
B. Temporary paved surfaces	At various stages of construction a variety of surfaces might be exposed. Care should be taken to minimize the use of sand, loose gravel, large rocks and other materials difficult for a narrow tired, two wheel vehicle to negotiate. Warning signs should be posted well in advance.							
C. Use of steel plates	It is often necessary to temporarily cover excavations. Special care should be exercised when steel plates are used for this purpose. Such plates are typically VERY slippery when wet and can easily cause a fall. Their edge should be perpendicular to the travel direction. Asphalt patching or similar material should be used to feather the edge. Warning signs should be posted							
6. Curbs - extruded	Extruded curbs and other structures should not be used to separate a bike lane from the adjacent traffic lanes. They present a hazard to the safe operation of a bike in the lane and make it dangerous or impossible to make a left turn. They also collect debris and make it more difficult to sweep the surface.	p12		p29	p24, 72	p18	p31	
7. Drainage/utility covers	Drainage grates adjacent to the roadway must not have openings large enough to trap the narrow wheel on many bicycles. All grates and utility covers should be flush with the adjacent pavement. Ideally they should not be placed in bicycle lanes or separated paths.	p12, 35	p4,5	p31	p31, C5	p17, 55	p30, 53	C5
8. Fences/Railings	All railings should be at least 1.5 m high relative to the adjacent riding surface. Where possible a shy distance of 0.5 m should be provided. A rub rail at the height of the handlebars and another at shoulder height should be provided. Vertical railing members can easily snag hands or parts of the bicycle and cause a fall. Chain link and similar fencing should not be used on railings.		p13	p28	p24, C6	p22		

Continued

Page B.1 lists source documents

Table B.1. Bicycle facilities matrix.

BICYCLE FACILITIES MATRIX		Source Documents						
Types of Facilities	Description and Comments	A	W	O	V	N	S	C
9. Ferries	Particularly in Western Washington, ferries represent a vital link in the transportation system. Encouraging bikes reduces the number of cars while still providing mobility at both ends of the trip.							
A. Car	Good bicycle access onto the ferry and adequate methods to secure bikes to prevent damage to them or nearby cars must be provided.							
B. Passenger only	Adequate bicycle retention systems are particularly important on passenger ferries since they place bikes in closer proximity to other passengers. Also, the small size of these ferries results in greater vessel motion.							
C. Terminals/parking	Secure and weather protected bicycle parking should be provided at all ferry terminals. Terminals should be designed so that bikes can easily reach the boarding areas.							
10. Intersections	Intersections (including driveways) are the most likely place for a car-bike collision. Intersections should be carefully designed to reduce the chance of conflict.	p18, 31						C6
A. Road/driveway	Driveways onto roads are common places for car-bike collisions. The key here is providing adequate sight distance so that cyclists traveling along the right edge of the road can be easily seen by those entering/leaving the driveway.		p6, 20		C7			
B. Road/road	Normal design procedures are usually adequate but the treatment of bike lanes at intersections requires special care.				C7			
C. Road/path	The intersection of bike paths with streets often occurs at mid-block and thus creates special hazards. Good sight lines and signs warning motorists and cyclists will help reduce the risk of collision. If the path is close to a parallel street it may be brought out to use the crosswalk.				C7			
11. Lighting	Bicycle facilities should be adequately lighted. Street lighting is usually sufficient for wide curb lanes and bike lanes. Separated paths may require security lighting to increase their social safety. Bike parking areas should be well lighted if used after dark to reduce the chance of theft and vandalism and also increase personal safety. Intersections of paths with roads must be well lighted.	p36	p4		p48, C10	p56	p54	C11
12. Maintenance	Regular maintenance is essential to ensure that the facilities are safe and comfortable to use. Road and paths surfaces should be swept regularly to remove glass and other debris. Litter should be promptly picked up. Signs should be kept in good repair. Some jurisdictions have started 'Adopt-A-Trail' programs to help with maintenance chores.	C3	p3	C10	C13	C9	p63	C5
Continued		Page B.1 lists source documents						

Table B.1. Bicycle facilities matrix.

BICYCLE FACILITIES MATRIX

Types of Facilities	Description and Comments	Source Documents						
		A	W	O	V	N	S	C
13. On-Road Facilities	In general, all roads should be thought of as forming the bicycle network and cyclists should be expected to use them for transportation purposes except in certain unusual circumstances.	p11	p2					C3 C4
A. Arterials - major/minor	Bicycle access is critical to efficient transportation. Wide (4.3m+) curb lanes, paved shoulders, and bike lanes (1.5m+) can increase safety and reduce conflicts with other road users.			p23	C4, C7			
B. Bicycle boulevards	Bicycle boulevards are streets selected to encourage cycling by reducing and slowing motor vehicle traffic. Often accomplished using traffic calming techniques including traffic diverters, preferential bicycle access, and small traffic circles. Stop signs are often removed along the boulevard with cross traffic being required to stop.							
C. Collectors / local streets	If low traffic volume and adequate width no special facilities necessary. Will be the site of most child cycling. Can be used as an alternative to busy parallel arterials.			p23	C4, C7			
D. Freeways	May provide only connections between certain destinations, especially in rural areas. Generally bicycles prohibited from using freeway shoulders in urban areas.		p21	p31				
E. Hybrid bike lane	Hybrid bike lanes are created on roads with wide curb lanes (~4.5 m) by painting a bicycle symbol with directional arrow approximately 1 m from the right edge of the lane. These markings are placed at regular intervals along the street but not at intersections where bikes are expected to integrate with other traffic based on their destination. No lane stripe is used to designate the bike lane.							
F. Stripped bike lane	A separately striped area adjacent to travel lane for the preferential use of bikes. Min. width is 1.2 m with some jurisdictions using 1.8 m. One way traffic only. Stripping should end well in advance of intersections. The stripes should at least be dashed adjacent to right turn lanes to encourage motorists to merge into the bike lane before turning right.	p16	p2,6	p24	C4, C7	C5	p36	
G. Wide curb lanes / shoulders	On any road can increase safety and attractiveness of the facility for most cyclists. Pavement must be of high quality without joints that could catch a wheel. Regular maintenance also critical.	p13			C4, C7	p25	p27 34	

Continued

Page B.1 lists source documents

Table B.1. Bicycle facilities matrix.

BICYCLE FACILITIES MATRIX		Source Documents						
Types of Facilities	Description and Comments	A	W	O	V	N	S	C
14. On-Street Parking	On street car parking can be dangerous for cyclists. Motorists entering and leaving parking stalls can fail to see an approaching cyclist. Cars parked on the street reduce sight lines and make driveways and intersections more dangerous.							C8
A. Diagonal	Diagonal parking is perhaps more dangerous than parallel parking since drivers exiting their stall have limited ability to see approaching cyclists.							
B. Parallel	The major hazard associated with parallel parking occurs when cyclists ride close to the parked cars and a door suddenly opens. Sufficient lane width should be provided to permit riding at least 1 m to the left of the parked cars.							
C. Parking and Bike Lanes	Striped bike lanes may be used adjacent to parallel parking but only if the bike lane is at least 2.5 m wide. Bike lanes should NOT be used with either diagonal or parallel parking since it will cause the most cyclists to ride too far to the right to be seen. Bike lanes should never be placed between the curb and a row of parked cars.							
D. Perpendicular	Perpendicular parking is the most hazardous since visibility is even worse than in the diagonal case. Whenever possible bicycles should not be encouraged to use street with this type parking.							
15. Pavement Structures	The type of pavement used for bicycle facilities is often dictated by that used on the adjacent roadway. Whether Portland cement and asphalt is used it is important that a proper sub-base be established and that the finished surface is very smooth (at least as smooth as provided for cars). Roots from trees adjacent to the facility should be prevented from erupting the paved surface.	p13, 32	p4,5	p30	p50, C5	p19, 52	p33	C5
16. Railroads	Inter-city rail permits cyclists to reach distant destinations. All passenger trains should permit bikes to be transported as either checked baggage or be permitted in the passenger cars.							P113
A. At-grade crossings	Grade crossings should be at right angles to the rails. Acute angle crossings increase the chance that the front wheel will be trapped in the flangeway resulting in a fall. Rubberized or concrete crossings are usually superior to concrete or wood. Roadway approaches should be at the same elevation as the rails.	p12						
B. Cars	Passenger cars should be designed so that bikes can be easily loaded and stowed.							
C. Terminals/platforms	Terminals should provide secure bicycle parking. Inter-city rail terminals should provide for the storage of bicycle boxes and equip an area where cyclists can assemble their bikes after disembarking.							

Continued

Page B.1 lists source documents

Table B.1. Bicycle facilities matrix.

BICYCLE FACILITIES MATRIX		Source Documents						
Types of Facilities	**Description and Comments**	**A**	**W**	**O**	**V**	**N**	**S**	**C**
17. Separated Facilities	Separated bicycle facilities should NOT be thought of as a substitute for accommodating bicycles on nearby roads. If the path receives heavy pedestrian and recreational cycling use it may be unsuitable for utilitarian cycling. Separated paths can meet an important recreational need. Careful design is required. They should be considered extensions of the street system.	p21	p1,4	p25, 36		C7	p46	C4 C6
A. Bike only	Bicycle only paths are very difficult to enforce and thus not recommended. These are sometimes considered with the thought that they can be made narrower than mixed use facilities. Adequate width is perhaps the most important consideration in the design of a safe and efficient off-street facility.				p21, C7			
B. Mixed use	Due to the nature of conflicts possible between cyclists, walkers, in-line skaters, children playing and other users, mixed use paths present a significant design challenge. Providing a wide (4.5m or more) paved surface will help reduce conflicts. Consideration should be given to providing parallel facilities for walkers and those on wheels. A longitudinal paint line or different pavement treatments may also reduce conflicts.	p36			p21. 70	p42, 56	p56	
C. Rail Trails	Converting abandoned rail lines to trails is one way to create separated facilities. The shallow grades and good sight lines found on such facilities makes them good for cycling. Adequate width must be provided to safely accommodate the expected mix of users. If grade separated crossings exist they should be utilized if possible.				p45			
D. Related Facilities	Good access to the facility is a must. Motor vehicle parking, water, and toilets may be required. Telephones should be available at intersections or otherwise in the area in the event of an emergency.				C12			
18. Sidewalks/ramps	Cycling on the sidewalk is generally not recommended for safety reasons. Sidewalks are primarily for pedestrian use. If there is no option then the sidewalk should be as wide as possible (4m min.) and the use of street furniture minimized. Sidewalks have a high accident potential at driveways and intersections. A ramp connecting two facilities can be a useful feature for cyclists.		p7	p27				

Continued

Page B.1 lists source documents

Table B.1. Bicycle facilities matrix.

BICYCLE FACILITIES MATRIX

Types of Facilities	Description and Comments	Source Documents A	W	O	V	N	S	C
19. Traffic Control Devices	Since bicycles are legal road vehicles they do not, in general, require special traffic control devices. The same standards and criteria used to sign streets and highways should be applied to bicycle facilities unless there is a valid reason to do otherwise. This is particularly true of Separated Facilities. As indicated, they should be considered extensions of the road system.	p13	MUTCD, p6				p33	
A. Bollards	Bollards or other forms of barrier posts are sometimes necessary to prevent motor vehicles from accessing a separated path or other bicycle facility. However, they should only be installed after it has been determined that a real problem exists. If used, one should be placed in the center of the path with additional bollards spaced to provide 1.5 m clearance. Further, they should be arranged in a line perpendicular to the axis of the path. Finally, they should be painted white and have reflectors.	p36						p230
B. Expanded Bike Streaming Lane	Expanded Bicycle Streaming Lanes can are placed at signalized intersections to facilitate bicycle traffic and reduce the chance of conflict with right turning vehicles. An EBSL is created by painting a second stop line 4-5 m from the normal stop line (next to the crosswalk) and designating the space between the stop lines as reserved for bikes. Usually a bike lane is provided on the right to provide direct access to the EBSL. When the light changes the cyclists are the first to cross.							p178
C. Paint	Paint applied to the roadway should not create a hazard to cyclists, particularly when wet.	p32	p7	p33	p69, C7,8		p68	p91
D. Raised Pavement Markers	Raised pavement markers constitute a significant hazard to cyclists and should not be applied in locations where cyclists are likely to travel (this explicitly includes the right edge line).	p32	p6	p30	p59	p50	p54	
E. Refuges	Refuges can protect a cyclist caught in the middle of a wide intersection who is unable to completely cross before the signal changes.				p67			
F. Signals	All traffic signals should be adjusted to detect bicycles. The most sensitive area of the detector should be stenciled with a bicycle symbol. At least the right most through lane and all left turn lanes should be so marked. In addition, the advance loop detectors should be adjusted to detect passing bikes and, if necessary, their sensitive areas marked. Care should be taken in setting the cycle times to ensure an adequate clearance interval for bikes.	p13	p6		p44, 70	p19		p200
G. Signs	Standard signs are adequate for most purposes to sign bicycle facilities. The BIKE ROUTE sign should not be used in the absence of sub-plates indicating destinations (with distances) to be found along the signed route. In addition, BIKE ROUTE signs must be part of a comprehensive system. At the junctions of separated trails with roadways the name of the road should be clearly visible to trail users.	Ref. MUTCD	p7	p33, 38	p31, 44, 67 C7, C8		p65	p303

Continued

Page B.1 lists source documents

Table B.1. Bicycle facilities matrix.

BICYCLE FACILITIES MATRIX		Source Documents						
Types of Facilities	Description and Comments	A	W	O	V	N	S	C
H. Speed bumps/traffic diverters	Some jurisdictions install speed bumps to reduce motor vehicle speeds. Most designs will easily cause a cyclist to be thrown from his bike. The approaches should be made gradual or a by-pass slot incorporated to permit the cyclist to avoid the bump. If traffic diverters are used, bicycle access should be provided. Traffic calming measures usually benefit cyclists.							C7
20. Transit/Light Rail	Linking bikes and transit offers significant mobility, energy, and air pollution benefits. Some cyclists may wish to take their bikes on the transit vehicle with them while others will desire to safely and securely park their bikes at the point they board transit. Access to the transit loading area often deserves special attention to facilitate access by bike.					p61		p113
A. Buses	At a minimum all transit buses should be equipped with bike racks capable of carrying at least 2 bikes. A more controversial question is whether bikes should be allowed on board the buses. Many systems allow bikes on board subject to space availability.	p38						p110
B. Roadway Conflicts	Given their relative sizes and different operating characteristics, local transit buses and bikes can often find themselves in conflict. The appearance of bus-only/HOV lanes on the right side of many urban roads exacerbates these problems. Conflicts often occur when the bus moves to the curb to load/unload. A bus bay to the right of the bus lane can reduce these conflicts.				p72			
C. Trains light/heavy	Light rail often travels on the same streets that cyclists wish to use and tracks are a significant hazard. Where tracks cross roadways they should do so at 90 degrees and a rubber crossing surface is superior to other designs.	p38						
D. Terminals/platforms	Transit terminals (including park&ride lots) should provide secure bicycle parking. Platforms should be easily reached from street level entrances and be large enough so that cyclists with their bikes do not create a hazard to other passengers.				p32			
Continued		Page B.1 lists source documents						

Table B.1. Bicycle facilities matrix.

BICYCLE FACILITIES MATRIX

Types of Facilities	Description and Comments	Source Documents A	W	O	V	N	S	C
21. Tunnels	See Bridges/Overpasses above. Tunnels often also create barriers to bicycle traffic.	p33			C9	p21	p52	p121
A. Bike only or shared with peds	Bridge comments (3.A.) also applicable here. In addition, design must not create hiding places for persons intent on doing harm. Good sight lines and absence of curves can help. Davis, CA, recommends elevating the roadway (rather than depressing the tunnel) in order to reduce the length of time cyclists are not visible from the surrounding area.							
B. Shared with motor vehicles	Bridge comments (3.B.) also applicable here. In addition, recognition should be made of the high levels of noise often found inside motor vehicle tunnels. If possible cyclists should be completely separated from the motor vehicle traffic. Poor air quality may also be a problem.							
22. Vegetation - Adjacent	It is important that vegetation near roadways and adjacent to paths be maintained so as to not create hazards for the cyclist and other users.							C11
A. Obstructing	All vegetation above 0.3 m in height should be trimmed back at least 1 m on each side of all paths. Vegetation at intersections should be trimmed to provide adequate sight lines.	p41			p132			
B Surface problems	Mulit-use trail surfaces may be prone to root damage from trees and shrubs next to the trail. Removal of all tress 1 m on each side and the installation of root barriers will help prevent this problem. Regular maintenance checks should be performed to monitor the state of the pavement and repairs made before any surface irregularities become too large.							p137
23. Workplace Facilities	Many people say that they would or might try commuting by bike but feel they need a shower and place to change clothes once they arrive at work. Some jurisdictions are now requiring that such facilities be provided when a building is built or remodeled.							
A. Clothes lockers	Clothes lockers should be large enough to accommodate a full suit of clothes or long dresses, shoes, underwear and toilet articles.				C12			
B. Showers	It is often possible to remodel a bathroom and add a shower stall in place of a toilet.				C12			

Page B.1 lists source documents

APPENDIX C

Sample Use Survey Forms

This Appendix contains examples of three survey instruments that can be used to gather different information about bicycle use and travel patterns.

Multi-use Trail Survey - Distributed to trail users/mail back

Figure C.1 shows the survey card distributed to users of the BGT/SRT in May 1990. The primary focus was to gather information about the respondents' use of the trails. The other side was self-addressed with Business Reply postage paid. Many chose to fill out the card and leave it at the station, however.

Regular Bicycle User Survey - Distributed through bike clubs/mail-back

Figure C.2 shows the two-sided survey form that was developed to gather detailed information about the cycling habits and experiences of "regular" bike riders. It was adapted from the form used by Kaplan (1975) and will be distributed to cyclists throughout Washington state in early 1995 who are members of organized bicycle clubs. It may also be used by the League of American Bicyclists in 1995 to repeat the original Kaplan study.

Travel Diary - Distributed to and returned from selected participants by mail

Figure C.3 presents an example of a travel diary form that can be used to gather detailed trip information from participants. This one was used in the Boulder County Origin/Destination Survey. (DRCOG 1992) This particular form was designed to gather information on trips by all modes, including bicycles.

(BLANK)

Date received: ____________ 001000 1 2 3 4 5 6

TRAIL USE SURVEY

Welcome to the trail. This study is very important for learning more about trail use. Please help us by answering the question and then place the card in the mail. Postage is prepaid. Thank you for your cooperation.

1. a. Where did you enter the trail? # ____________________
   (# please give an address, major intersection or significant landmark)

   b. Where did you leave the trail? # ____________________

   c. If, A & B are the same where did you turn around? # ____________________

   d. Estimate your total distance traveled on the trail: _______ miles.

2. What activity did you do on the trail?
   walk__; jog__; bicycle__; equestrian__; other (specify)____________

3. What was the purpose of your use of the trail today? * recreation__;
   school__; shopping__; training__; work__; other (specify)____________

   How many days in the last week have you used the trail? ___
   How many times in the last month? ___ How many times in the last year? ___

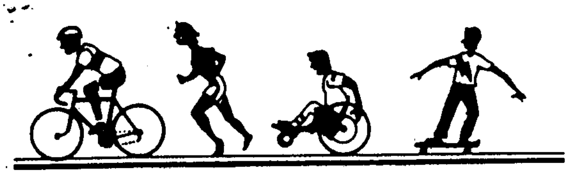
4. a. By which method did you reach the trail?
   foot__; bicycle__; bus__; car__; other (specify)____________

   b. Estimate the distance you travel to get to the trail? ________ miles

5. Where did you begin your trip? # ____________________
   (# please give an address, major intersection or significant landmark)

6. If your non-motorized trip began before you entered the trail or continued beyond the trail, what was the total distance of the trip? _______ miles.

7. How many accidents have you been involved in on the trail in the last year?
   bicycle/bicycle___ bicycle/dog___ bicycle/pedestrian___ falls___
   pedestrian/car ___ bicycle/car___ other (specify)____________



8. Your Age:___ Sex: Male__ Female__ Zip code of residence:__________

9. Occupation: Student___ Clerical___ Professional___ General Labor___
   Skilled Labor___ Homekeeper___ Other (specify)____________

10. Income Level:

less the $10,000___	30,000 - $39,999___	60,000 - $69,999___
10,000 - $19,999___	40,000 - $49,999___	70,000 - $79,999___
20,000 - $29,999___	50,000 - $59,999___	80,000 & up ___

11. Comments on trail use and trails:____________________

* If you made a second trip on the trail today, with a different purpose, please fill out a separate card covering that trip.

Figure C.1. Multiuse trail survey form.

1995 - CBC Regular Bicycle User Questionnaire SERIAL NUMBER ______ Leave Blank

Dear Cyclist:

In 1975 a national survey of 4000 cyclists was conducted to gather information about them and the type of cycling they did in the previous calendar year. The results were used to guide cycling policy nationally and locally. Clearly a lot has changed in the past 20 years and we are interested in comparing you and your cycling with the 1975 group.

This is survey is being conducted by the GAC in cooperation with the Human Powered Transportation Program at the University of Washington and its results will be used in a various research projects. Transportation planners, traffic engineers, and many local agencies need to know the riding habits of regular bicycle users in order to help provide for safe and efficient bicycling. You can help by taking a few minutes to fill out the following questionnaire and return it in the envelope provided. All responses will be tabulated so that individual replies will not be identifiable and only summaries of the responses received will be reported.

INSTRUCTIONS: To provide a basis for comparison with other studies we ask that only cyclists 16 years of age or older reply. If there is more than one such cyclist in your household please have the most active rider over 16 respond.

REPLY BASED ON THE RIDING YOU DID IN CALENDAR YEAR 1994 (unless specifically directed otherwise).

Please answer by blackening the circle [O] or filling in the blank:

ABOUT YOUR RIDING

1. What type of BICYCLE do you ride the MOST?

   Road/Racing O 1 Mountain O 2 Hybrid/Commuter O 3

   Touring O 4 Tandem O 5 Other O 6 ________________

2. What is the TOPOGRAPHY like where you do most of your RIDING?

   Mostly flat O 1 Mostly rolling O 2 Mostly steep hills or mountainous O 3

3. Do YOU and/or your BICYCLE have the following?

	Yes	No		Yes	No
a. Rear view mirror	O 1	O 2	b. Lights	O 1	O 2
c. Odometer	O 1	O 2	d. Bicycle Registration	O 1	O 2
e. Helmet	O 1	O 2			

   f. If you have a helmet, how often do you wear it?

   Never O 1 Occasionally O 2 Usually O 3 Always O 4

4. Considering the CLIMATE where you live, how many MONTHS per year (on average) are SUITABLE for cycling? __ __ months.

5. Below what TEMPERATURE do you NOT ride your bicycle? __ __ __ degrees F.

6. Do you OBEY the vehicle traffic LAWS that apply to you as a bicycle RIDER?

   Never O 1 Occasionally O 2 Usually O 3 Always O 4

7. Do you belong to a local BICYCLE CLUB? Yes O 1 No O 2

8. How many continuous years have YOU USED a bicycle regularly? ("regularly" is defined as at least 3 times a month during suitable riding conditions).

   Less than 1 year O 1 1 to 4 years O 2 5 to 10 years O 3 More than 10 years O 4

9. In 1994, how many months did YOU ride regularly (see Q8) ? __ __ months

10. During the months that YOU rode in 1994, approximately how many ROUND TRIPS and MILES PER MONTH (average) did you ride for:

	PURPOSE	Avg. Rnd trips/Mo	Avg. Miles/Mo
a.	Work and/or School Trips	__ __ __	__ __ __
b.	Shopping, personal business, etc	__ __ __	__ __ __
c	On-road Recreation/Touring	__ __ __	__ __ __
d.	Off-road/Mtn Bike Rec/Touring	__ __ __	__ __ __
e.	Non-track Road Racing (include training)	__ __ __	__ __ __
f.	Off-road/Mtn Bike Racing	__ __ __	__ __ __
g.	Exercise	__ __ __	__ __ __

   h. Mileages are based on odometer readings O 1 or are estimates O 2

11. For the ONE ACTIVITY in question #10 that you listed as having the GREATEST NUMBER of round trips, show approximately what PERCENTAGE of riding was done on:

   a. Major streets/highways (moderate/heavy traffic): ___%

   b. Minor streets/roads (light traffic, county roads): ___%

   c. Special on-street bicycle facilities(bike lanes, routes): ___%

   d. Paved, off-street (sidewalks, bike paths, "no motor vehicles") ___%

   e. Unpaved, off-road (trails, gravel roads) ___% Total 100%

12. How SAFE do you usually feel RIDING on:

		Very Safe	Safe	OK	Unsafe
a.	Off-street bike paths	O 1	O 2	O 3	O 4
b.	Streets with marked bike lanes	O 1	O 2	O 3	O 4
c.	Streets with wide curb lanes	O 1	O 2	O 3	O 4
d.	Light traffic streets without bike lanes	O 1	O 2	O 3	O 4
e.	Heavy traffic streets without bike lanes	O 1	O 2	O 3	O 4

13. During 1994 did you have one or more COLLISIONS or SERIOUS FALLS resulting in INJURIES and/or PROPERTY DAMAGE in excess of $50 while riding your bicycle?

   Yes O 1 No O 2 (SKIP TO Q. 14)

   If YES, a. How many?__ __ b. How many reported to police? __ __

   c. Total property damage $__ __ __ __.00 (All accidents)

   d. Total medical expenses $ __ __ __ __.00 (All accidents)

14. How SERIOUS was your MOST RECENT collision or fall in 1994?

No collisions or falls in 1994	O 0	(SKIP TO Q. 17)
No damage to bicycle, equipment, or person	O 1	
Bicycle damaged only, no personal injury	O 2	
Minor scrapes and bruises	O 3	
Required emergency room treatment or doctor	O 4	
Overnight hospital stay or continued doctor visits	O 5	
Left terminally ill, in a coma, or "vegetable" state	O 6	

(Continued on back)

Figure C.2. Regular bicycle user survey - page 1.

15. At the time of your MOST RECENT COLLISION or FALL (Q. 14), in what ACTIVITY were you participating, and on what TYPE facility? (Leave blank if no collisions or falls in 1994.)

a. ACTIVITY:

Work and/or School Trips O 1 Shopping, personal business O 2
On-road Recreation/Touring O 3 Exercise O 4
Off-road/Mtn Bike Rec/Touring O 5 Off-road/Mtn Bike Racing O 6
Non-track Road Racing (include training) O 7

b. FACILITY:

Major streets/highways (moderate/heavy traffic): O 1
Minor streets/roads (light traffic, county roads): O 2
Special on-street bicycle facilities(bike lanes, routes): O 3
Paved, off-street (sidewalks, bike paths, "no motor vehicles") O 4
Unpaved, off-road (trails, gravel roads) O 5

16. In your most RECENT COLLISION or FALL, did you COLLIDE with: (Leave blank if none.)

No other object (fall) O 1 A moving motor vehicle? O 2
A stationary motor vehicle? O 3 Another bicycle? O 4
A pedestrian? O 5 Dog or animal? O 6
Fixed Object? O 7 Other? (explain) O 8 ____________

17. a. In calendar year 1994: How many TOTAL MILES did you RIDE? _ _ _ _ _

b. Mileage is based on odometer readings O 1 or are estimates O 2

c. How many TOTAL HOURS do you estimate you spent riding in 1994? _ _ _ _

18. What PERCENTAGE of your 1994 riding was on:

a. weekdays? _ _ _ % b. weekends? _ _ _ % Total = 100%

19. Do you RIDE:

	Never	Occasionally	Frequently
a. After dark?	O 1	O 2	O 3
b. In the rain?	O 1	O 2	O 3

20. In your experience, what FRACTION of motorists:

a. Are AWARE OF and WATCH OUT for cyclists _ _ %

b. Are UNAWARE OF and do NOT watch out for cyclists _ _ %

c. Are openly HOSTILE and HARASS cyclists _ _ % TOTAL = 100%

21. This question concerns COMMUTING to WORK or SCHOOL. (SKIP TO Q. 22 if no commuting)

a. DISTANCE from home to work or school: _ _ _ miles.

b. Average TRAVEL TIME from home to work or school: _ _ _ minutes

c. What is your USUAL commute mode:

Auto O 1 Carpool O 2 Transit O 3 Walk O 4 Bike O 5

d. If you do NOT currently commute by bike, what is the <u>MOST</u> significant reason?

Distance O 1 Time O 2 Unsafe routes O 3 Terrain O 4 Weather O 5

Lack of facilities (parking/showers) at destination O 6 Other O 7 ____________

22. How MUCH bicycling do you think you will do in the CURRENT YEAR (1995) as compared to the PAST YEAR (1994)?

Much less O 1 Less O 2 About the same O 3 More O 4 Much More O 5

23. Did you RIDE your bicycle LAST WEEK? a. Yes O 1 No O 2

b. If YES, how many round trips? _ _ _

c. If NO, why not ? ____________

<u>ABOUT YOU AND WHERE YOUR LIVE</u>

24. AGE: _ _ 25. GENDER: Female O 1 Male O 2

26. Married O 1 Single O 2

27. EDUCATION - highest level

High school O 1 Some College O 2 College Degree O 3

28. City: ____________, Zip Code: _ _ _ _ _ (5 digit)

29. Total HOUSEHOLD income per year

Less than $15,000 O 1 $15,000 to $29,999 O 2

$30,000 to $44,999 O 3 $45,000 to $59,999 O 4

$60,000 or more O 5

30. In your HOUSEHOLD, a. How many CYCLISTS over 16 years old? _ _

b. How many total RESIDENTS? _ _

31. What is the POPULATION of the metropolitan area where you live?

Greater than 2.5 million O 1 1 million to 2.5 million O 2

250,000 to 1 million O 3 5,000 to 250,000 O 4

Rural/less than 5,000 O 5

32. How many AUTOMOBILES do you have AVAILABLE for you to use? _ _

33. How many functional BICYCLES are there in your household? _ _

34. What is the TOPOGRAPHY like in the area where you LIVE?

Mostly flat O 1 Mostly rolling O 2 Mostly steep hills or mountainous O 3

35. Any comments? ____________

____

____

Thank You

Please complete and return in the envelope provided BEFORE February 1, 1995.

If your envelope is missing, mail the completed questionnaire to:

Bill Moritz
Human Powered Transportation
Mail Stop FT-10
University of Washington
Seattle, WA 98195

Figure C.2. Regular bicycle user survey - page 2.

PERSONAL TRAVEL LOG

DRCOG
Denver Regional Council of Governments

Please Read First
Questions? Call 1-800-447-8287

- Thanks for helping to improve Boulder County's transportation.
- Review the label to the right; make corrections if needed.
- Answer the three general questions below the label.
- Use the trip log below to record all trips. Please remember to:
  - √ Record trips in the order you make them and include all the specific information requested for each trip.
  - √ Record your trip even if made with another household member.
  - √ If you walked or biked for recreation treat it as a trip to the farthest point you went to, and a trip to where you started from.
  - √ If you changed your mode of travel (example, driving to a bus stop), enter each leg separately.
- Use the form throughout the day so your information is more complete and more accurate.
- Bad weather on your travel day? Record your travel on the next clear weekday (Tuesday through Thursday).
- Return your travel log, even if you made no trips on your travel day.

My travel day began at:
[ ] Home
[ ] Another location, as shown on right

Name of Place Kind of Place
Address/ Intersecting Streets
City State Zip Code

General Questions (Please Check Appropriate Answer):

Did you work on your travel day? .... Yes [ ] No [ ]
Did you make any trips on your travel day? .... Yes [ ] No [ ]
Did you have an auto available for use on your travel day? .... Yes [ ] No [ ]

	WHERE did this trip end?	KIND OF PLACE (Restaurant, doctor's office, grocery store)	PURPOSE of trip (Circle one)	TIME of trip (Circle AM or PM)	MODE of travel (Circle one)	IF DRIVER Number in vehicle (include self)	COST Cash Bus/Taxi Fare, Parking, Etc.
1 First I Went To:	Name of Place Address or Intersecting Streets City State Zip Code		1 Return Home 2 Go to Work 3 Shop 4 School 5 Social/ Recreation 6 Personal 7 Eat Meal 8 Pick up/drop off Passenger 9 Change Mode of Travel 0 Work-Related	BEGIN ___:___ AM PM END ___:___ AM PM	1 Car/Van/Truck Driver 2 Car/Van/Truck Passenger 3 RTD Bus 4 School or Other Bus 5 Taxi 6 Motorcycle 7 Bike 8 Walk 9 Other ______		Cost: ______ Payment Method: 1 Cash 2 Weekly Pass or Payment 3 Monthly Pass or Payment 4 Other ______
2 Then I Went To:	Name of Place Address or Intersecting Streets City State Zip Code		1 Return Home 2 Go to Work 3 Shop 4 School 5 Social/ Recreation 6 Personal 7 Eat Meal 8 Pick up/drop off Passenger 9 Change Mode of Travel 0 Work-Related	BEGIN ___:___ AM PM END ___:___ AM PM	1 Car/Van/Truck Driver 2 Car/Van/Truck Passenger 3 RTD Bus 4 School or Other Bus 5 Taxi 6 Motorcycle 7 Bike 8 Walk 9 Other ______		Cost: ______ Payment Method: 1 Cash 2 Weekly Pass or Payment 3 Monthly Pass or Payment 4 Other ______

recycled paper

OVER

Figure C.3. Travel diary form. (DRCOG 1992)

APPENDIX D.

1990 Burke-Gilman Trail/Sammamish River Trail (BGT/SRT) User Survey

User counts and surveys have been conducted along the BGT/SRT every five years since 1980. The most recent was completed in May 1990 and involved 12 hour (0700-1900) user counts (by mode) taken at six locations on a Saturday (the 19th) and a Tuesday (the 22nd). In addition, postage-paid survey cards (Appendix C) were distributed to as many users as would accept them.

At the time the total length of the combined trails was 40 km, and a 2.5 km "missing link" broke the trail approximately in the middle. The Gas Works station was near Lake Union in Seattle while the Marymoor station was in Redmond.

User Counts

The count totals are shown in Table D.1. Note that the total numbers do not represent the total number of cyclists on the trails those days, as it is likely that some individuals were counted at several stations and perhaps in both directions if they completed a round trip on the trail.

At four stations on the Saturday an average of about 200 bikes per hour passed by. On Tuesday the University station showed by far the highest bike counts, averaging over 115 bikes per hour.

Weather conditions can dramatically affect the number of trail users, particularly those engaged in recreational activities. The weather on these days was dry and partly sunny, with mild temperatures; thus the data are probably typical of similar days in May.

Survey Responses

While almost 3,200 people completed cards (1905 from Saturday, 1286 from Tuesday), no record was kept of the number distributed, so no response rate is available. In addition, the respondents can not be considered random, since only those willing to take a card, fill it out, and return it are included. That said, the responses received do represent the most complete picture available of the types of people using the BGT/SRT.

Data from each card were entered into a database and analyzed to produce the results shown in Table D.2.

Bike Commuters

Cyclists using the BGT/SRT for commuting were of special interest to this project. Thus additional analyses were performed on the responses from the Tuesday group. Those cyclists reporting either a work or school trip purpose were analyzed separately. There were 475 such users. Almost 2/3 of this group were going to or from work, while 1/3 were going to or from school. This group reported the highest average use rates, with the means and medians quite close in all three time frames (week, month, and year). If accurate, they could be characterized as almost daily weekday users.

Table D.1. May 1990 BGT/STR user counts.

May 19, 1990 SATURDAY	Bikes		Joggers		Walkers		Other		Totals		GRAND TOTALS
	E	W	E	W	E	W	E	W	E	W	
Site:											
GAS WORKS	998	1003	101	117	225	297	9	7	1333	1424	2757
UNIVERSITY	1196	1264	133	133	90	105	9	9	1428	1511	2939
SHERIDAN BEACH	1247	1238	87	91	120	140	0	0	1454	1469	2923
KENMORE	907	896	21	20	16	15	1	1	945	932	1877
WOODINVILLE	1032	1039	52	69	35	26	11	13	1130	1147	2277
MARYMOOR	1220	1164	150	179	140	158	40	48	1550	1549	3099
TOTALS E&W	6600	6604	544	609	626	741	70	78	7840	8032	15872
GRAND TOTALS		13204		1153		1367		148			15872

May 22, 1990 TUESDAY	Bikes		Joggers		Walkers		Other		Totals		GRAND TOTALS
	E	W	E	W	E	W	E	W	E	W	
Site:											
GAS WORKS	433	374	86	98	55	58	9	11	583	541	1124
UNIVERSITY	649	748	163	157	153	183	9	9	974	1097	2071
SHERIDAN BEACH	324	293	65	63	141	148	1	1	531	505	1036
KENMORE	171	159	19	19	7	20	0	0	197	198	395
WOODINVILLE	262	266	50	40	37	43	6	3	355	352	707
MARYMOOR	264	282	85	86	67	80	7	5	423	453	876
TOTALS E&W	2103	2122	468	463	460	532	32	29	3063	3146	6209
GRAND TOTALS		4225		931		992		61			6209

Table D.2. May 1990 BGT/SRT summary survey data.

		Saturday. May 19,1990			Tuesday, May 22, 1990								
		All Users			All Users			Non-Bike Commuters			Bike Commuters		
SURVEY CARDS RETURNED:		1905			1286			88 (6.8%) [Work/Schoool]			475 (36.9%) [Work/School]		
ENTRY/EXIT POINTS:		Entry	Exit		Entry	Exit		Entry	Exit		Entry	Exit	
Location	GasWks	373	299		222	136		6	6		99	38	
	UW	272	387		258	541		19	56		86	317	
	Blakely	172	132		231	107		57	22		111	31	
	COH	77	61		77	39		3	1		49	12	
	Sandpt	69	54		74	39		0	0		49	17	
	MathewsBh	64	53		36	28		0	0		18	12	
	City Limits	48	44		17	11		1	1		4	1	
	SheridnBh	32	28		33	31		1	1		1	2	
	LkForPrk	78	76		51	44		0	0		15	4	
	Kenmore	159	171		68	64		1	1		13	11	
	Bothell	136	148		57	52		0	0		12	9	
	Woodnvle	53	54		36	33		0	0		5	4	
	Winery	25	20		10	9		0	0		2	1	
	SamV/Tolt	10	10		1	1		0	0		0	0	
	SixtyAcs	18	18		2	3		0	0		0	0	
	Redmond	110	106		42	45		0	0		1	4	
	Marymoor	203	223		62	59		0	0		6	2	
TOTAL RESPONSE		1899	1884		1277	1242		88	88		471	465	
ACTIVITY:		Count	%		Count	%		Count	%		Count	%	
Mode:	Bike	1431	75.3%		832	64.9%		0	0.0%		475	100.0%	
	Equs	6	0.3%		3	0.2%		0	0.0%		0	0.0%	
	Jog	242	12.7%		195	15.2%		8	9.1%		0	0.0%	
	Walk	207	10.9%		240	18.7%		78	88.6%		0	0.0%	
	Other	14	0.7%		11	0.9%		2	2.3%		0	0.0%	
TOTAL RESPONSE		1900			1281			88			475		
PURPOSE:		Count	%		Count	%		Count	%		Count	%	
	Rec	1071	56.3%		382	30.5%		0	0.0%		0	0.0%	
	School	119	6.3%		222	17.7%		53	60.2%		169	35.6%	
	Shop	2	0.1%		8	0.6%		0	0.0%		0	0.0%	
	Train	546	28.7%		297	23.7%		0	0.0%		0	0.0%	
	Work	104	5.5%		343	27.4%		35	39.8%		306	64.4%	
	Other	59	3.1%		27	2.2%		0	0.0%		0	0.0%	
TOTAL RESPONSE		1901			1252			88			475		
FREQUENCY OF USE:		Week	Month	Year	Week	Month	Year	Week	Month	Year	Week	Month	Year
	Maximum	49	99	999	20	90	900	10	40	500	20	90	900
	Average	2.7	9.8	80.0	3.9	16.4	148.1	4.8	20.5	192.0	4.8	21.3	199.6
	Median	2	7	32	4.0	16	115	5	20	200	5	20	200
	Std Dev	2.4	9.6	115.4	2.1	10.1	124.3	1.8	8.4	115.8	2.1	10.6	134.3

Table D.2. May 1990 BGT/SRT summary survey data.

		Saturday, May 19,1990			Tuesday, May 22, 1990								
		All Users			All Users			Non-Bike Commuters			Bike Commuters		
SURVEY CARDS RETURNED:		1905			1286			88 (6.8%) [Work/Schoool]			475 (36.9%) [Work/School]		
ACCESS MODE TO TRAIL:		Count	%		Count	%		Count	%		Count	%	
	Bike	1015	53.5%		741	58.0%		16	18.2%		452	95.2%	
	Bus	0	0.0%		0	0.0%		0	0.0%		0	0.0%	
	Car	622	32.8%		266	20.8%		14	15.9%		17	3.6%	
	Foot	250	13.2%		267	20.9%		58	65.9%		4	0.8%	
	Other	11	0.6%		3	0.2%		0	0.0%		2	0.4%	
TOTAL RESPONSE		1898			1277			88			475		
TRAIL DISTANCE TRAVELED:		KM			KM			KM			KM		
	Maximum	92			92			33			67		
	Average	23.2			12.3			3.2			7.2		
	Median	17			7			2			5		
	Std Dev	21.8			15.8			3.8			7.8		
ACCESS DISTANCE TO TRAIL:		KM			KM			KM			KM		
	Maximum	165			165			42			42		
	Average	8			4.5			3			3		
	Median	3			2			0			2		
	Std Dev	15.2			8.5			6.8			3.8		
TOTAL TRIP DISTANCE:		KM			KM			KM			KM		
	Maximum	233			150			17			83		
	Average	37.3			17.5			4.3			10.7		
	Median	23			8			3			7		
	Std Dev	37.8			21			3.5			10.7		
ACCIDENT EXPERIENCE:		Victims	Total Acc.	% Acc	Victims	Total Acc.	% Acc	Victims	Total Acc.	% Acc	Victims	Total Acc.	% Acc
	Bike/Bike	60	66	20.9%	46	49	20.8%	1	1	11.1%	27	29	29.9%
	Bike/Car	7	8	2.5%	12	12	5.1%	2	2	22.2%	5	5	5.2%
	Bike/Dog	21	29	9.2%	17	19	8.1%	0	0	0.0%	6	7	7.2%
	Bike/Ped	42	48	15.2%	38	54	22.9%	3	4	44.4%	9	10	10.3%
	Falls	97	120	38.0%	69	82	34.7%	1	1	11.1%	38	43	44.3%
	Ped/Car	2	2	0.6%	5	7	3.0%	0	0	0.0%	0	0	0.0%
	Other	33	43	13.6%	12	13	5.5%	1	1	11.1%	3	3	3.1%
TOTAL RESPONSE		262	316		199	236		8	9		88	97	

Table D.2. May 1990 BGT/SRT summary survey data.

			Saturday, May 19,1990		Tuesday, May 22, 1990					
			All Users		All Users		Non-Bike Commuters		Bike Commuters	
SURVEY CARDS RETURNED:			1905		1286		88 (6.8%) [Work/Schoool]		475 (36.9%) [Work/School]	
RESIDENCE:										
	ZIP	Area	Count	%	Count	%	Count	%	Count	%
On Trail	011,012,021	Bothell	130	7.3%	76	6.4%	1	1.2%	15	3.3%
	052,053	Redmond	136	7.7%	66	5.5%	0	0.0%	6	1.3%
	072	Woodinville	53	3.0%	29	2.4%	0	0.0%	3	0.7%
	103,105,115,125	Seattle	587	33.1%	564	47.2%	65	75.6%	300	66.1%
	155,195	N. City/LFP/UW	130	7.3%	100	8.4%	5	5.8%	28	6.2%
	SUBTOTAL		1036	58.4%	835	69.8%	71	82.6%	352	77.5%
Adjacent	004-008	Bellevue	95	5.4%	31	2.6%	1	1.2%	1	0.2%
	033,034	Kirkland	77	4.3%	41	3.4%	0	0.0%	4	0.9%
	107,117,133,177	N.Seattle	124	7.0%	82	6.9%	4	4.7%	36	7.9%
	102,109,112,119	S. Shp Canal	165	9.3%	97	8.1%	5	5.8%	31	6.8%
	SUBTOTAL		461	26.0%	251	21.0%	10	11.6%	72	15.9%
Other	000-099	Varies	105	5.9%	54	4.5%	2	2.3%	13	2.9%
	100-199	Seattle +	107	6.0%	41	3.4%	1	1.2%	12	2.6%
	200-299	Sno Co +	28	1.6%	8	0.7%	0	0.0%	2	0.4%
	All others	Varies	36	2.0%	7	0.6%	2	2.3%	3	0.7%
	SUBTOTAL		276	15.6%	110	9.2%	5	5.8%	30	6.6%
	TOTAL RESPONSE		1773		1196		86		454	
GENDER:			Count	%	Count	%	Count	%	Count	%
		Females	730	38.6%	461	36.2%	51	58.6%	133	28.3%
		Males	1161	61.4%	812	63.8%	36	41.4%	337	71.7%
	TOTAL RESPONSE		1891		1273		87		470	
OCCUPATION:			Count	%	Count	%	Count	%	Count	%
		Clerical	85	4.6%	55	4.6%	8	9.1%	12	2.6%
		General Labor	26	1.4%	20	1.7%	0	0.0%	8	1.7%
		Homekeeper	65	3.5%	51	4.2%	2	2.3%	4	0.9%
		Professional	1171	64.0%	622	51.7%	23	26.1%	229	49.1%
		Skilled Labor	100	5.5%	65	5.4%	5	5.7%	17	3.6%
		Student	290	15.8%	321	26.7%	45	51.1%	182	39.1%
		Other	94	5.1%	68	5.7%	5	5.7%	14	3.0%
	TOTAL RESPONSE		1831		1202		88		466	

Table D.2. May 1990 BGT/SRT summary survey data.

	Saturday, May 19,1990			Tuesday, May 22, 1990								
	All Users			All Users			Non-Bike Commuters			Bike Commuters		
SURVEY CARDS RETURNED:	1905			1286			88 (6.8%) [Work/Schoool]			475 (36.9%) [Work/School]		
AGE:	All	Females	Males	All	Females	Males	All	Females	Males	All	Females	Males
Oldest	85	74	85	89	89	81	82	82	74	76	76	73
Average	37	35.7	37.6	37.4	37.5	37.4	33.1	32.9	33.1	34.1	32.6	34.6
Median	35	34	36	35	35	35	29	28	29	32	31	32
Youngest	7	8	7	4	16	5	18	18	20	15	16	15

	Saturday All Users Count	%	Tuesday All Users Count	%	Non-Bike Commuters Count	%	Bike Commuters Count	%
0-9	9	0.5%	2	0.2%	0	0.0%	0	0.0%
10-19	66	3.6%	23	1.8%	6	7.0%	3	0.6%
20-29	446	24.1%	367	29.2%	39	45.3%	172	37.1%
30-39	629	34.0%	414	32.9%	21	24.4%	187	40.3%
40-49	436	23.6%	239	19.0%	10	11.6%	68	14.7%
50-59	170	9.2%	112	8.9%	5	5.8%	22	4.7%
60-69	68	3.7%	74	5.9%	3	3.5%	8	1.7%
70-79	23	1.2%	24	1.9%	1	1.2%	4	0.9%
80+	1	0.1%	3	0.2%	1	1.2%	0	0.0%
TOTAL RESPONSE	1848		1258		86		464	

INCOME:	Saturday All Users Count	%	Tuesday All Users Count	%	Non-Bike Commuters Count	%	Bike Commuters Count	%
$0-10K	203	11.4%	195	16.2%	30	36.1%	88	19.0%
$10-20K	257	14.5%	232	19.2%	23	27.7%	124	26.7%
$20-30K	340	19.1%	224	18.6%	19	22.9%	92	19.8%
$30-40K	338	19.0%	190	15.8%	5	6.0%	57	12.3%
$40-50K	191	10.7%	118	9.8%	2	2.4%	41	8.8%
$50-60K	139	7.8%	83	6.9%	0	0.0%	26	5.6%
$60-70K	87	4.9%	57	4.7%	0	0.0%	15	3.2%
$70-80K	49	2.8%	22	1.8%	2	2.4%	6	1.3%
>$80K	174	9.8%	85	7.0%	2	2.4%	15	3.2%
TOTAL RESPONSE	1778		1206		83		464	
Average	$32K		$27K		$13K		$22K	
Median	$35K		$25K		$15K		$25K	

NOTE:
Data gathered from response cards returned by trail users (either at survey stations or mailed postage paid). Survey hours 7 AM to 7 PM each day.
Survey conducted by volunteers from the Cascade Bicycle Club with the assistance of the Seattle Engineering Department, King County Parks, and the International Bicycle Fund. Dave Moser designed the survey cards and organized their collection..
Data entry partially funded by Scott Rutherford, UW. Analysis performed using Lotus 1-2-3 by W. Moritz, UW.