# CONSERVE BY BICYCLE PROGRAM STUDY

# PHASE I REPORT APPENDICES A THROUGH P

June 2007

Sprinkle Consulting

Kittelson & Associates, Inc.
Transportation Engineering/Planning

CUTR

rails-to-trails conservancy

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# APPENDIX A Program Study Scope

## Conserve by Bicycle Program Study
## Scope of services

Background:

In 2005, the Florida Legislature created FS 335.07, Conserve by Bicycle Program within the Florida Department of Transportation.-As part of this program a study has been authorized.

The purposes of the Conserve by Bicycle Program are to:

- Save energy by increasing the number of miles ridden on bicycles, thereby reducing the usage of petroleum-based fuels.
- Increase efficiency of cycling as a transportation mode by improving interconnectivity of roadways, transit and bicycle facilities.
- Reduce traffic congestion on existing roads.
- Provide recreational opportunities for Florida's residents and visitors.
- Provide healthy transportation and recreation alternatives to help reduce the trend toward obesity and reduce long-term health costs.
- Provide safe ways for children to travel from their homes to their schools by supporting the Safe Paths to Schools Program.

Goals:

The goals of this study are to determine:

- Where energy conservation and savings can be realized when more and safer bicycle facilities, such as bicycle paths, bicycle lanes, and other safe locations for bicycle use, are created which reduce the use of motor vehicles in a given area.
- Where the use of education and marketing programs can help convert motor vehicle trips into bicycle trips.
- How, and under what circumstances, the construction of bicycling facilities can provide more opportunities for recreation and how exercise can lead to a reduction of health risks associated with a sedentary lifestyle.
- How the Safe Paths to Schools Program and other similar programs can reduce school-related commuter traffic, which will result in energy and roadway savings as well as improve the health of children throughout the state.
- How partnerships can be created among interested parties in the fields of transportation, law enforcement, education, public health, environmental restoration and conservation, parks & recreation, and energy conservation to achieve a better possibility of success for the program. The above stakeholder groups for instance, may be brought into new or existing groups such as the Bicycle and Pedestrian Advisory Committee operated by Florida Department of Transportation

The study shall produce measurable criteria that can be used by the department to determine where and under what circumstances the construction of bicycling facilities will reduce energy consumption and the need for and cost of roadway capacity, as well as realizing the associated health benefits.

Tasks (Phase 1):

1) The consultant shall assemble a steering team consisting of the State Pedestrian/Bicycle Coordinator, and at a minimum, representatives of metropolitan planning organizations, law enforcement agencies, the Office of Greenways and Trails of the Department of Environmental Protection, the Department of Health, Department of Community Affairs, Department of Education, community interest groups and the general public. The consultant will also prepare a public involvement plan which outlines the public involvement activities to be undertaken during the study. The Consultant will also complete an evaluation of the public involvement activities upon the completion of the project. The public involvement activities will include meetings and/or workshops to collect data from a representative population of the state. All public involvement activities will be documented and coordinated with the activities of the Steering Team. The steering team shall meet regularly, throughout the state, to receive input from stakeholders, and evaluate and refine the study findings and recommendations.
2) The Consultant will complete a literature search which will highlight case studies of successful programs which have achieved some or all of the goals listed above. Research will include an evaluation of existing Florida-based programs that relate to the study goals, out-of-state statewide research, and national studies/programs. These case studies will be evaluated to determine which components would be most applicable in Florida.
3) With guidance from the steering team, pilot projects (facilities, education, encouragement and/or enforcement) and locations will be selected from ongoing programs (e.g. local TIPs, local jurisdiction or state agency programs, etc.) to demonstrate the principles illustrated by the case studies. To extent possible, the case study literature research should include background data that is representative of Florida, its regions and the various commuter patterns in different areas of the State. All examples will be accompanied by data collection prior to implementation where possible. See Phase 2 for completion of this task.
4) A final report will be produced which documents the study and makes recommendations to the legislature on how to best implement the conserve by bike program. The report will include a stand alone Executive Summary for use by the Legislature and other stakeholders interested in the study findings.
5) The consultant, with direction and guidance from the steering team, will develop an implementation plan along with roles and responsible entities to carry out the recommendations of the study.

Project Deliverables (Phase 1):

1) Public Involvement Plan Document & Evaluation
2) Case Study Technical Memorandum
3) Draft & Final Report

Tasks (Phase 2):

In addition, a post project data collection and evaluation plan will be included for all examples. The actual post project data collection and evaluation will be completed after the completion of this study as a separate phase. Specific data needs will be determined by the steering team.

Project Deliverables (Phase 2):

1) Draft and Final Report for this Phase

Timeline:

By July 1, 2007, study shall be completed and shall be submitted to the Governor, the President of the Senate, the Speaker of the House of Representatives, the Secretary of Transportation, the Secretary of Environmental Protection, and the Secretary of Health.

By July 1, 2008, phase 2 of the study will be complete and shall be submitted to the project manager within FDOT.

Consultant Not Employee or Agent:

The Consultant and its employees, agents, representatives, or subconsultants/subcontractors are not employees of the Department and are not entitled to the benefits of State of Florida employees. Except to the extent expressly authorized herein, Consultant and its employees, agents, representatives, or subconsultants/subcontractors are not agents of the Department or the State for any purpose or authority such as to bind or represent the interests thereof, and shall not represent that is an agent or that it is acting on the behalf of the Department or the State. The Department shall not be bound by any unauthorized acts or conduct of Consultant.

Ownership of Works and Inventions:

The Department shall have full ownership of any works of authorship, inventions, improvements, ideas, data, processes, computer software programs, and discoveries (hereafter called intellectual property) conceived, created, or furnished under this Agreement, with no rights of ownership in Consultant or any subconsultants/subcontractors. Consultant and subconsultants/subcontractors shall fully and promptly disclose to the Department all intellectual property conceived, created, or furnished under this Agreement. Consultant or subconsultants/subcontractor hereby assigns to the Department the sole and exclusive right, title, and interest in and to all intellectual property conceived, created, or furnished under this Agreement, without further consideration. This Agreement shall operate as an irrevocable assignment by Consultant and subconsultants/subcontractors to the Department of the copyright in any intellectual property created, published, or furnished to the Department under this Agreement, including all rights thereunder in perpetuity. Consultant and subconsultants/subcontractors shall not patent any intellectual property conceived, created, or furnished under this Agreement. Consultant and subconsultants/subcontractors agree to execute and deliver all necessary documents requested by the Department to effect the assignment of intellectual property to the Department or the registration or confirmation of the Department's rights in or to intellectual property under the terms of this Agreement. Consultant agrees to include this provision in all its subcontracts under this Agreement.

## APPENDIX B Steering Committee Members

| NAME | AFFILIATION |
|---|---|
| Dennis Scott | FDOT |
| Dave Blodgett | FDOT |
| Jena Brooks | DEP |
| Melanie Weaver Carr | FDOT |
| Jennifer Carver | DCA |
| Dave Cummings | FSU Police Department |
| Amy Datz | FDOT |
| Laura Hallam | Florida Bicycle Association |
| David Henderson | Miami-Dade MPO |
| Mark Horowitz | Broward County MPO |
| Larry Hymowitz | FDOT District 4 |
| Dwight Kingsbury | FDOT |
| Mary Anne Koos | FDOT |
| Sean Masters | FDOT District 1 |
| Dan Moser | Lee County Health Department |
| Marlie Sanderson | Gainesville MPO |
| Ruth Steiner | University of Florida |
| Sean Timmons | PTA |
| Karl Welzenbach | Volusia County MPO |

# APPENDIX C Intercept Survey

## Florida Department of Transportation
## CORRIDOR TRAVEL SURVEY

We at the Florida Department of Transportation are working to provide you **the best** transportation system. To help accomplish this, we need to better understand travelers' characteristics along this corridor.

Please help us out by taking a couple of minutes to fill out this brief survey regarding your present trip. Then simply fold it, **seal it**, and drop it in the nearest mailbox – it's pre-addressed and postage paid. Thank you for your valued time and help!

What is today's date? ____/____/2007

**Tell us about yourself…**

1. Are you male or female?
☐ Male ☐ Female

2. What is your age?
☐ Under 16 ☐ 16-21 ☐ 22-49 ☐ 50-64 ☐ 65+

3. What do you consider to be your current employment status (check all that apply)?
☐ Full ☐ Part ☐ Unemployed ☐ Retired ☐ Student

4. If employed outside the home, which of the following best describes your job?
☐ Managerial/Administrator/In-House Sales
☐ Professional/Technical
☐ Clerical
☐ Craftsman/Mechanic/Manufacturing/Laborer
☐ Sales
☐ Equipment Operator/Trucker/Driver
☐ Service Worker
☐ University or College Faculty/Staff
☐ Military
☐ Other (Please Specify) ________________________________

**Tell us about your present trip…** (if your overall trip has multiple stops, please refer only to the current portion of your trip for Questions #5-11)

5. What is the primary **purpose** of your **present** trip (please check only one response)?
☐ Work
☐ Work-Related (meetings, etc.)
☐ Shopping
☐ Errands (dry cleaning, banking, etc.)
☐ Personal Business (doctor, dentist, etc.)
☐ Social (visit family or friends)
☐ Recreation (exercise, gym, park, etc.)
☐ Return Home (from work)
☐ School
☐ Other (Please Specify) ________________________

6. What is the **closest intersection** of streets to where you **began** your present trip and the name of the business there, if applicable?
______________________ / ______________________
Name: ________________________________________

7. What is the approximate **duration** of your present trip (to the nearest 5 minute increment)?
____ minutes

8. Of this duration, approximately how many minutes will you spend using your **current mode of transportation** (motor vehicle, bicycle, walking, etc.)? ____

9. What is the **closest intersection** of streets to the **destination** of your present trip and the name of the business there, if applicable?
______________________ / ______________________
Name: ________________________________________

10. How many people are presently traveling with you?
☐ 0 ☐ 1 ☐ 2 ☐ 3 or more

11. **If part of your present trip involves riding a bus**, how many **bus transfers** will you make?
☐ 0 ☐ 1 ☐ 2 or more

12. **Tell us about your household…**
(please include yourself in all responses)
____ Number of persons age 16+
____ Number of licensed drivers
____ Number of employed (full or part) persons
____ Number of children age 0-4
____ Number of elementary school aged children
____ Number of middle school aged children
____ Number of high school aged children
____ Number of working motor vehicles at your home
____ Number of working bicycles at your home

**Thank you for participating in this survey!**

**Thank you for filling out this survey! Please refold, seal, and mail this postage-paid and pre-addressed survey.**

# Florida DOT Corridor Travel Survey

## Win One of Four Gift Certificates to Area Restaurants and Movie Theatres

**by completing and returning this survey!**

We at the Florida Department of Transportation are working to provide you **the best** transportation system. To help accomplish this, we need to better understand travelers' characteristics along this corridor. Your response will help improve travel in the region.

**Return Survey by ________________ to be eligible for prizes. One survey per person.**
**Name: ____________________ Contact info (phone/e-mail): ________________________________**

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

**BUSINESS REPLY MAIL**
FIRST-CLASS MAIL PERMIT NO. 100 LUTZ, FL

POSTAGE WILL BE PAID BY ADDRESSEE

**FLORIDA DEPARTMENT OF TRANSPORTATION**
**c/o PEYTON McLEOD**
**SPRINKLE CONSULTING INC.**
**18115 US HIGHWAY 41 NORTH, SUITE 600**
**LUTZ, FL 33549-6473**

## Florida DOT Corridor Travel Survey

13. If you are currently commuting to/from work or making a utilitarian (non-recreational) trip of any kind, and this trail were not present, by what mode would you be traveling?

- ☐ Car
- ☐ Bus
- ☐ Walk
- ☐ Bicycle
- ☐ Would not be making trip

14. How did you access the trail today?

- ☐ Car
- ☐ Bus
- ☐ Walk
- ☐ Bicycle

15. About how many miles did you travel to get to the trail?

_________ miles

**Thank you!**

## APPENDIX D Variable Definitions

1. Bicycle Facility Type – type of facility (designated bike lanes, paved shoulders, or shared use path adjacent to roadway)

2. Width of Bicycle Facility – width of facility (ft)

3. Length of Bicycle Facility – length of facility (mi); in some cases, only a subset of the facility is used as the study corridor, and the length used is the length of this subset

4. Signalized Intersections per Mile – based on the number of signalized intersections the facility crosses; if the corridor begins and ends at signalize intersections, only one of these is counted

5. Unsignalized Intersections per Mile – based on the number of unsignalized intersections the facility crosses

6. Average ADT of Unsignalized Intersections – during the development of the Bicycle Level of Service Model, the volumes of the individual driveways were found to be less significant than other variables, and were not collected

7. Driveways per Mile – based on the number of driveways the facility crosses, regardless of driveway type

7.2 Lanes Crossed per Mile – based on the total number of lanes the facility crosses, including lanes from all intersections and driveways; driveways without lane markings are assumed to have two lanes, except for residential driveways leading to single-car garages

8. Presence of Street Lights (Y/N) – coded as “Y” if street lights are present for the majority of the corridor

9. Drinking Water Facilities per Mile – the number of establishments at which beverages could be quickly procured by travelers, including convenience stores and fast food restaurants; for trails, water fountains are also included

10. Percent of Facility Through/Adjacent to Attractions – attractions are defined as parks, waterfront, or otherwise scenic views

11. Adjacent Property Value of the Surrounding Area – represented by a surrogate, the average of the median household incomes of the Census tracts that coincide with the facility's network influence area

12. Population Density of Surrounding Area – the average of the population densities of the Census tracts that coincide with the facility's network influence area

13. Bicycle Network Connectivity – the degree of connectivity of the bicycle network in the network influence area, as defined in Appendix G, the "Development of the Network Travel Quality Continuity Measure" of the Phase I Summary Report

14. Pedestrian Network Connectivity – the degree of connectivity of the pedestrian network in the network influence area, as defined in Appendix G, the "Development of the Network Travel Quality Continuity Measure" section of the Phase I Summary Report

15. Transit Network Connectivity - the degree of connectivity of the transit network in the network influence area, defined as the decimal fraction of the network influence area located within one-half mile of a fixed transit route

16. Motor Vehicle Network Connectivity – the degree of connectivity of the motor vehicle network in the network influence area, assumed to be 1

17. Bicycle Level of Service – the calculated bicycle level of service of the study corrector, as calculated using FDOT's *Bicycle Level of Service Model* based on field-collected inputs

18. Pedestrian Level of Service – the calculated pedestrian level of service of the study corrector, as calculated using FDOT's *Pedestrian Level of Service Model* based on field-collected inputs

19. Motor Vehicle Level of Service – the calculated motor vehicle level of service of the study corridor using FDOT's ARTPLPAN software and associated inputs

20. Transit Level of Service - the calculated transit level of service of the study corridor using FDOT's ARTPLPAN software and associated inputs

21. Age of the Surrounding Area – the average of the median ages of the Census tracts that coincide with the facility's network influence area

22. Age of Traveler – the average age of intercept survey respondents

23. Gender of Traveler – the percentage breakdown of survey respondents by gender

24. Children Age 0-4 per Traveler Household – the average number of children age 0-4 living in survey respondents' households

25. Elementary School Students per Traveler Household – the average number of children attending elementary school living in survey respondents' households

26. Middle School Students per Traveler Household – the average number of children attending middle school living in survey respondents' households

27. High School Students per Traveler Household – the average number of children attending high school living in survey respondents' households

28. Adults per Traveler Household – the average number of adults living in survey respondents' households

29. Eligible Drivers per Household – the average number of eligible drivers living in survey respondents' households

30. Car Ownership by Traveler Household – the average number of motor vehicles owned by survey respondents and their households

31. Bicycle Ownership by Traveler Household – the average number of bicycles owned by survey respondents and their households

32. Employment Status of Traveler – the percentage breakdown of survey respondents by employment status

33. Occupation Category of Traveler – the percentage breakdown of survey respondents by occupation category

34. Average Trip Length – the average trip length of survey respondents for the trips during which they were intercepted

35. Trip Purpose – the percentage breakdown of trip purposes of the survey respondents' trips during which they were intercepted

36. Origin/Destination Locations – the origins and destinations of survey respondents for the trips during which they were intercepted, provided as either a nearby intersection or name of business

37. In-Vehicle Travel Time – the average in-vehicle travel time of survey respondents for the trips during which they were intercepted

38. Out-of-Vehicle Travel Time – the average out-of-vehicle travel time of survey respondents for the trips during which they were intercepted (*i.e.* time spent walking from the origin to the respondent's motor vehicle)

39. Number of Transfers – the average number of transfers made by transit survey respondents

40. Average Travel Group Size – the average number of people traveling with the survey respondent, inclusive, on the trips during which they were intercepted

## APPENDIX E Network Analysis Zones

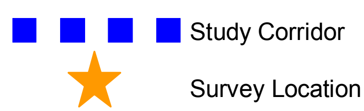
# Network Analysis Zone

## #1 - 16th St S from 62nd Ave S to Pinellas Point Dr S, St. Petersburg


0.54 in = 2100 ft     Local

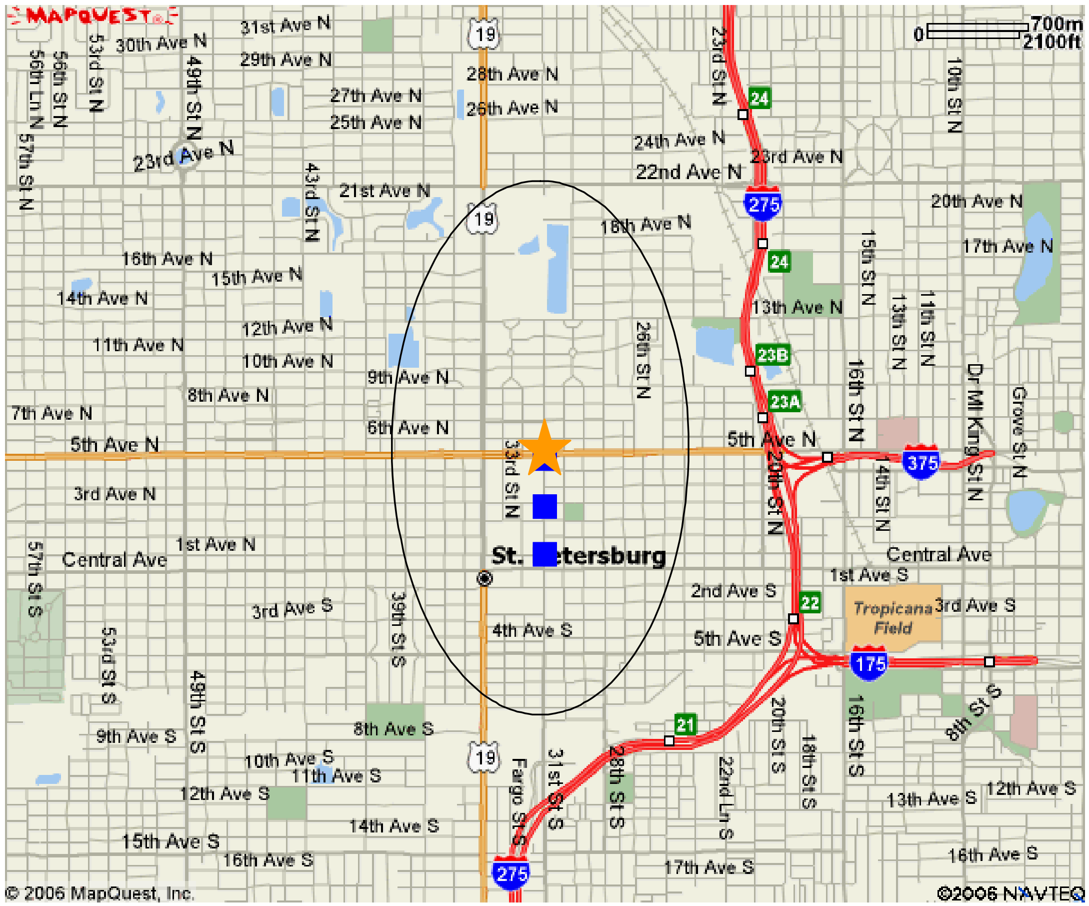
Length r = 0.2*5.68 = 1.14 mi (1.55 in)

Width r = 0.2*5.68 = 1.14 mi ( 1.55 in)



# Network Analysis Zone

## #2 - 31st St N from Central Ave to 5th Ave N, St. Petersburg




0.54 in = 2100 ft     Collector

Length r = 0.225*5.05 = 1.14 mi (1.55 in)

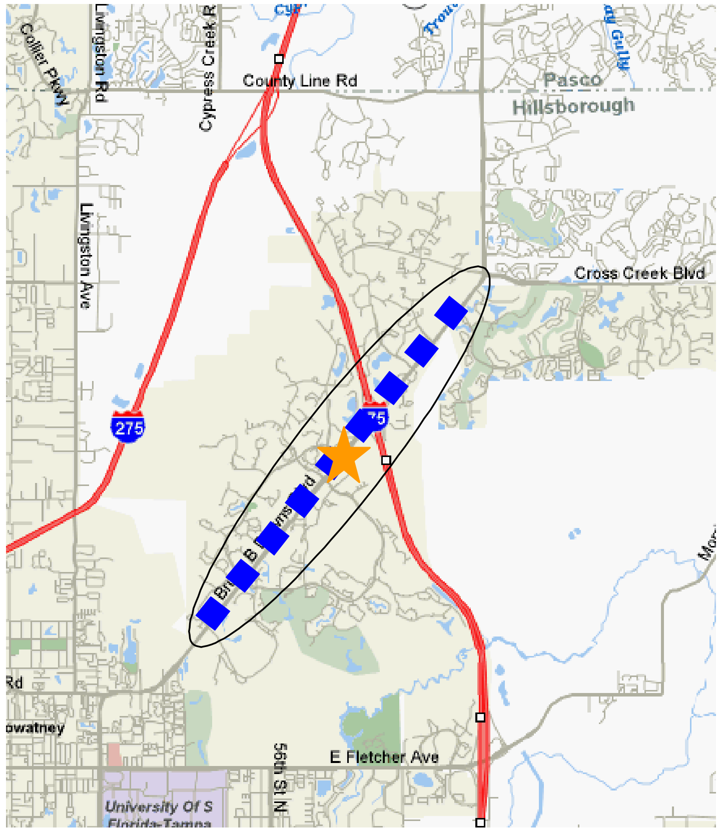
Width r = 0.125*5.05 = 0.63 mi (0.86 in)

Study Corridor

Survey Location

# Network Analysis Zone

## #3 - CR 581 from Amberly Dr to Hunter's Green Dr, New Tampa




0.49 in = 5280 ft     Arterial

Length r = 0.25*11.09 = 2.77 mi (1.36 in)

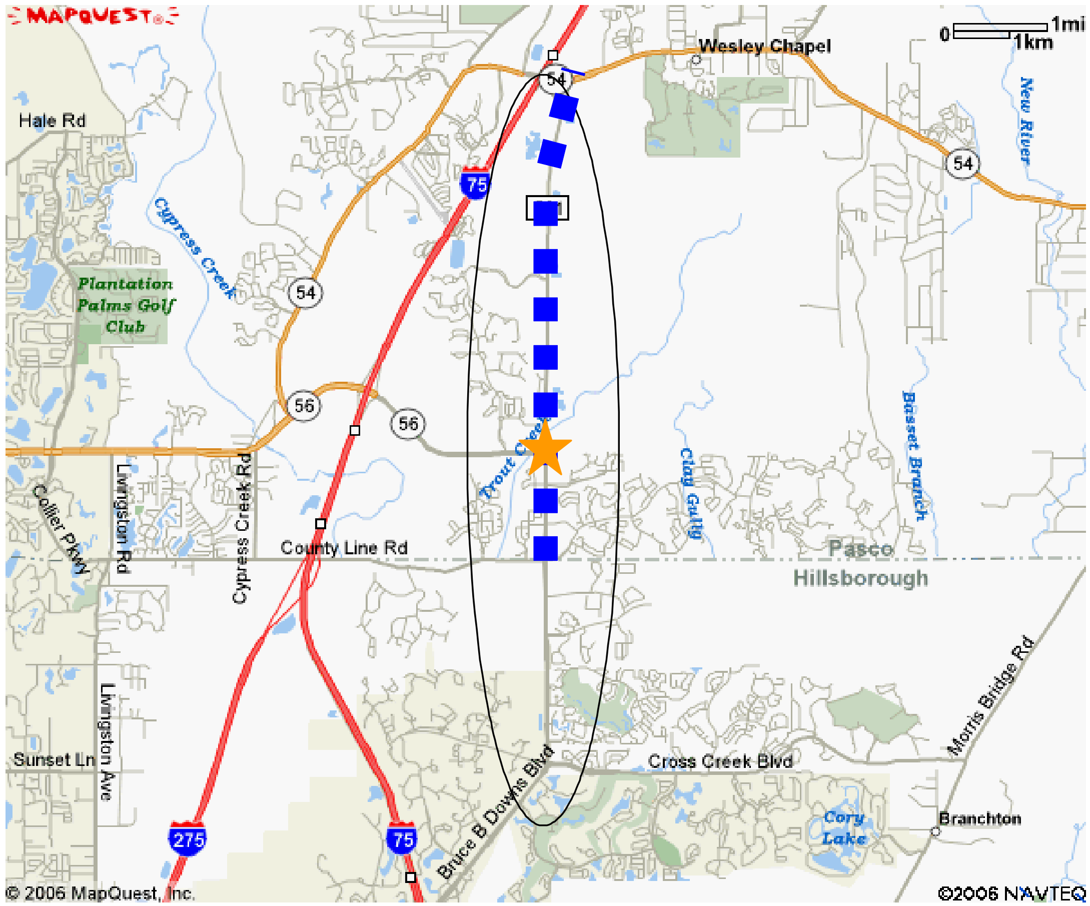
Width r = 0.05*11.09 = 0.55 mi (0.27 in)

Study Corridor

Survey Location

# Network Analysis Zone

## #4 - SR 581 from Hillsborough County Line to SR 54, Wesley Chapel




0.54 in = 5280 ft Arterial

Length r = 0.25*16.13 = 4.03 mi (2.18 in)

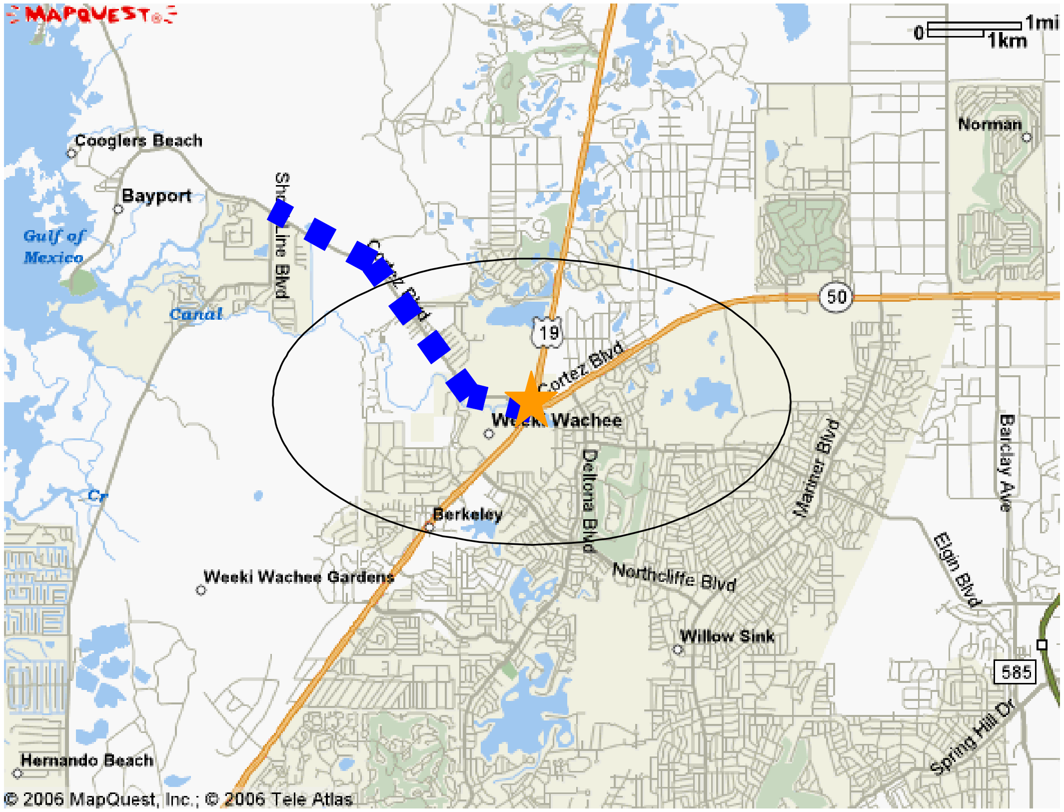
Width r = 0.05*16.31 = 0.81 mi (0.44 in)

Study Corridor

Survey Location

# Network Analysis Zone

## #5 - CR 550 from Shoal Line Blvd to US 19, Weeki Wachee




0.54 in = 5280 ft Collector

Length r = 0.225*12.34 = 2.78 mi (1.50 in)

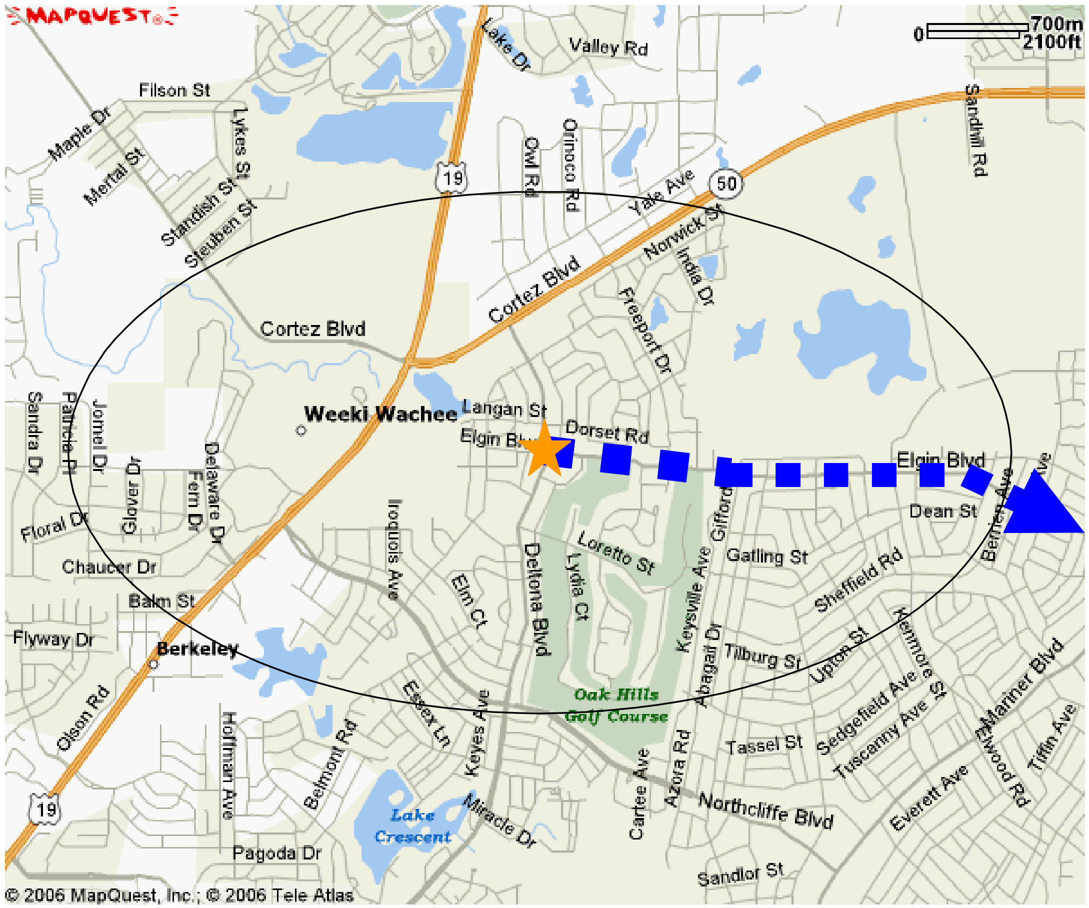
Width r = 0.125*12.34 = 1.54 mi (0.83 in)

Study Corridor

Survey Location

# Network Analysis Zone

## #6 - Elgin Blvd from Deltona Blvd to Mariner Blvd, Spring Hill




0.54 in = 2100 ft     Collector

Length r = 0.225*8.92 = 2.01 mi (2.73 in)

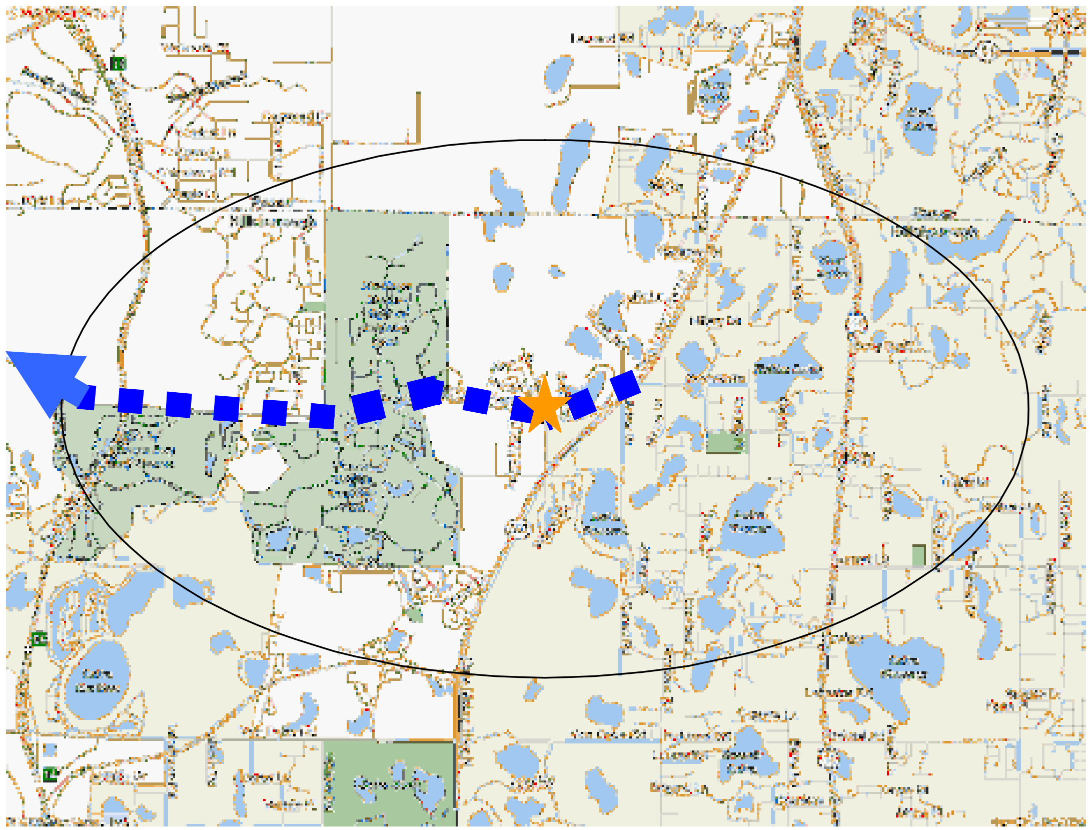
Width r = 0.125*8.92 = 1.11 mi (1.51 in)

Study Corridor

Survey Location

# Network Analysis Zone

## #7 - Lutz-Lake Fern Rd from Gunn Hwy to Dale Mabry Hwy, Lutz



0.34 in = 2100 ft Collector

Length r = 0.225*14.56 = 3.28 mi (2.80 in)

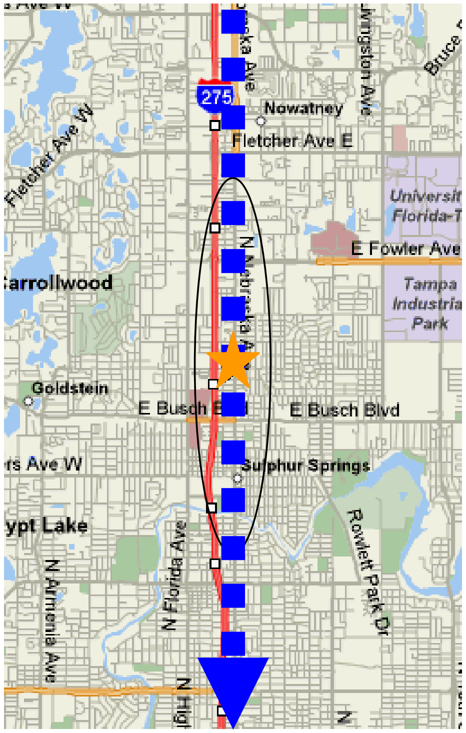
Width r = 0.125*14.56 = 1.82 mi (1.56 in)

■ ■ ■ ■ Study Corridor

★ Survey Location

# Network Analysis Zone

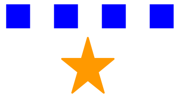
## # 8 - US 41 from Kennedy Blvd to Bearss Ave, Tampa




0.54 in = 5280 ft Arterial

Length r = 0.25*8.07 = 2.02 mi (1.09 in)

Width r = 0.05*8.07 = 0.40 mi (0.22 in)

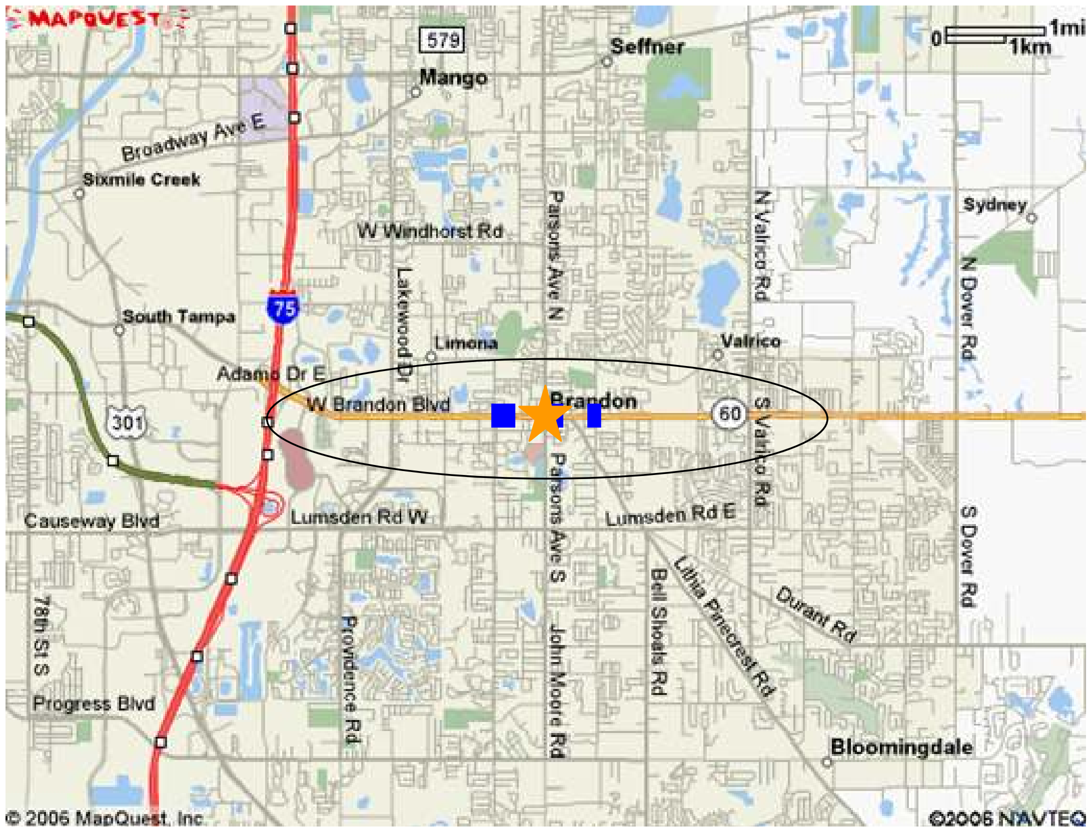


Study Corridor

Survey Location

# Network Analysis Zone

## #9 - SR60 from Kings Ave to Kingsway Rd, Brandon




0.57 in = 5280 ft    Arterial

Length r = 0.25* =

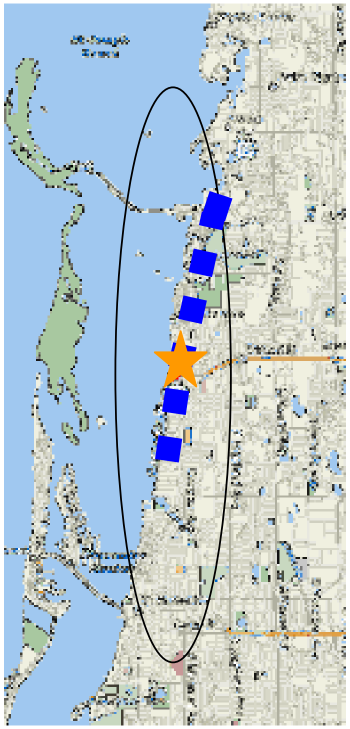
Width r = 0.05* =

Study Corridor

Survey Location

# Network Analysis Zone

## #10 - US Alt 19 from Union St to Orange St, Dunedin (Pinellas Trail)



0.54 in = 5280 ft Arterial

Length r = 0.25*12.47 = 3.12 mi (1.68 in)

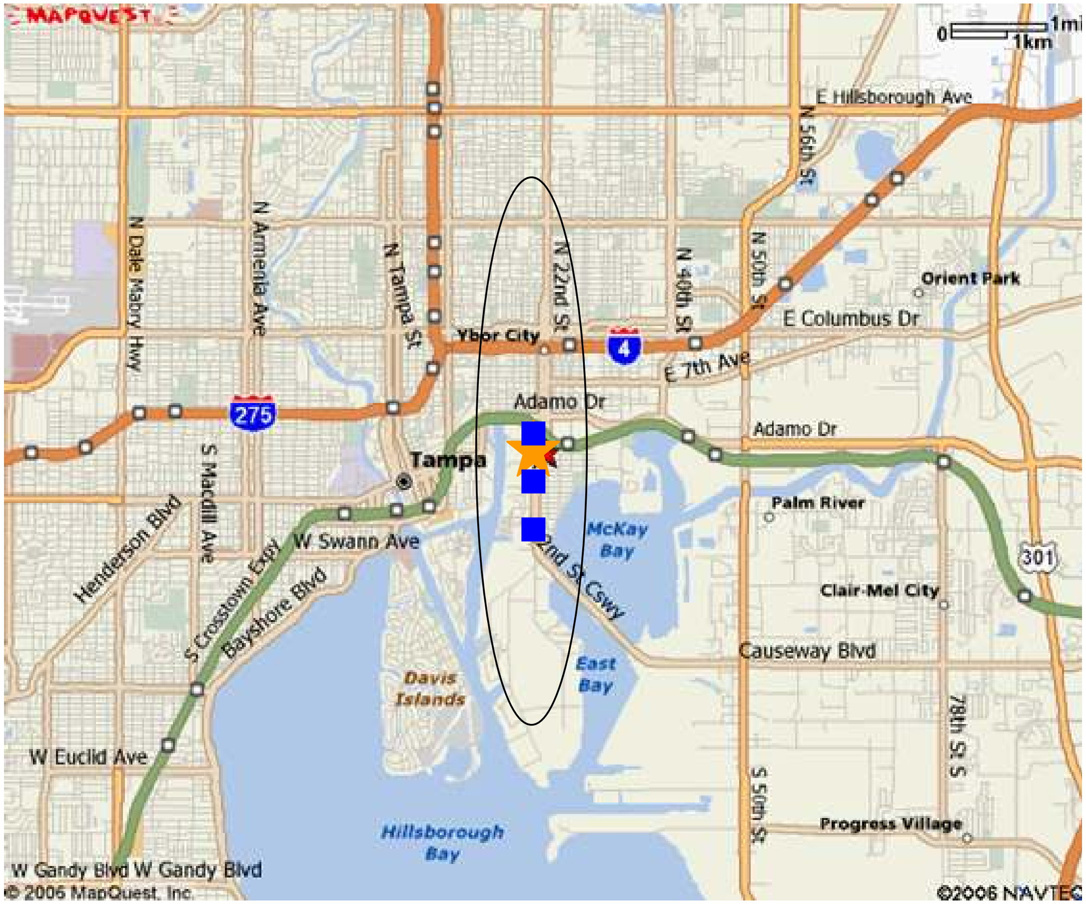
Width r = 0.05*12.47 = 0.62 mi (0.33 in)

Study Corridor

Survey Location

# Network Analysis Zone

## # 11 - S 20th St from Adamo Dr to Bermuda Blvd, Tampa




0.55 in = 5280 ft Arterial

Length r = 0.25*11.55 = 2.89 mi (1.59 in)

Width r = 0.05*11.55 = 0.58 mi (0.32 in)

Study Corridor

Survey Location

# Network Analysis Zone

## #12 - US 1 from I-95 to SW 67$^{th}$ Avenue, Miami (M Path)


1.15 in = 5280 ft Arterial

Length r = 0.25*10.40 = 2.60 mi (2.99 in)

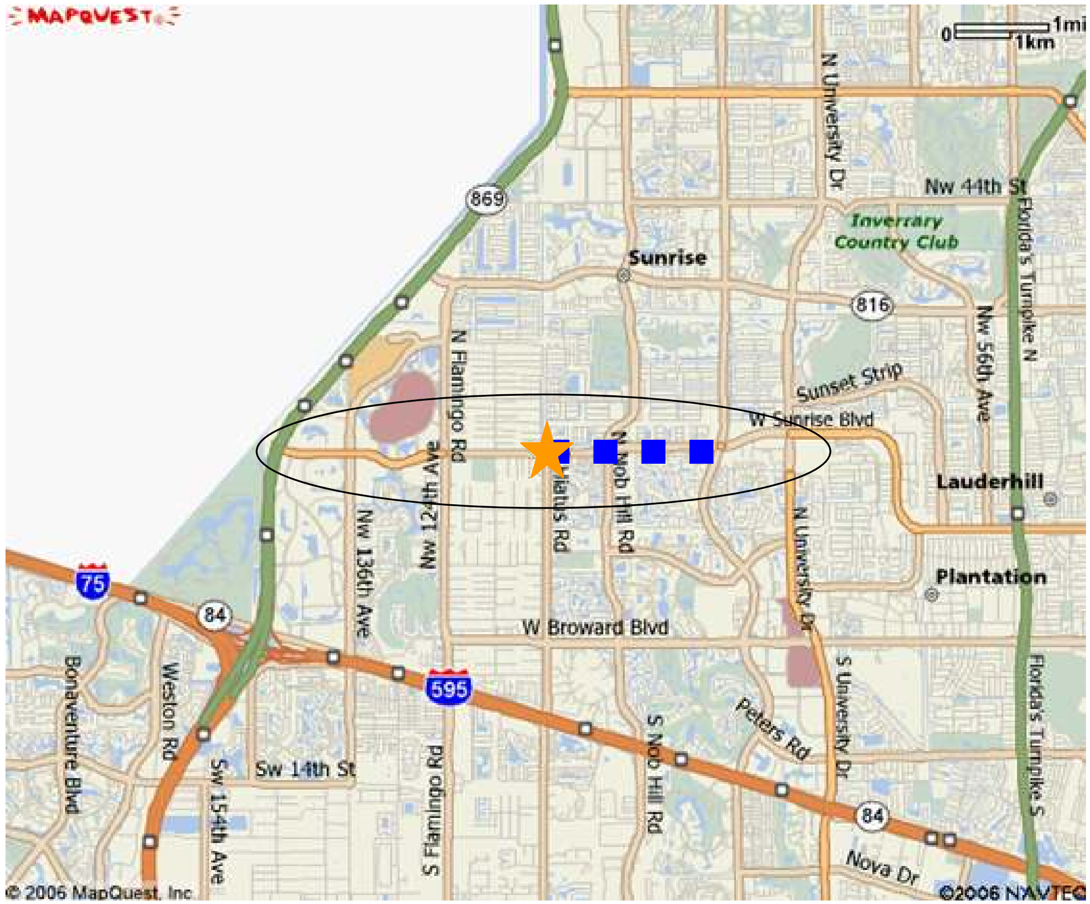
Width r = 0.05*10.40 = 0.52 mi (0.60 in)

■ ■ ■ ■ Study Corridor

★ Survey Location

# Network Analysis Zone

## #13 - Sunrise Blvd from Hiatus Rd to Pine Island Rd, Plantation




0.55 in = 5280 ft     Arterial

Length r = 0.25*12.07 = 3.02 mi (1.66 in)

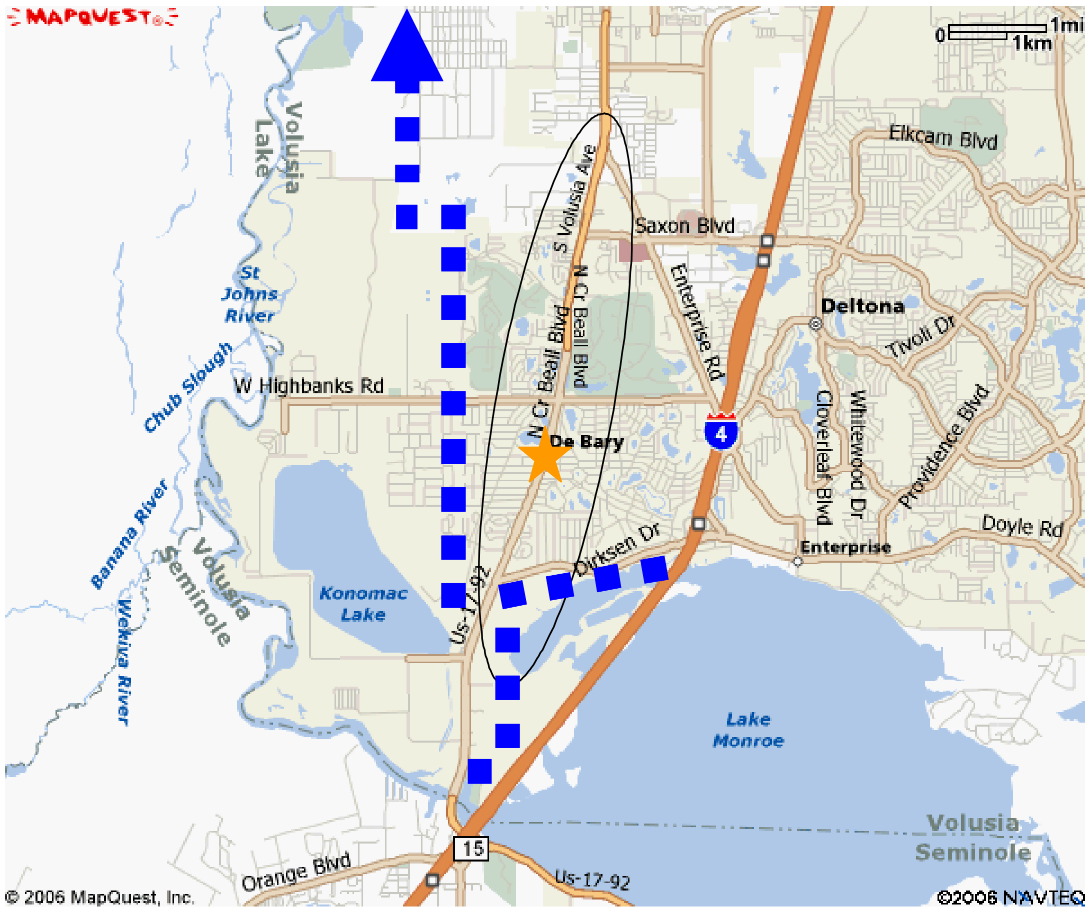
Width r = 0.05*12.07 = 0.60 mi (0.33 in)

Study Corridor

Survey Location

# Network Analysis Zone

## #14 - Spring to Spring Trail, Orange City




0.55 in = 5280 ft Arterial

Length r = 0.25*12.23 = 3.06 mi (1.68 in)

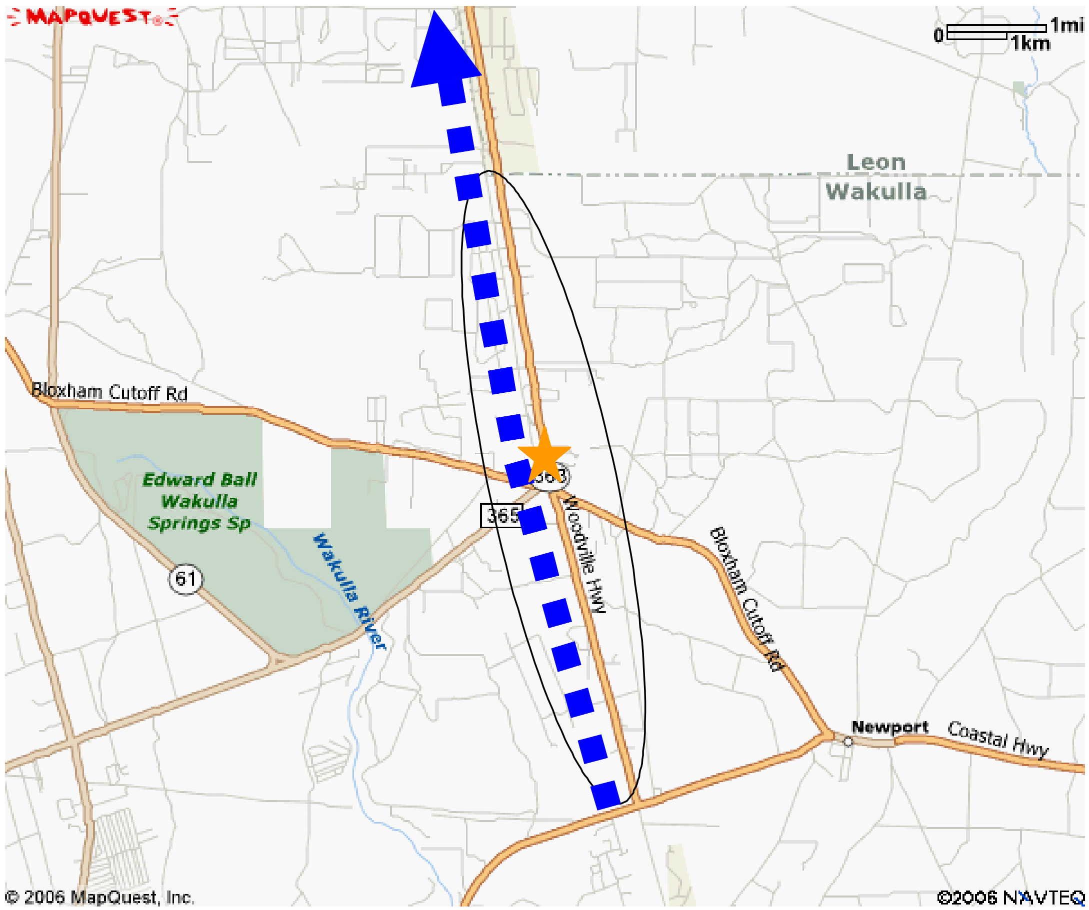
Width r = 0.05*12.23 = 0.61 mi (0.34 in)

Study Corridor

Survey Location

# Network Analysis Zone

## #15 - St Marks Trail, Wakulla




0.55 in = 5280 ft    Arterial

Length r = 0.25*13.62 = 3.40 mi (1.87 in)

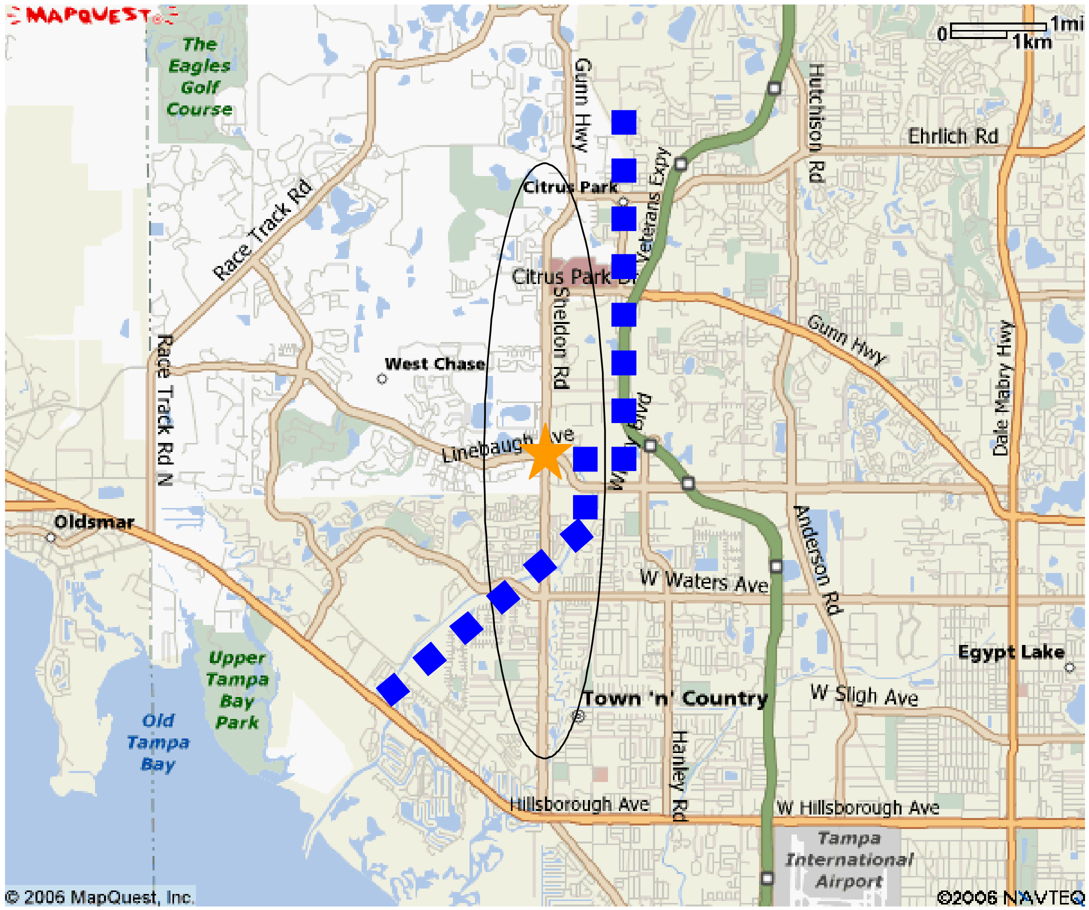
Width r = 0.05*13.62 = 0.68 mi (0.37 in)

Study Corridor

Survey Location

# Network Analysis Zone

## #16 - Upper Tampa Bay Trail, Tampa




0.55 in = 5280 ft  Arterial

Length r = 0.25*12.54 = 3.13 mi (1.72 in)

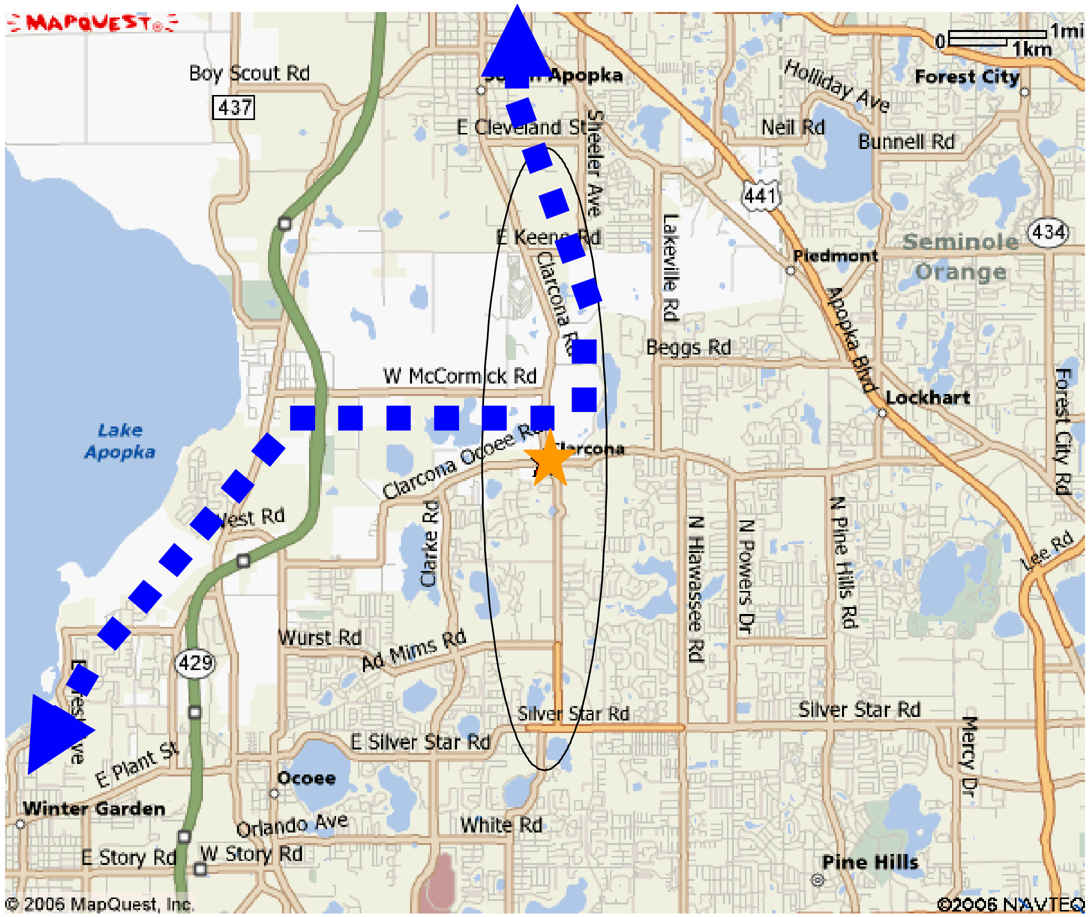
Width r = 0.05*12.54 = 0.63 mi (0.35 in)

Study Corridor

Survey Location

# Network Analysis Zone

## #17 - West Orange Trail, Apopka




0.55 in = 5280 ft  Arterial

Length r = 0.25*13.08 = 3.27 mi (1.80 in)

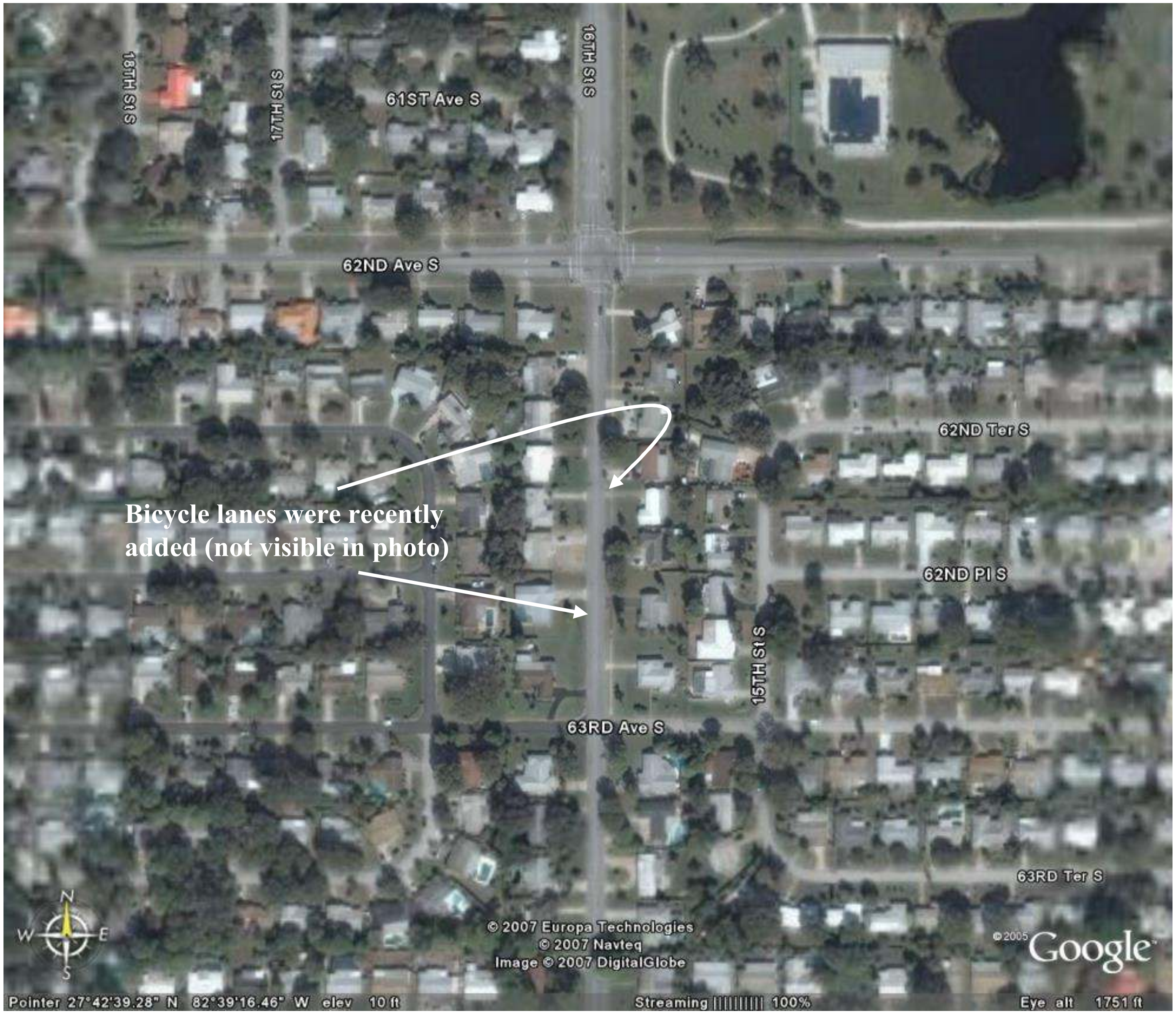
Width r = 0.05*13.08 = 0.65 mi (0.36 in)

Study Corridor

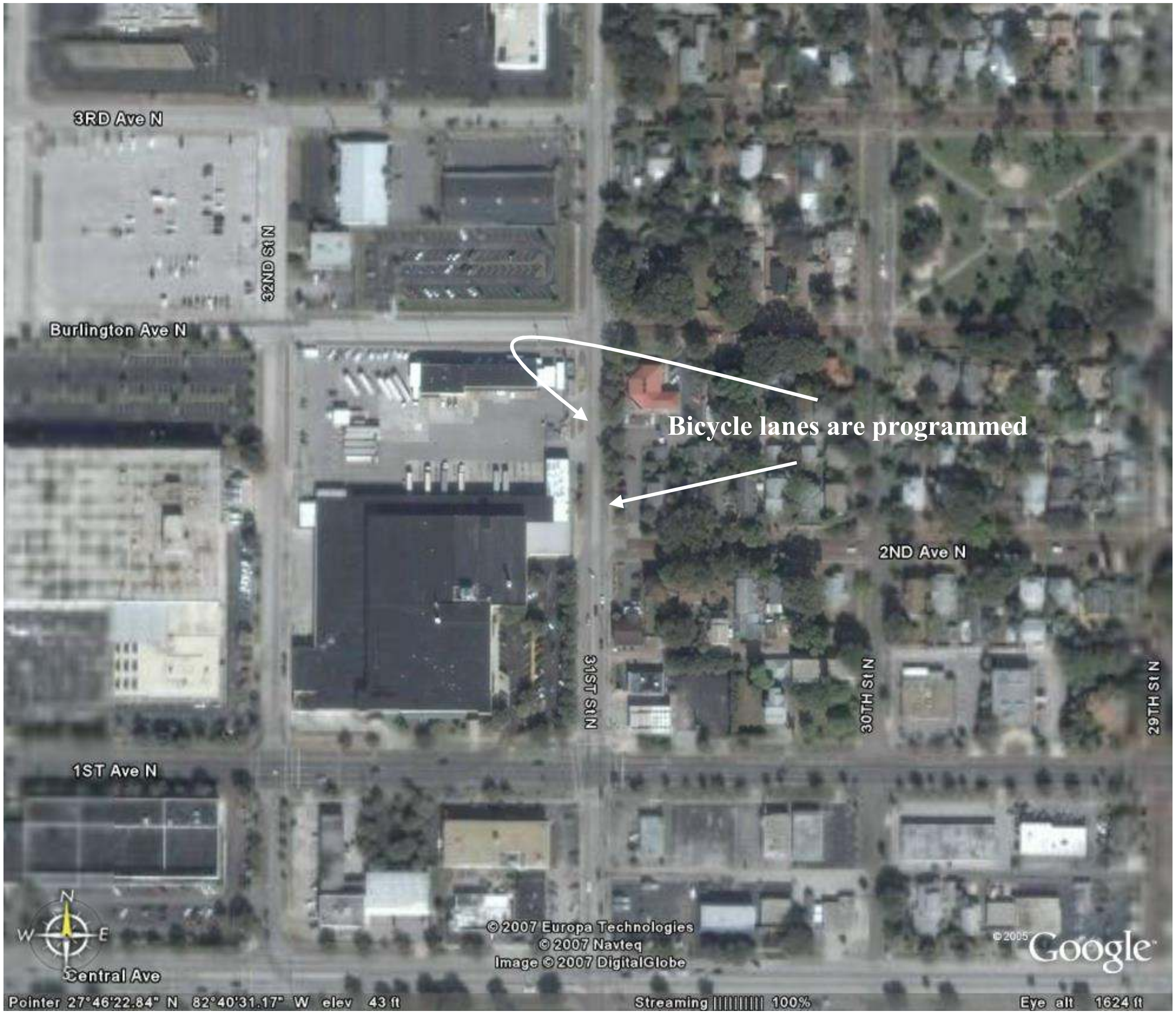
Survey Location

# APPENDIX F Aerials of Study Corridors

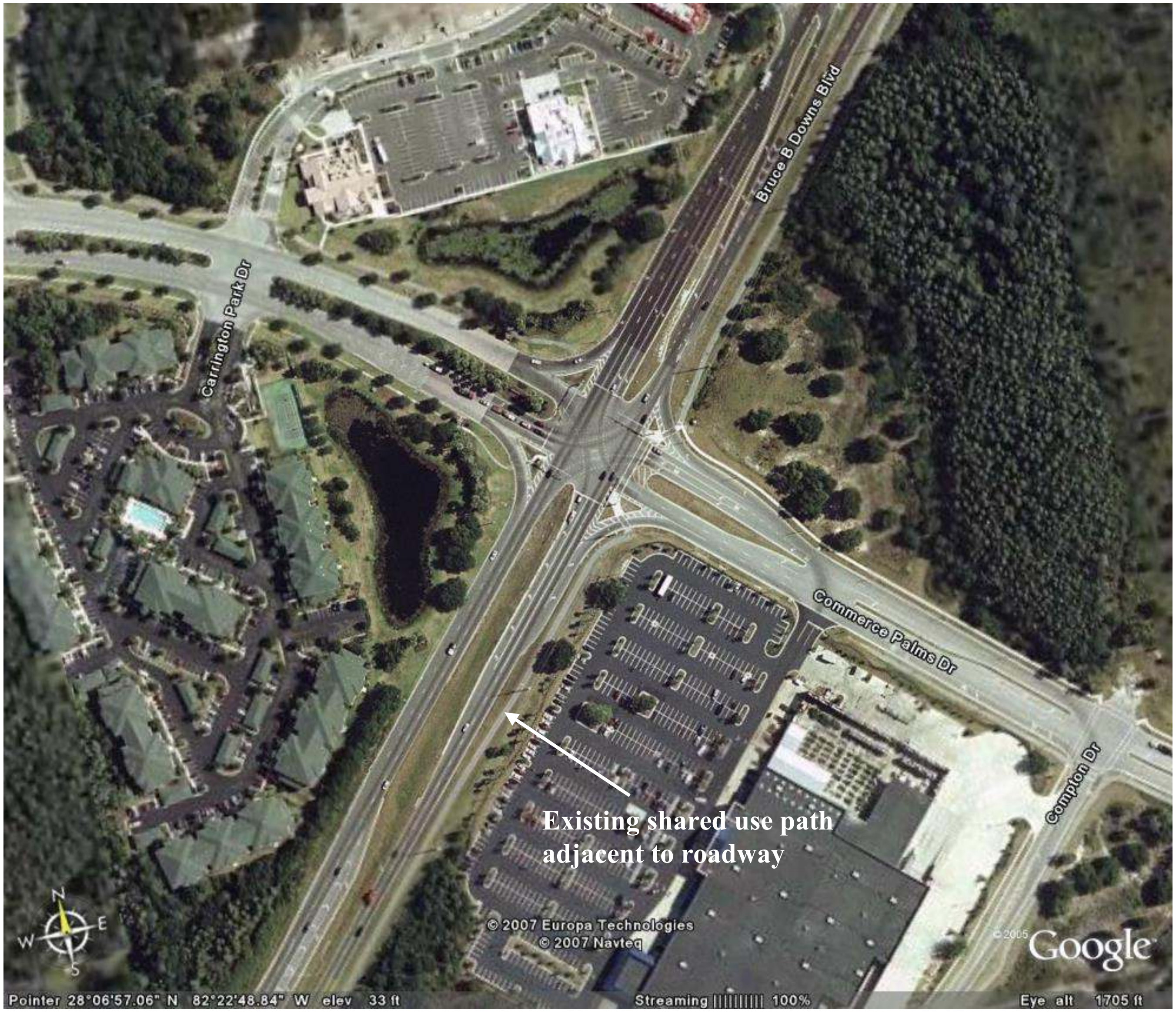
#1 – 16$^{th}$ St S, St. Petersburg



#2 – 31st St N at 5th Ave N, St. Petersburg



#3 – CR 581, New Tampa

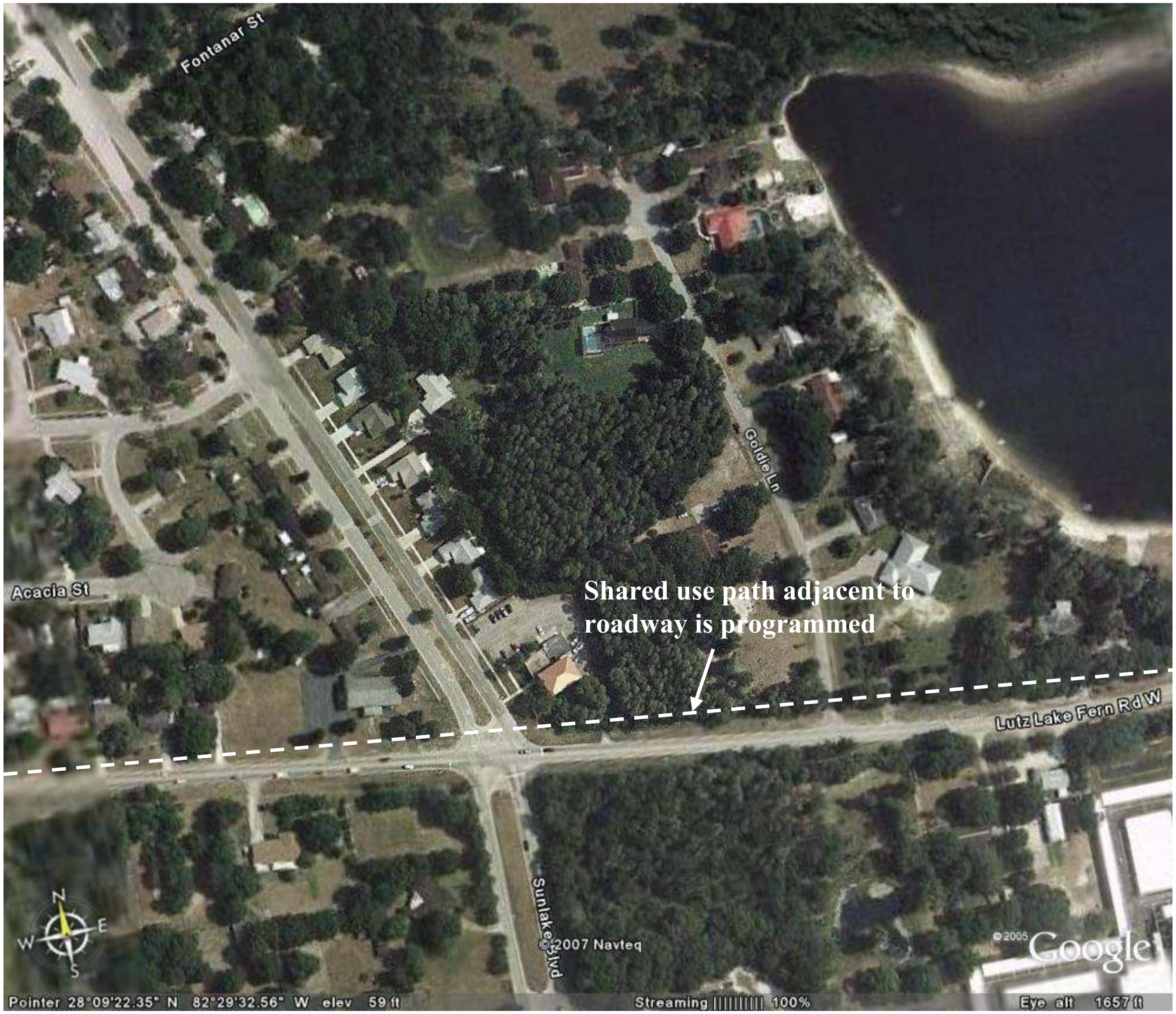


#4 – SR 581, Wesley Chapel

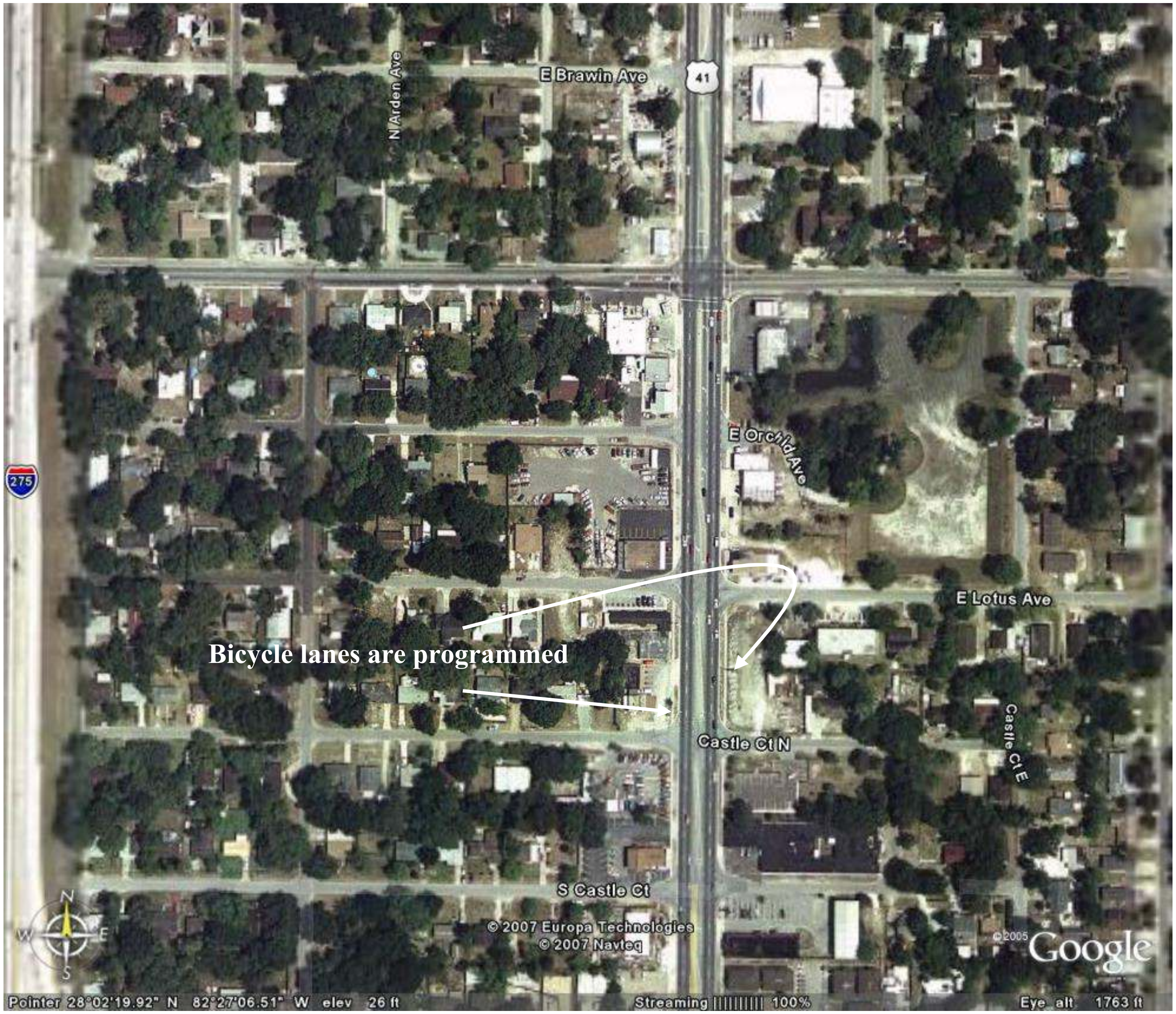
#5 – CR 550, Spring Hill

#6 – Elgin Blvd., Spring Hill

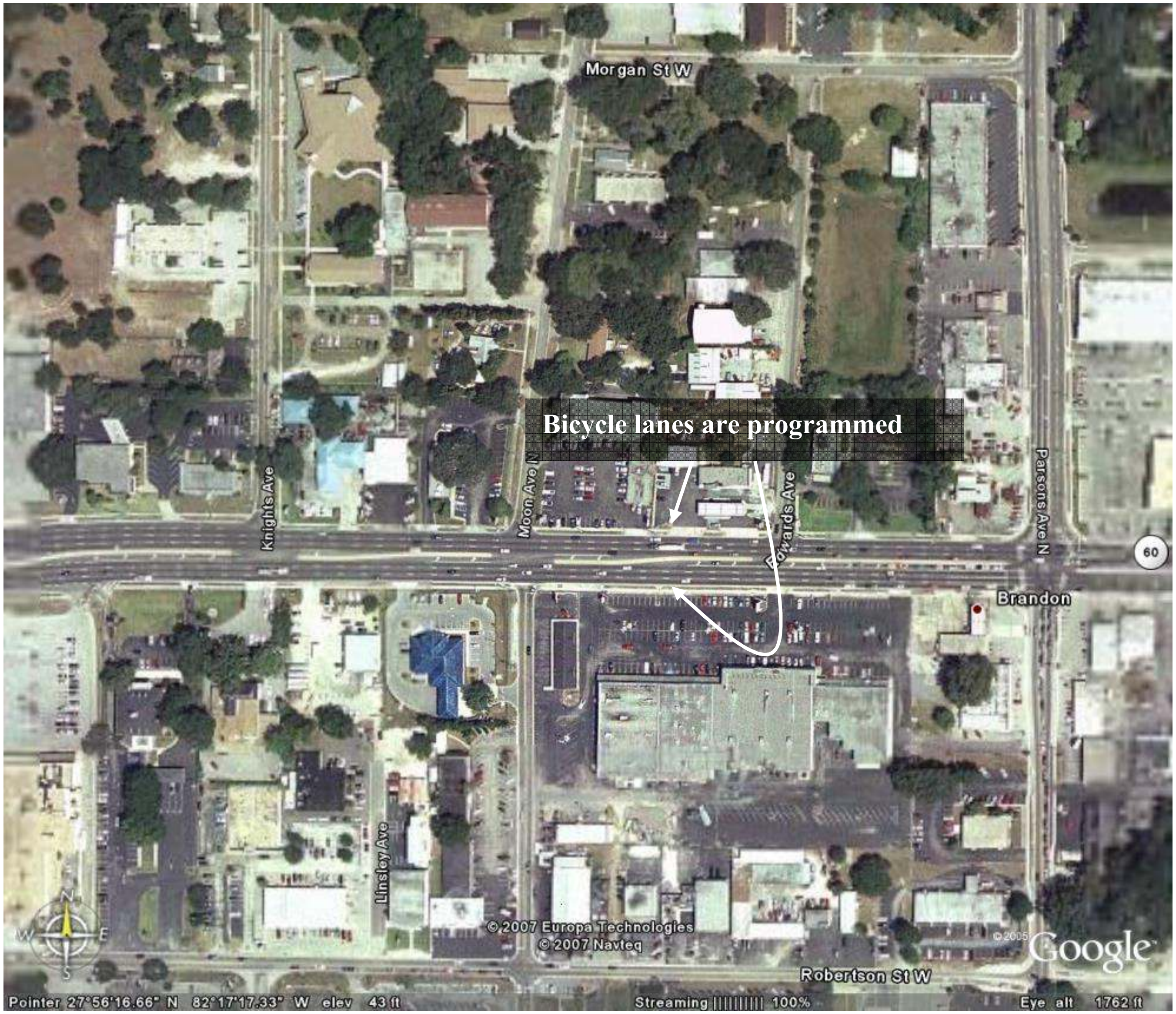
#7 – Lutz-Lake Fern Road, Lutz



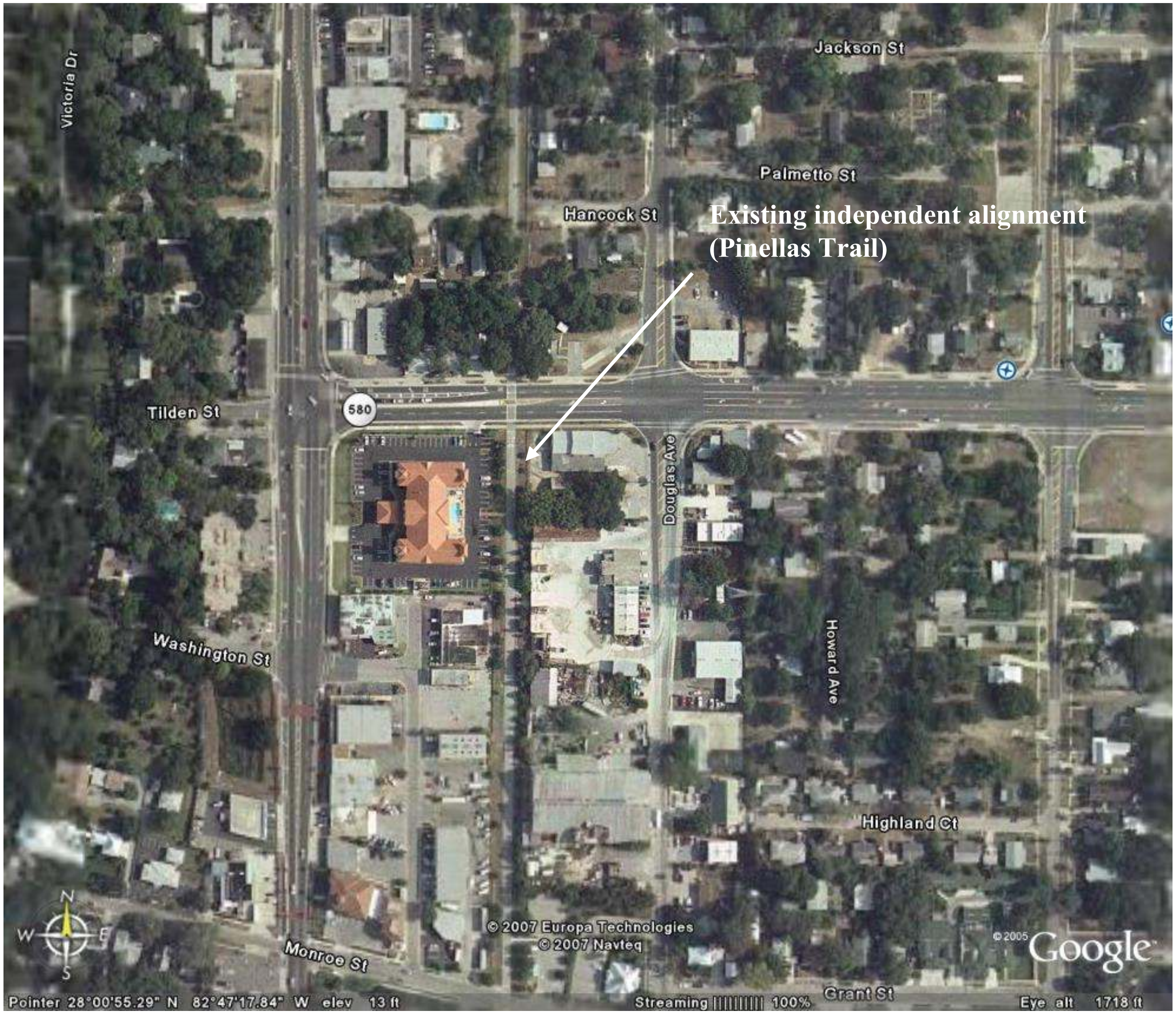
#8 – Nebraska Avenue, Tampa



#9 – SR 60, Brandon



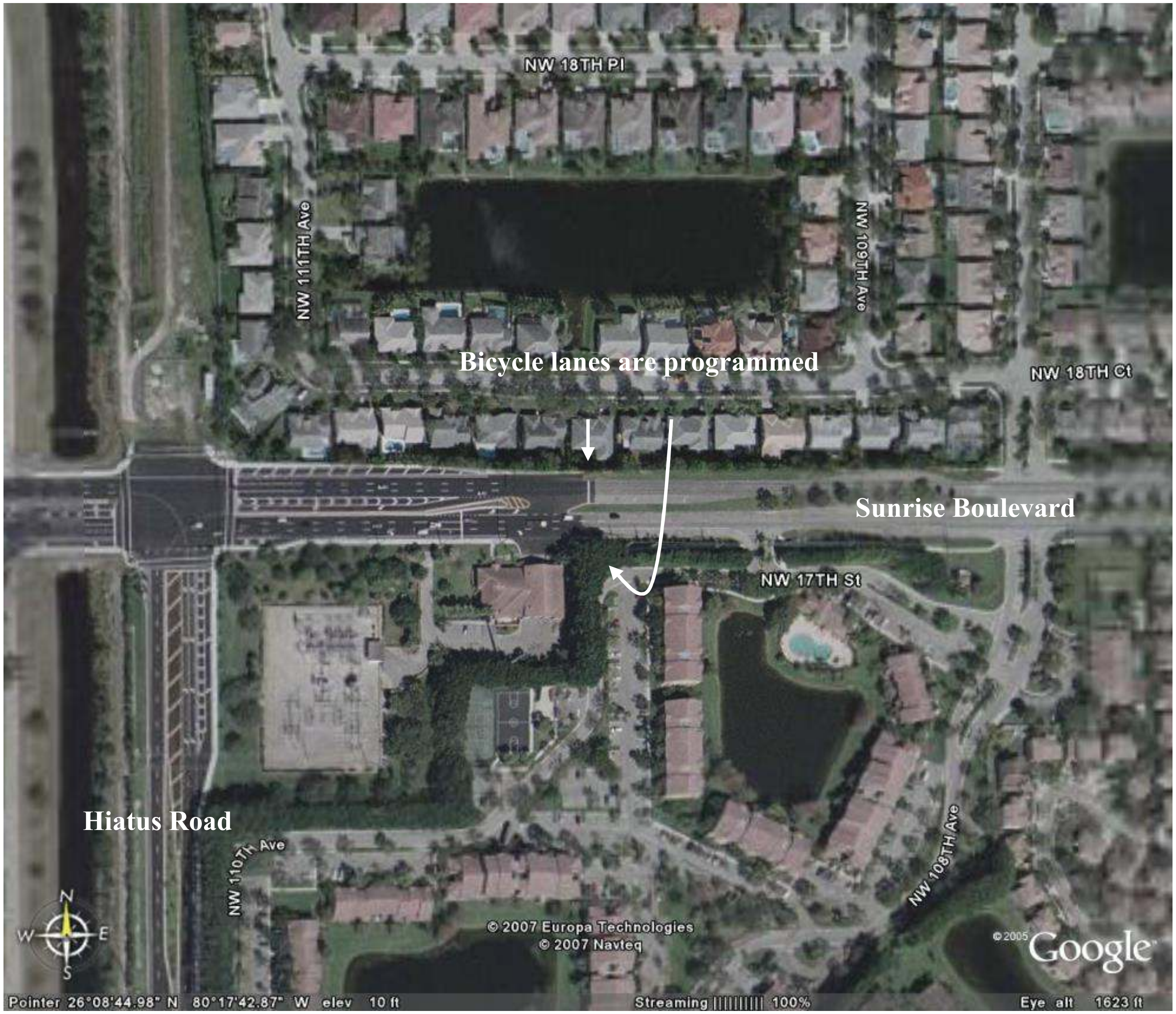
#10 – Pinellas Trail, Dunedin



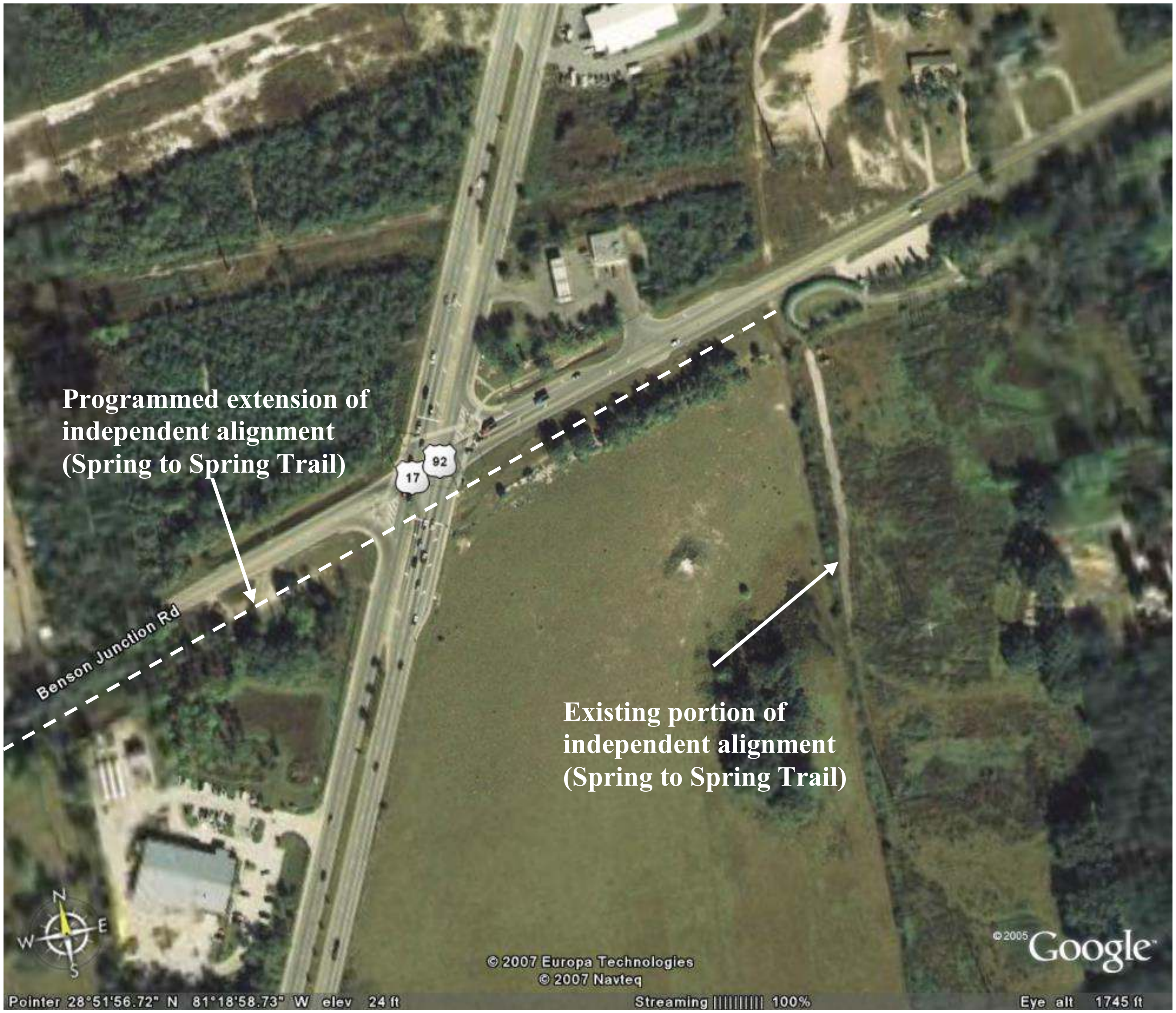
#11 – 20th Street, Tampa

#12 – M Path, Miami

#13 – Sunrise Blvd., Plantation



#14 – Spring to Spring, Orange City



#15 – St. Marks Trail, Tallahassee

#16 – Upper Tampa Bay Trail, Tampa

#17 – West Orange Trail, Apopka

# APPENDIX G Development of the Network Friendliness Measure

## INTRODUCTION

The Florida Department of Transportation, specifically District 7, is developing a corridor-level mode shift model. This model will predict the degree to which the construction of a non-motorized facility along a corridor will induce a shift from the motor vehicle mode to the bicycle mode. It is expected that many variables could play a role in the mode shift. The three major categories of these variables are demographic characteristics of the travelers (*i.e.*, age and income), trip characteristics (*i.e.*, length and purpose), and corridor characteristics. One of the corridor characteristics expected to significantly affect mode shift is the measure of connectivity and/or the travel quality continuity (also known as network friendliness) of the transportation network surrounding the corridor.

The first question to be addressed when determining this network-based measure is what defines a "transportation network" for a particular mode. While the most basic definition of networks refers to the extent and interconnectedness of streets and roadways, such a viewpoint does not capture the function of networks, particularly for bicycling, walking, and transit, because it fails to include how well travelers are *accommodated* on the network's facilities. Regardless of the type of accommodation provided by the different modes (capacity for motor vehicles, safety and comfort for bicycles and pedestrians, and headways for the transit mode), accommodation is always a factor in how well the network serves travelers. For example, a corridor may provide a connection to the surrounding transit network, but if the connected routes have buses running only once a week, not much is gained by that connection. In this sense, one might question whether a network beyond the corridor in question truly exists.

## CONNECTIVITY AND CONTINUITY

In the traditional sense, network connectivity has simply referred to the degree to which streets and roadways connect to each other. A high degree of connectivity has traditionally been characterized by tightly spaced facilities that intersect each other frequently and rarely end in a cul-de-sac. A grid street network is an example of a network with good "connectivity." In contrast, a street network with many cul-de-sacs which all feed into a low number of collectors and arterials has much poorer "connectivity." It is generally believed that networks with good "connectivity" are conducive to bicycle travel because they reduce the distance (and thus the time) required to bike or walk to and from origins and destinations by creating more direct bicycle routes.

Several measures have been developed in recent years that attempt to quantify the somewhat abstract idea of connectivity, generally for the auto mode. In an effort to identify the level of connectivity in the metropolitan area of Portland, Oregon, Dill (*1*) defines and tests several of these measures. Among the most noted of these measures are:

- the Link-Node Ratio, which is measured by dividing the number of links (segments between nodes) in a study area by the number of nodes (intersections plus cul-de-sac termini);
- the Connected Node Ratio, which is a ratio of the number of street intersections to intersections plus the number of cul-de-sacs, thus capturing the number of connected nodes relative to the total number of nodes; and
- Intersection Density, which is simply the number of street intersections per unit of area.

While all of these measures (and other similar ones) provide some method for quantifying connectivity, they fail to take into account the *quality of the accommodation* provided by the network facilities, an aspect particularly important for the bicycle mode. Without an accommodation factor, the true "network" of facilities is not being taken into account. All other characteristics being equal, it is intuitively apparent that an improved corridor surrounded by roads with good bicycle accommodation (level of service) is more likely to induce mode shifts than one surrounded by roads with poor bicycling conditions. In other words, construction of an attractive and safe bicycle facility will not attract many bicyclists if all of the connecting roads are perceived as being hazardous. It is proposed that this potential measure be referred to as "network friendliness." [Note: The subsequent discussion and measure refer specifically to the bicycle mode for illustrative purposes.]

In developing this measure, the question arises of whether to include all roads within the defined analysis zone. While local streets tend to provide better levels of service to bicyclists because of their relatively low motor vehicle volumes, they are frequently less appealing to motorists contemplating a shift to the bicycle mode because they do not offer the fastest or most direct route of travel. Because virtually all travelers, regardless of mode, are sensitive to travel time considerations, this can be an important point. Nonetheless, local streets are viable travel routes and are part of the network that motorists take into account when deciding whether to shift modes. Therefore, part of the difficulty in determining an appropriate measure involves the decision whether to all classes of roadways and, if they are all included, whether some weighting system should exist.

The approach described below offers a method to quantify the network friendliness measure.

**THE MEASUREMENT**

The following formula represents the proposed method for calculating the network friendliness measure:

Network Friendliness Measure =

$$f_A(T)\frac{\sum\left(D_A \frac{1}{LOS_A}\right)}{\sum LOS_A}\frac{\sum D_A}{\sum D_{ACL}} + f_C(T)\frac{\sum\left(D_C \frac{1}{LOS_C}\right)}{\sum LOS_C}\frac{\sum D_C}{\sum D_{ACL}} + f_L(T)\frac{\sum\left(D_L \frac{1}{LOS_L}\right)}{\sum LOS_L}\frac{\sum D_L}{\sum D_{ACL}} \qquad \textbf{Eq. 1}$$

Or

$$\frac{1}{\sum D_{ACL}}\left(f_A(T)\sum\left(D_A \frac{1}{LOS_A}\right) + f_C(T)\sum\left(D_C \frac{1}{LOS_C}\right) + f_L(T)\sum\left(D_L \frac{1}{LOS_L}\right)\right)$$

**Eq. 2**

where:

T = average trip length along the study corridor

D = length of roadway

A = arterial roadways

C = collector roadways

L = local roadways

ACL = sum of the lengths of all arterial, collector, and local roadways

LOS = Bicycle Level of Service

and:

$$f_A(T) = \frac{1.6}{1 + e^{-0.5T+3}} + 0.8 \qquad \textbf{Eq. 3}$$

$$f_C(T) = 1.1 - \frac{0.8}{1 + e^{-0.5T+3}} \qquad \textbf{Eq. 4}$$

$$f_L(T) = 1.2 - \frac{1}{1 + e^{-0.5T+3}} \qquad \textbf{Eq. 5}$$

The score resulting from this equation represents the sum of three components (shown in Eq. 1), each of which represents the role of one of the three functional classifications of roadway (arterial, collector, and local). In turn, each of these components is comprised of three factors 1) the weighting of the functional roadway class as determined by the average trip length of motorists traveling along the corridor, 2) the proportion of the network that the functional class represents, and 3) the level of accommodation (*i.e.,* Bicycle LOS) provided by the network facilities within that particular functional class. When all three functional roadway classes are summed, an accurate representation of the overall network that motorists take into account when contemplating a mode shift away from the automobile emerges.

The first of these factors is important because it determines how much each of the functional roadway classes is weighted in the overall equation. As trip length increases, the likely attractiveness of, or likelihood that motorists will consider, lower-class roadways decreases relative to higher-class roadways. Therefore, in the equation, the exponent of the trip length in the denominator increases as the functional classification shifts from arterial down to local, and local roads receive far less emphasis as trip length increases. Conversely, local roads are given more emphasis as trip length approaches zero and local roads are more likely to be part of the motorist's trip.

While the first factor considers the importance of the classes in relation to *trip length*, the second factor considers the *prevalence* of the classes. Even if trip lengths are long (which would indicate motorists' reliance primarily on arterial roadways), arterials cannot play an important role if they are not prevalent within the network. The proportion of the class to the overall network allows for the inclusion of prevalence in the overall equation.

The third factor reflects the role that the quality of bicycle accommodation on the surrounding network plays. More specifically, it uses the FDOT-adopted *Bicycle Level of Service* measure (*2*) to incorporate, at a fundamental level, the perceived degree of safety and comfort provided to bicyclists. Through the inclusion of this level of service measure for each of the classes, the attractiveness of the facilities plays a role in the determination of the network's level of accommodation.

On a hypothetical network wherein all streets have a bicycle level of service of A (Bicycle LOS=1.0) and the roadway classes have an equal share of the total study network, travel quality continuity is 1, regardless of the average trip length of the motorists within the corridor. This scenario is used as the "base case" by which the network friendliness measure has been normalized (the minimum value for the measure is "0"). The three components in this scenario demonstrate the impact of the roadway classes at different trip lengths, with the impact of local and collector streets decreasing as trip length increases, while the impact of arterials becomes greater before leveling off at a very high average trip length.

This network friendliness measure shows promise as a variable to be included in the mode shift model. It provides quantification of network friendliness such that all facilities are incorporated proportionally to their importance to the potential mode shift and that the accommodation level of the facilities themselves (as opposed to their mere existence) is taken into consideration. It is proposed that the measure be used in the model development stage as a way to incorporate the important effects of network connectivity and continuity on travelers' decisions to shift modes.

## ELLIPSE SHAPE OF THE ANALYSIS ZONE

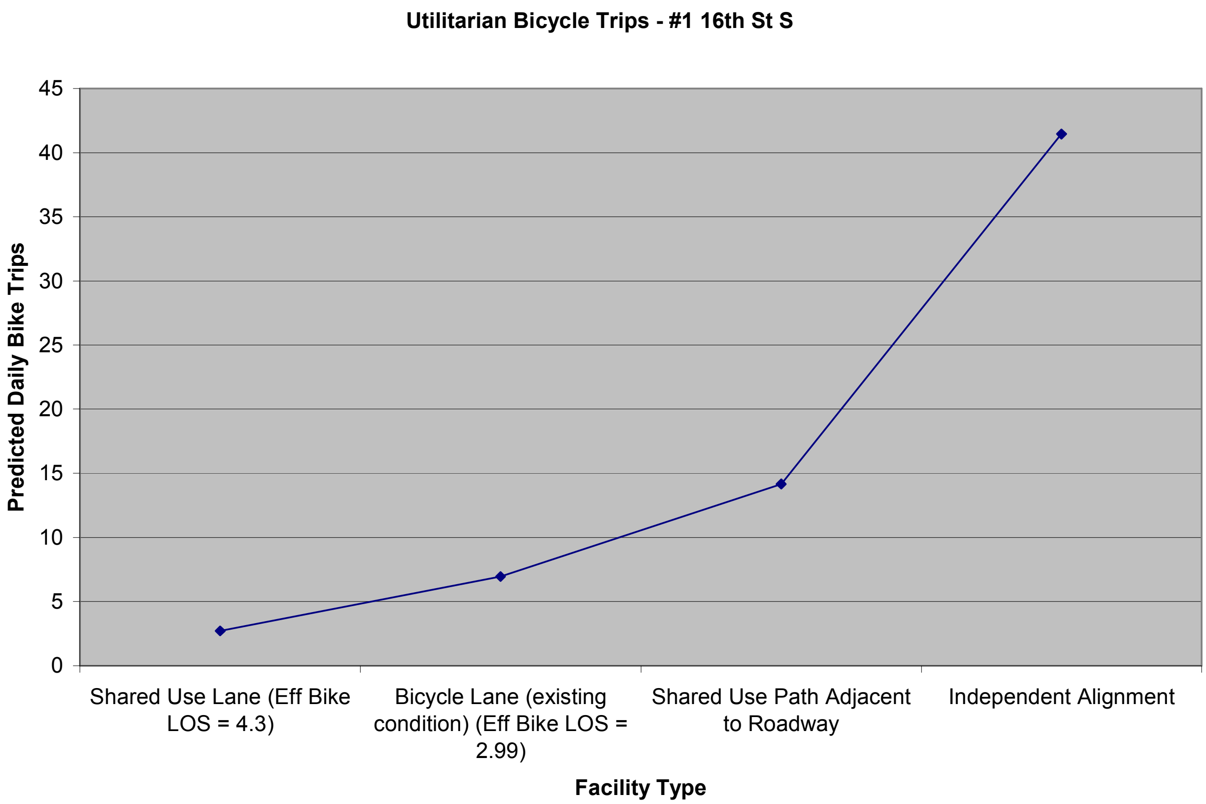
In addition to the formulation described above, the shape of the analysis zone for the improved corridor must be defined in some manner. The trip direction will be defined as the direction of the corridor being improved (or along extensions of the facility being improved) and will therefore be used to define the length of the analysis zone. In addition, there will be some area of influence to either side of the corridor, some width of the study corridor. To represent the area of influence, the researchers defined the analysis zone by an ellipse shape around the improvement section under consideration, with the shape of that ellipse dependent upon the average motorist trip length along the facility. Higher trip lengths would lead to more "stretched" ellipses, while shorter trip lengths would result in more spherical shapes.

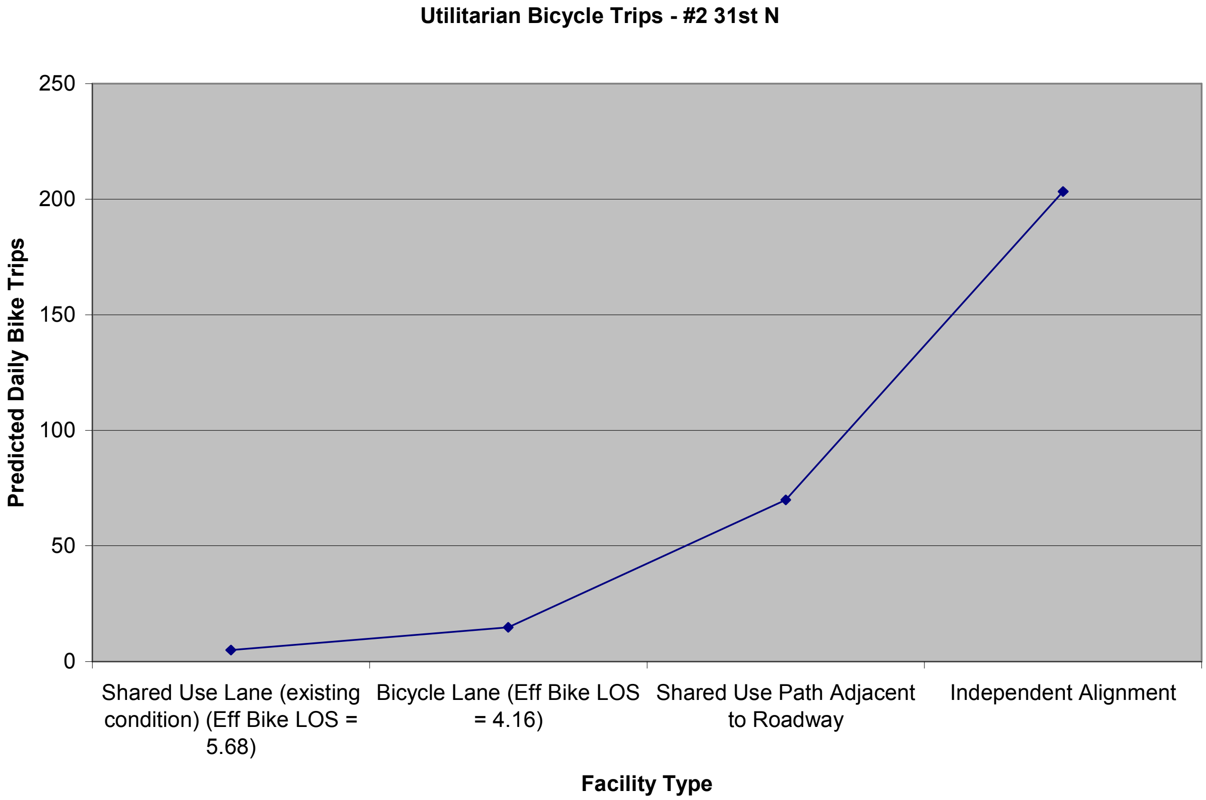
## REFERENCES

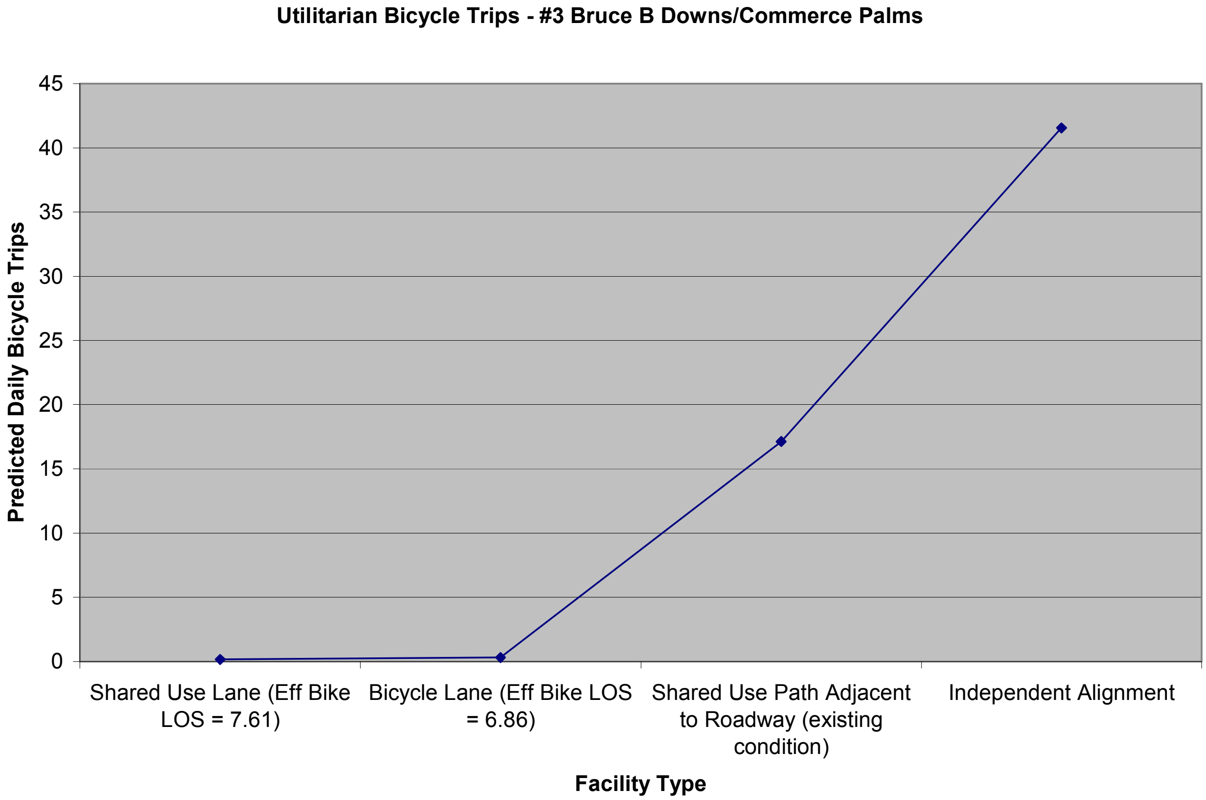
1. Dill, Jennifer. *Measuring Connectivity for Bicycling and Walking* In *TRB 2004 Annual Meeting*. CD_ROM. Transportation Research Board, National Research Council, Washington, D.C., 2004.
2. FDOT, *2002 Quality / Level of Service Handbook*, Florida Department of Transportation, 2002, pp. 17-19.

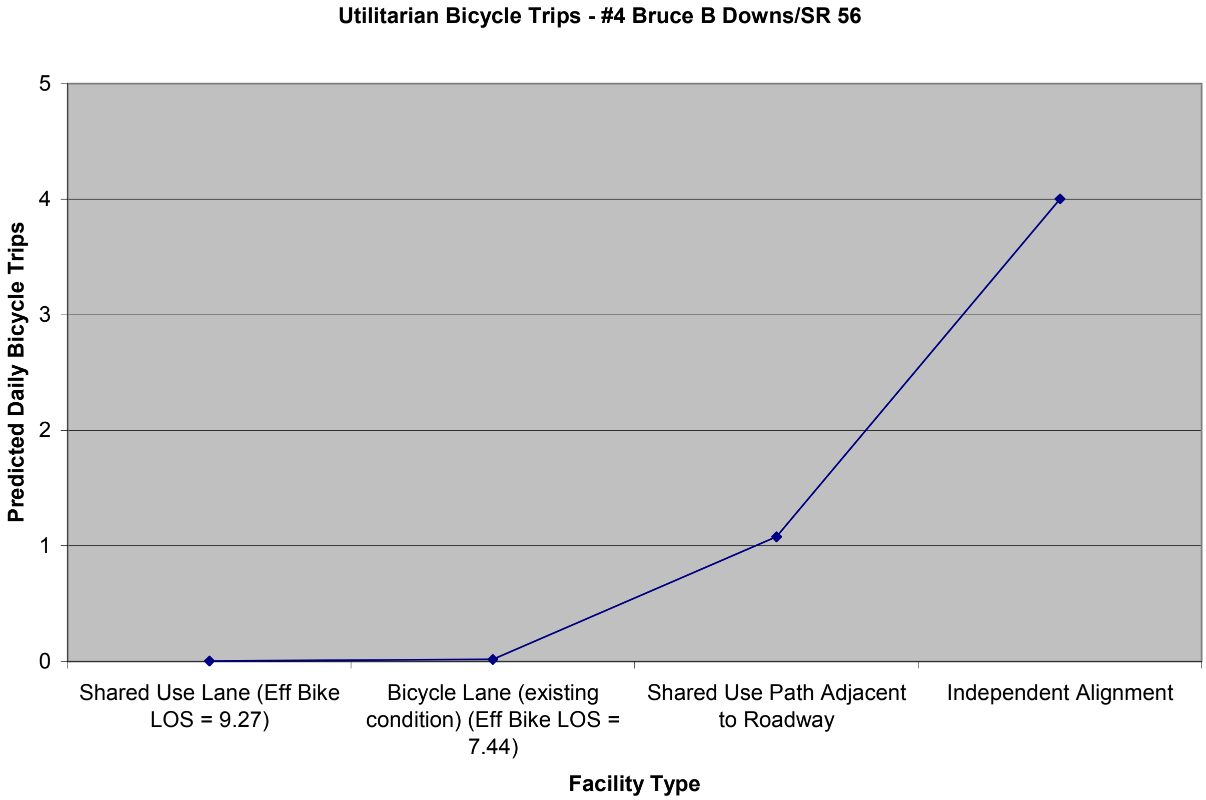
## APPENDIX H Sensitivity Analysis, Mode Shift Model, by Facility Type

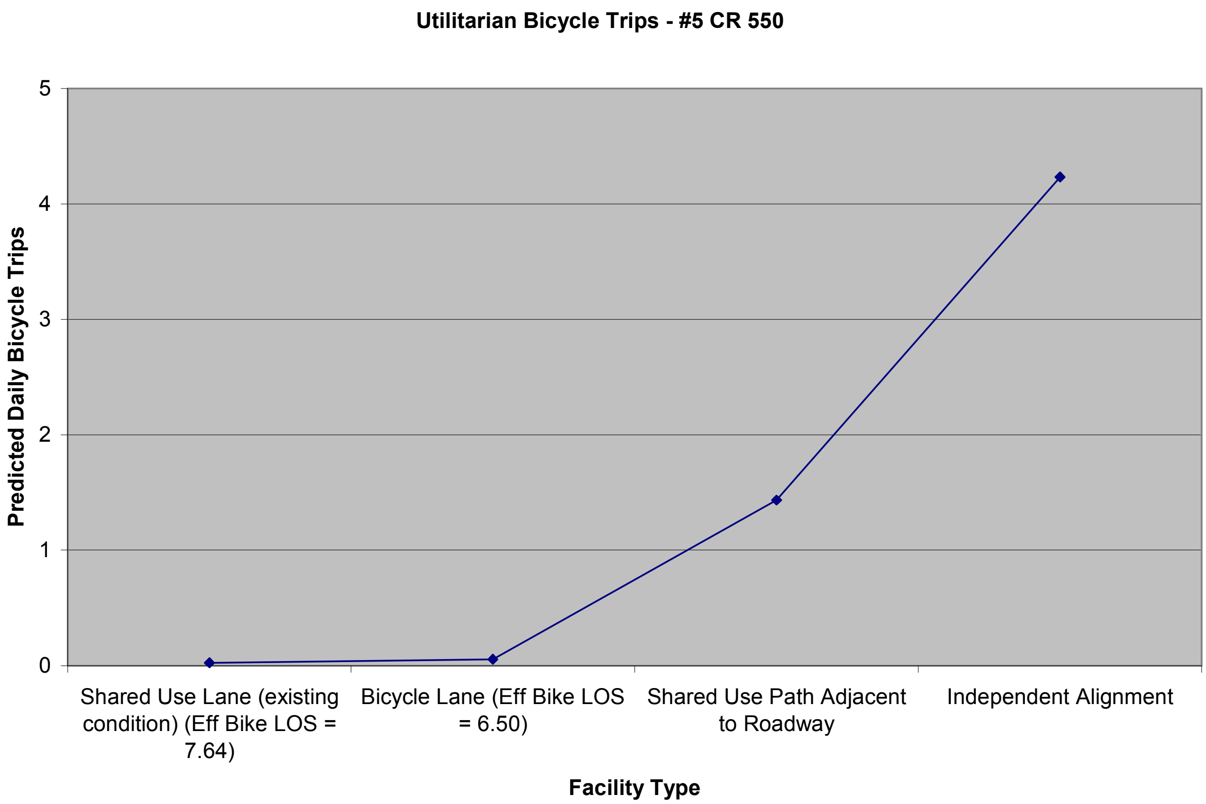
The researchers tested the mode shift model by varying the facility type (and therefore the bicycle LOS, the pedestrian LOS, bicycle connectivity, and pedestrian connectivity), while holding other variables constant. These charts show how the predicted daily number of utilitarian bicycle trips increases as facility type goes from no bike facilities to bike lane, shared use path adjacent to roadway, and independent alignment, resulting in improved bicycle LOS and improved network connectivity. The reader is reminded that these charts depict only utilitarian trips, not recreational trips.

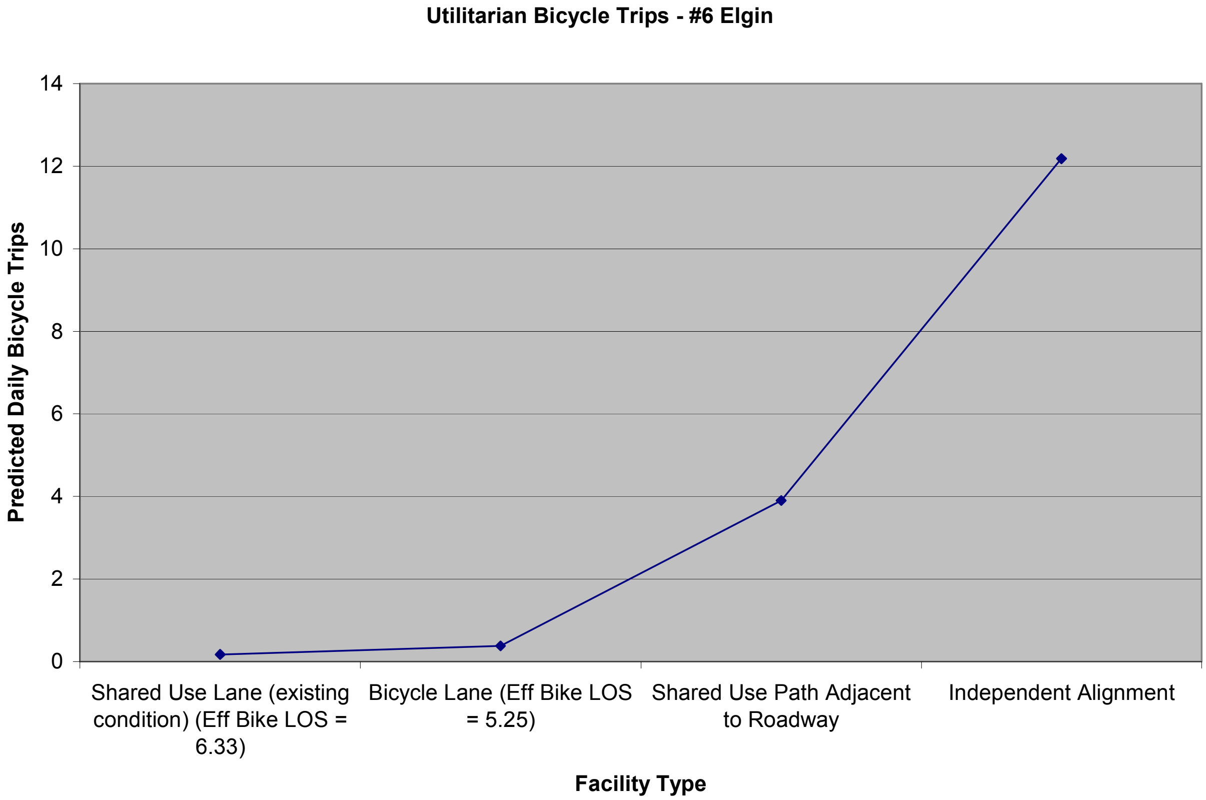

Utilitarian Bicycle Trips - #1 16th St S
Predicted Daily Bike Trips
45
40
35
30
25
20
15
10
5
0
Shared Use Lane (Eff Bike LOS = 4.3)
Bicycle Lane (existing condition) (Eff Bike LOS = 2.99)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type

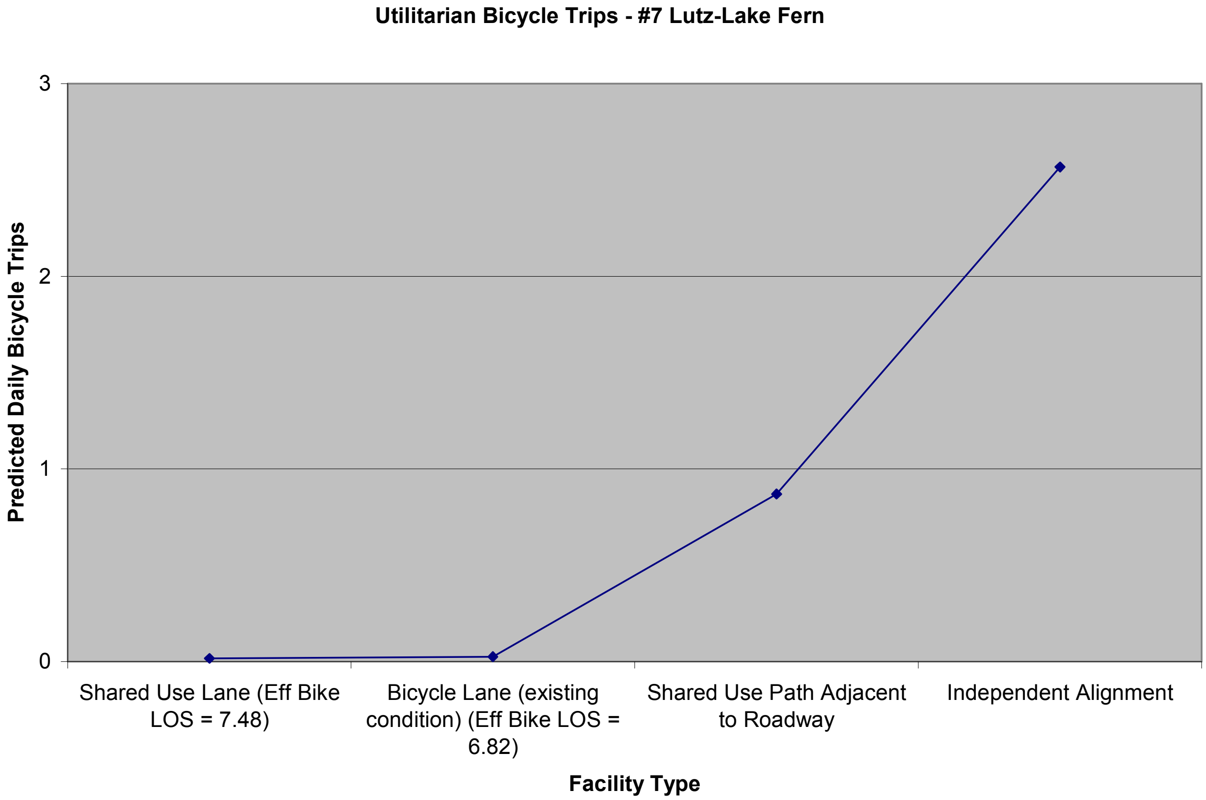

Utilitarian Bicycle Trips - #2 31st N
Predicted Daily Bike Trips
250
200
150
100
50
0
Shared Use Lane (existing condition) (Eff Bike LOS = 5.68)
Bicycle Lane (Eff Bike LOS = 4.16)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type

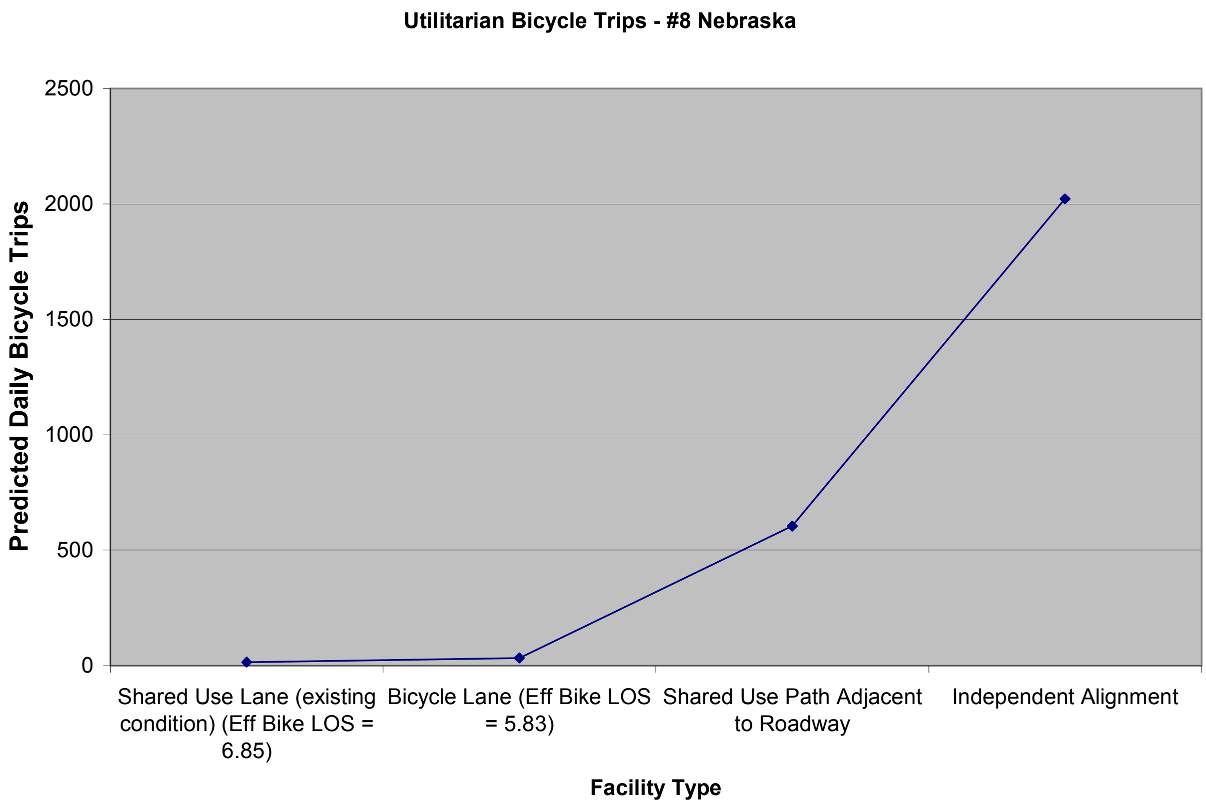

Utilitarian Bicycle Trips - #3 Bruce B Downs/Commerce Palms
Predicted Daily Bicycle Trips
45
40
35
30
25
20
15
10
5
0
Shared Use Lane (Eff Bike LOS = 7.61)
Bicycle Lane (Eff Bike LOS = 6.86)
Shared Use Path Adjacent to Roadway (existing condition)
Independent Alignment
Facility Type

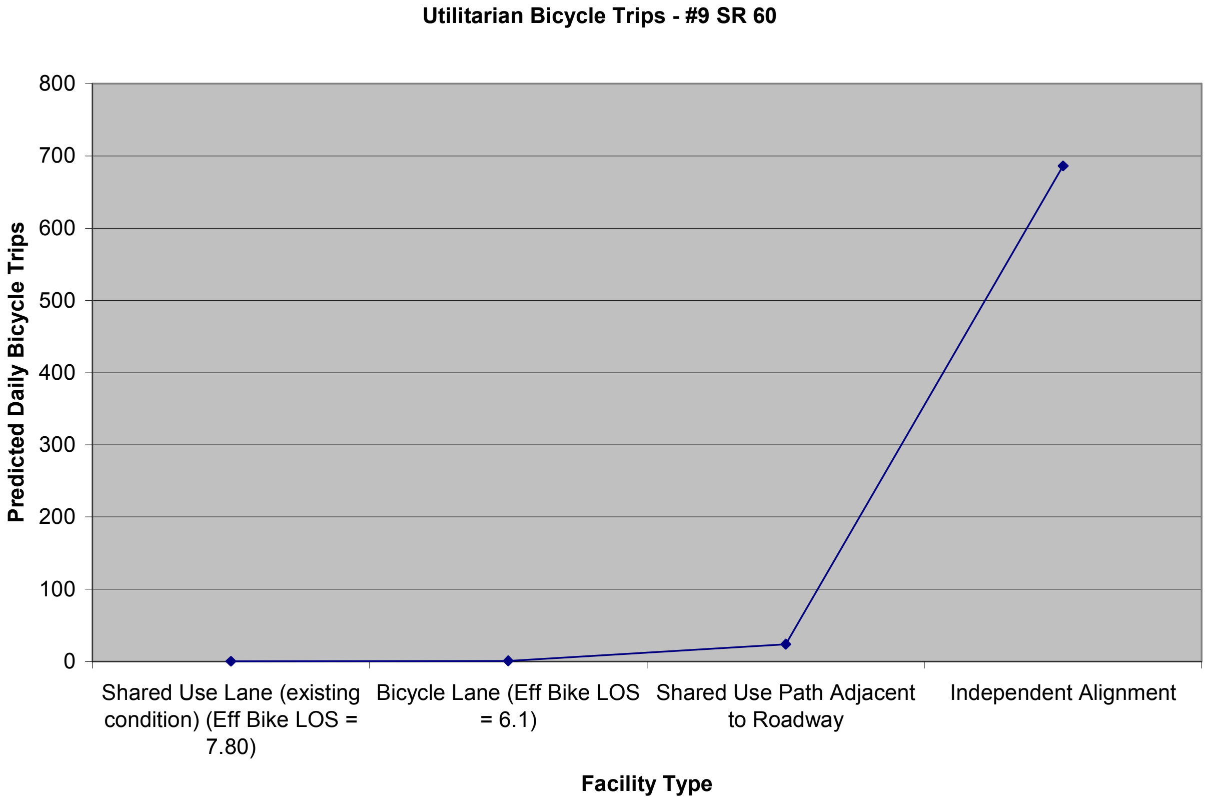

Utilitarian Bicycle Trips - #4 Bruce B Downs/SR 56
Predicted Daily Bicycle Trips
0
1
2
3
4
5
Shared Use Lane (Eff Bike LOS = 9.27)
Bicycle Lane (existing condition) (Eff Bike LOS = 7.44)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type

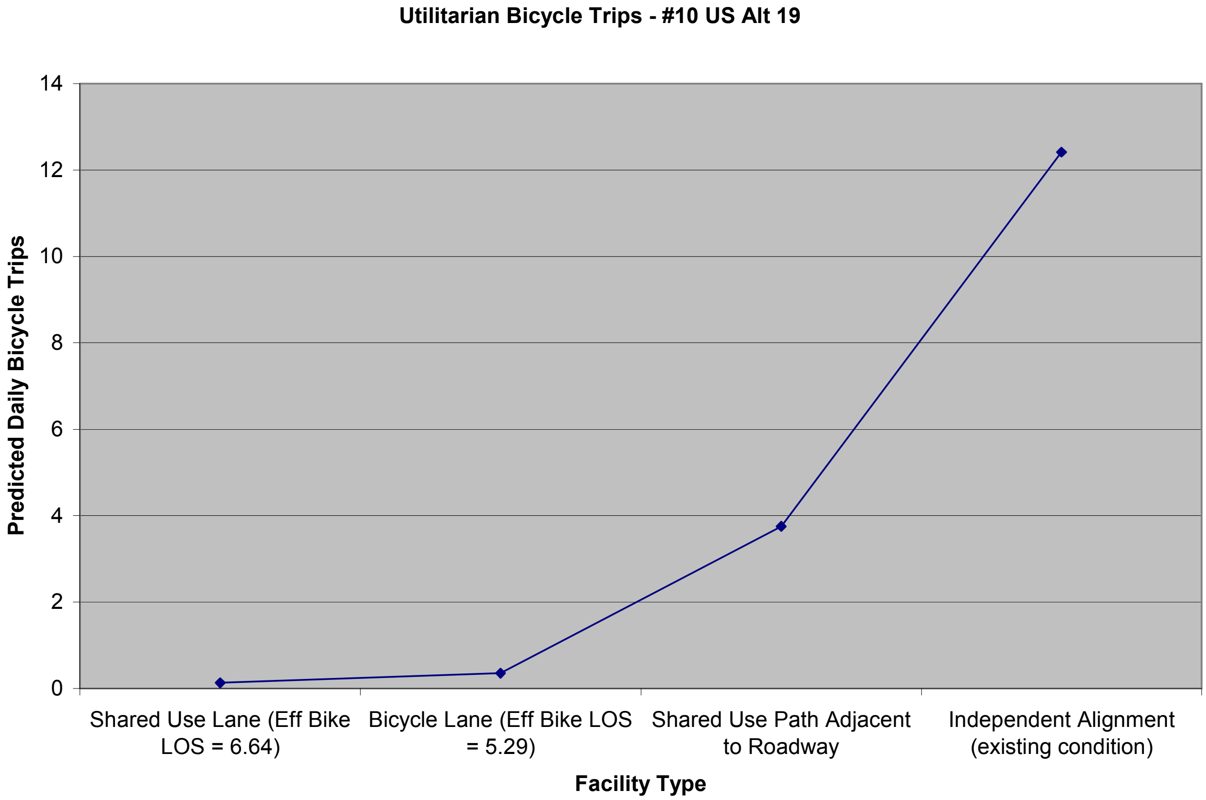

Utilitarian Bicycle Trips - #5 CR 550
Predicted Daily Bicycle Trips
0
1
2
3
4
5
Shared Use Lane (existing condition) (Eff Bike LOS = 7.64)
Bicycle Lane (Eff Bike LOS = 6.50)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type

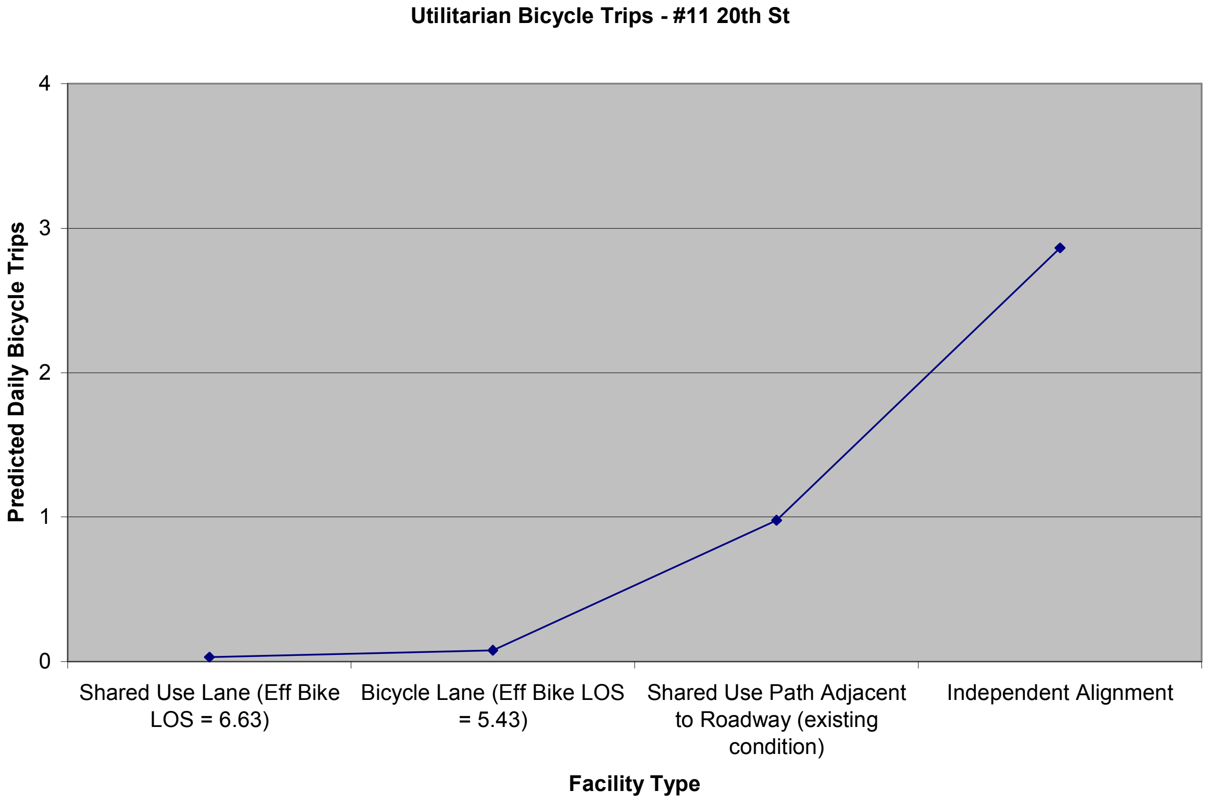

Utilitarian Bicycle Trips - #6 Elgin
Predicted Daily Bicycle Trips
0
2
4
6
8
10
12
14
Shared Use Lane (existing condition) (Eff Bike LOS = 6.33)
Bicycle Lane (Eff Bike LOS = 5.25)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type

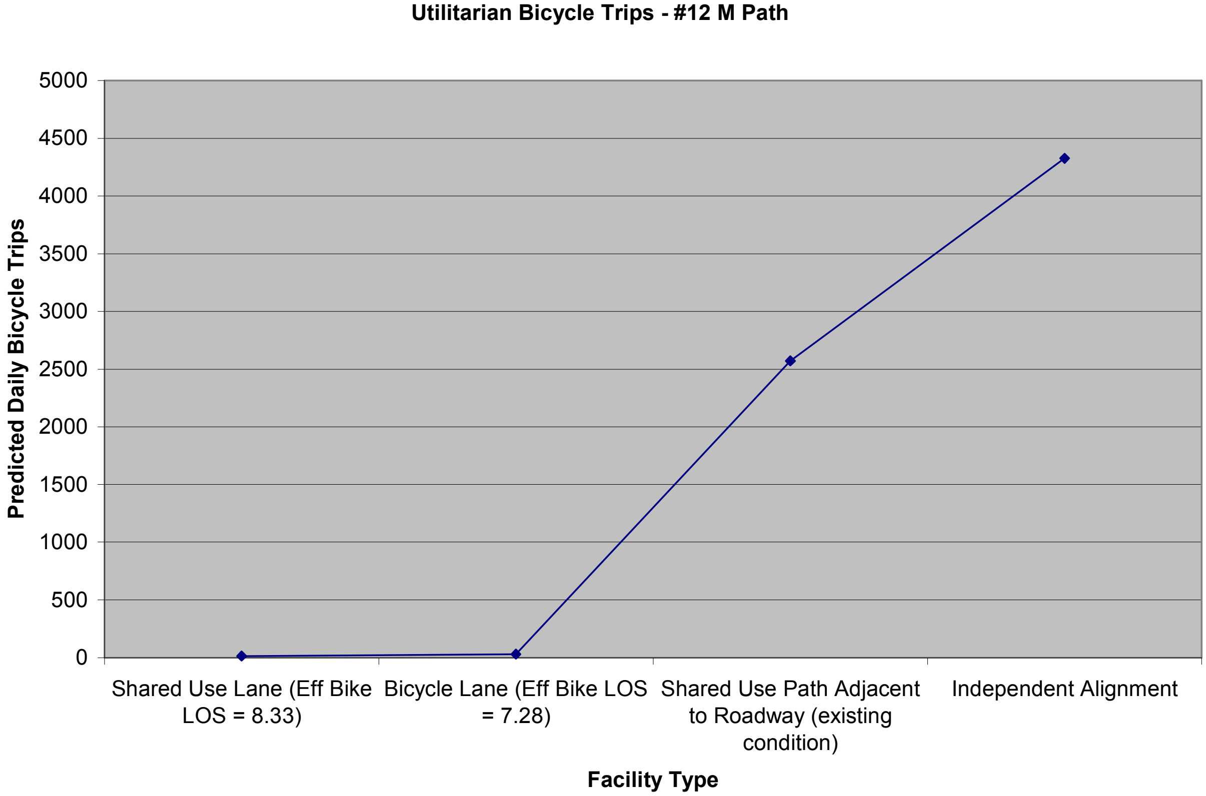

Utilitarian Bicycle Trips - #7 Lutz-Lake Fern
Predicted Daily Bicycle Trips
0
1
2
3
Shared Use Lane (Eff Bike LOS = 7.48)
Bicycle Lane (existing condition) (Eff Bike LOS = 6.82)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type

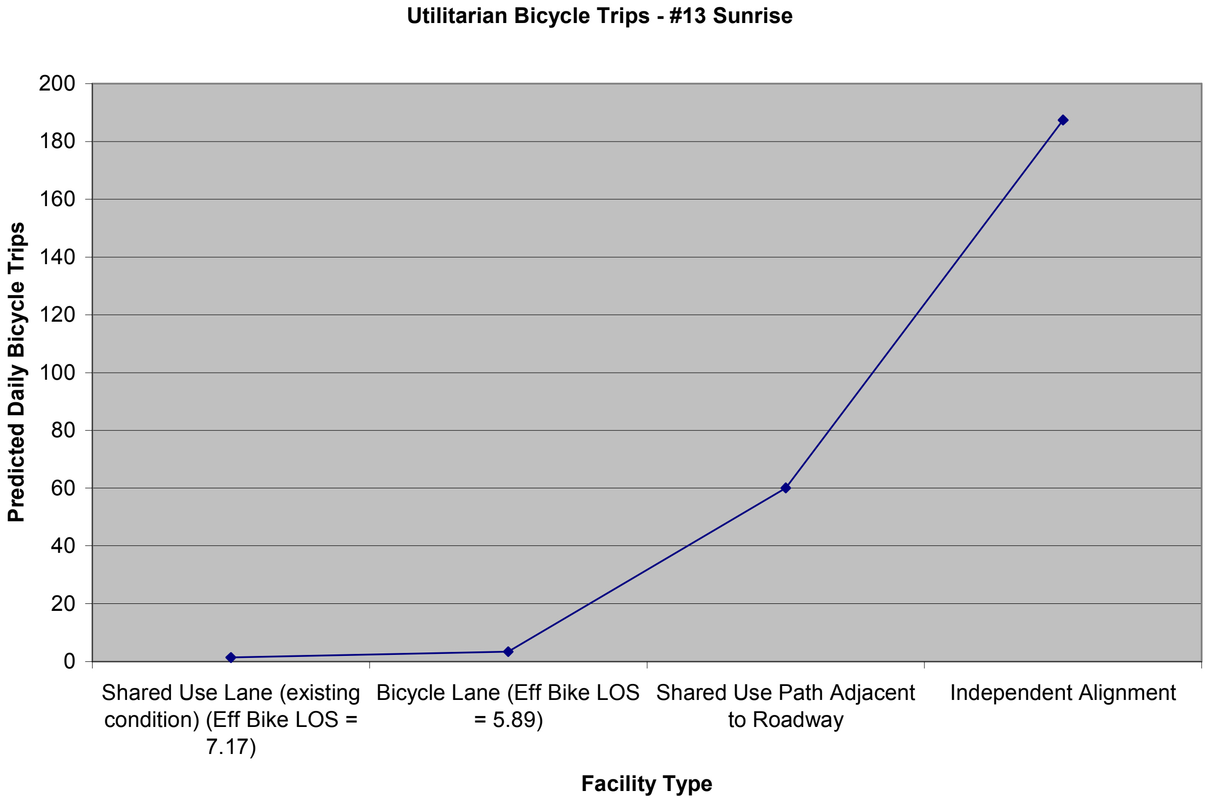

Utilitarian Bicycle Trips - #8 Nebraska
Predicted Daily Bicycle Trips
2500
2000
1500
1000
500
0
Shared Use Lane (existing condition) (Eff Bike LOS = 6.85)
Bicycle Lane (Eff Bike LOS = 5.83)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type

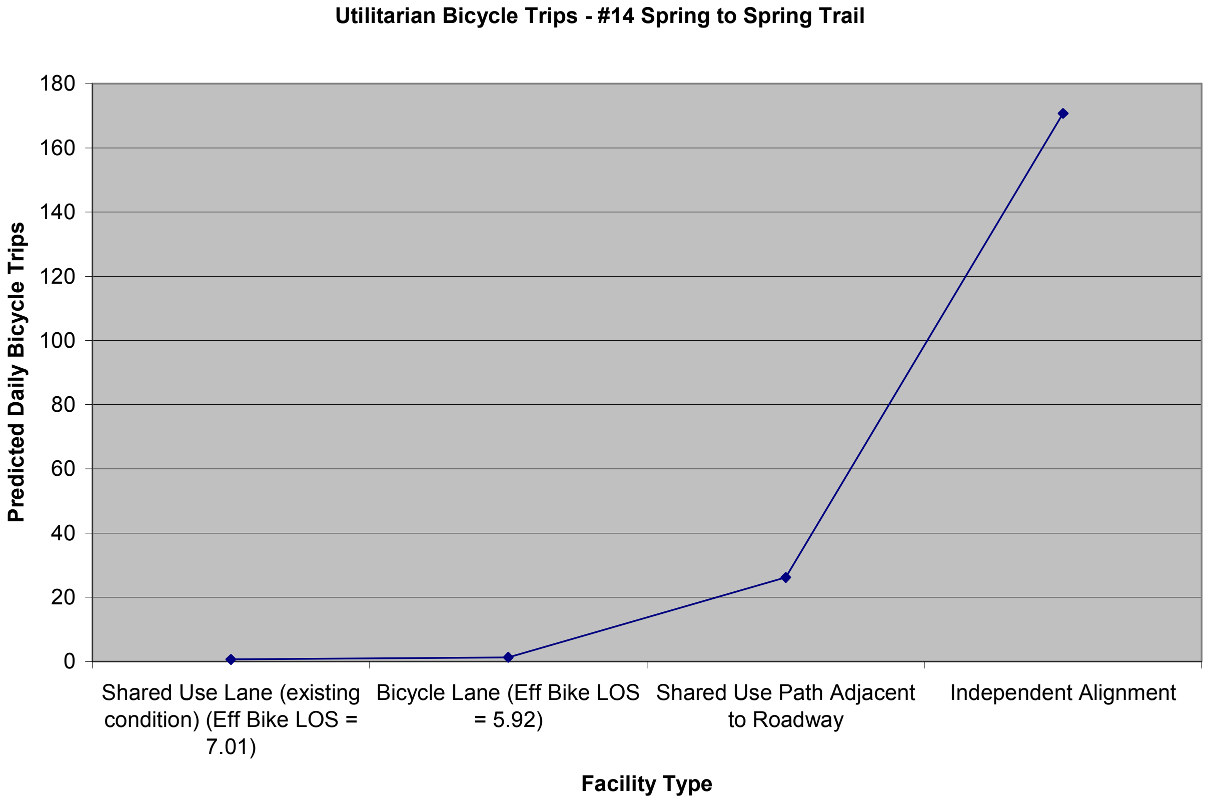

Utilitarian Bicycle Trips - #9 SR 60
Predicted Daily Bicycle Trips
0
100
200
300
400
500
600
700
800
Shared Use Lane (existing condition) (Eff Bike LOS = 7.80)
Bicycle Lane (Eff Bike LOS = 6.1)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type

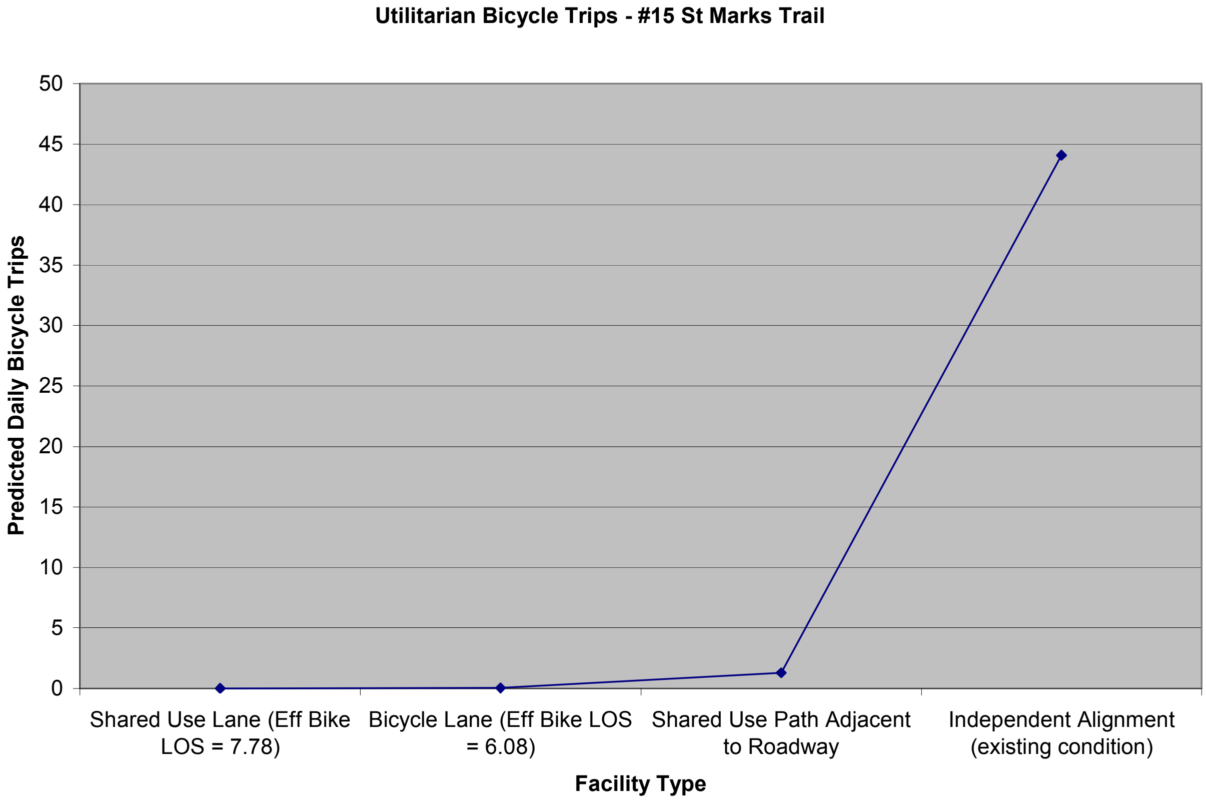

Utilitarian Bicycle Trips - #10 US Alt 19
Predicted Daily Bicycle Trips
0
2
4
6
8
10
12
14
Shared Use Lane (Eff Bike LOS = 6.64)
Bicycle Lane (Eff Bike LOS = 5.29)
Shared Use Path Adjacent to Roadway
Independent Alignment (existing condition)
Facility Type

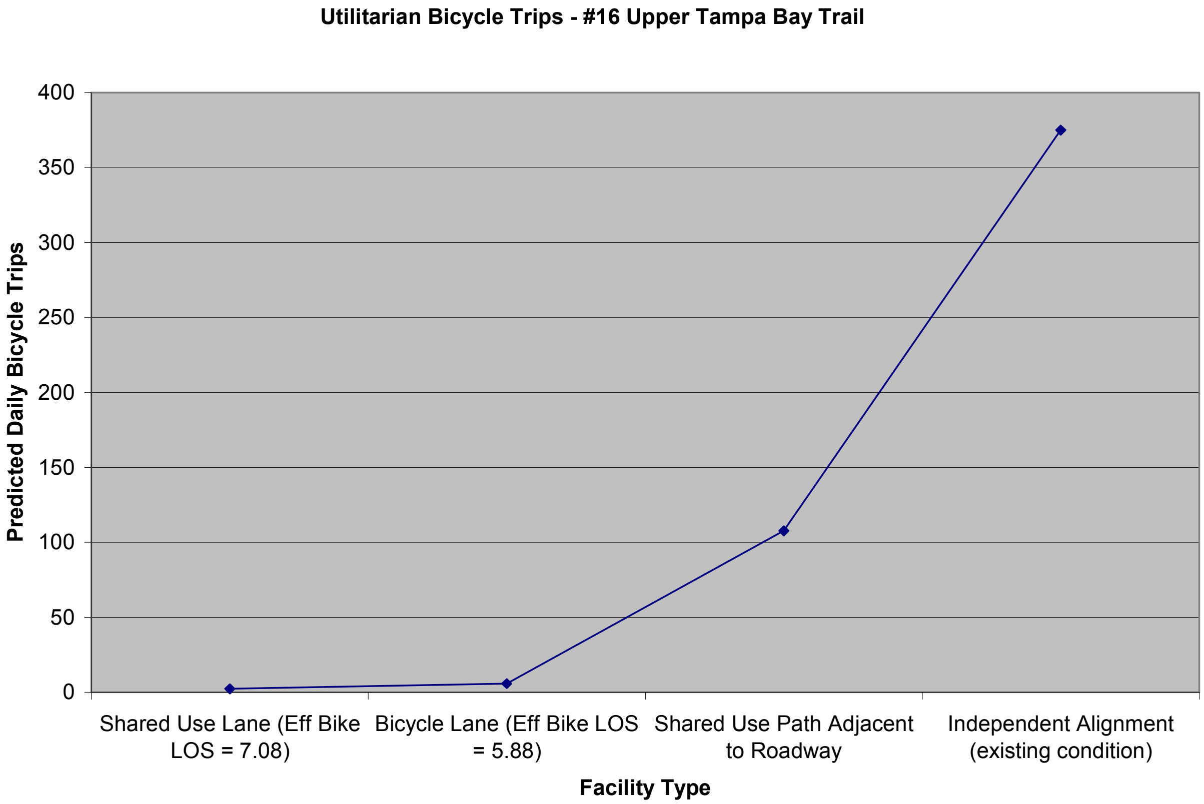

Utilitarian Bicycle Trips - #11 20th St
Predicted Daily Bicycle Trips
0
1
2
3
4
Shared Use Lane (Eff Bike LOS = 6.63)
Bicycle Lane (Eff Bike LOS = 5.43)
Shared Use Path Adjacent to Roadway (existing condition)
Independent Alignment
Facility Type

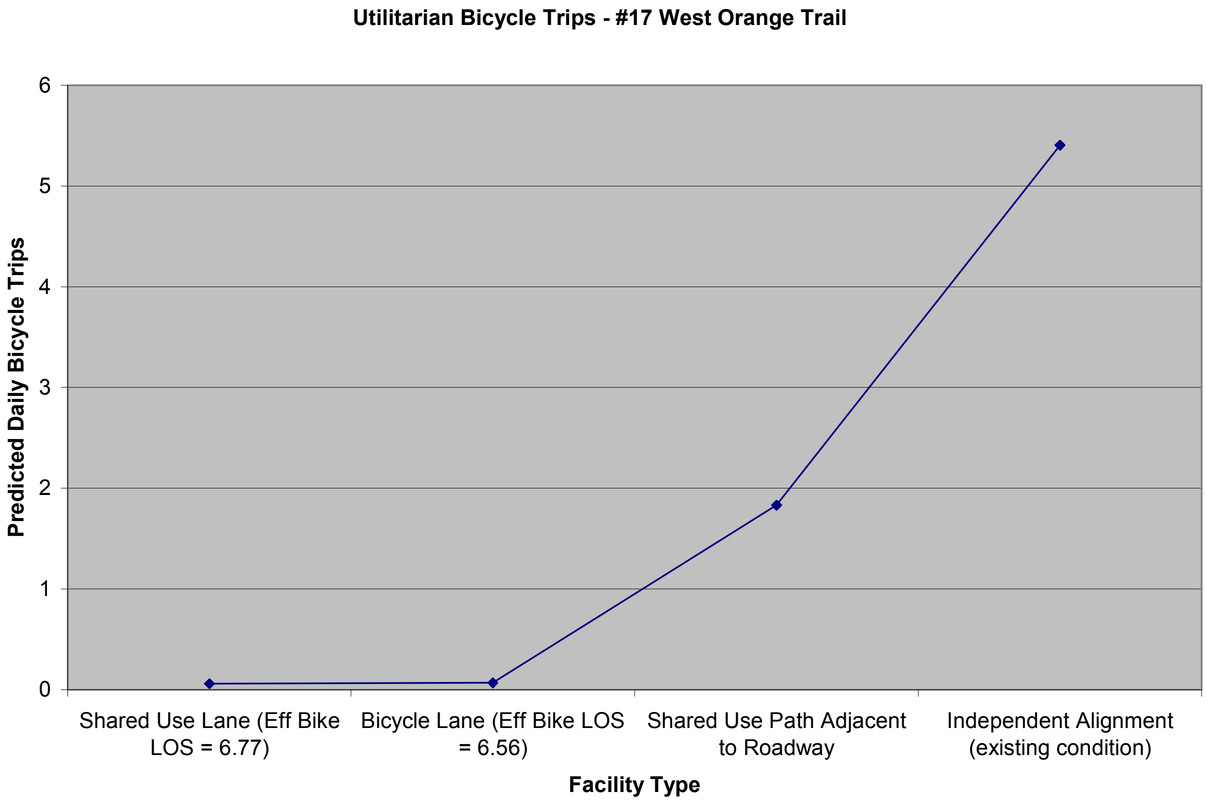

Utilitarian Bicycle Trips - #12 M Path
Predicted Daily Bicycle Trips
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Shared Use Lane (Eff Bike LOS = 8.33)
Bicycle Lane (Eff Bike LOS = 7.28)
Shared Use Path Adjacent to Roadway (existing condition)
Independent Alignment
Facility Type


Utilitarian Bicycle Trips - #13 Sunrise
Predicted Daily Bicycle Trips
200
180
160
140
120
100
80
60
40
20
0
Shared Use Lane (existing condition) (Eff Bike LOS = 7.17)
Bicycle Lane (Eff Bike LOS = 5.89)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type


Utilitarian Bicycle Trips - #14 Spring to Spring Trail
Predicted Daily Bicycle Trips
180
160
140
120
100
80
60
40
20
0
Shared Use Lane (existing condition) (Eff Bike LOS = 7.01)
Bicycle Lane (Eff Bike LOS = 5.92)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type

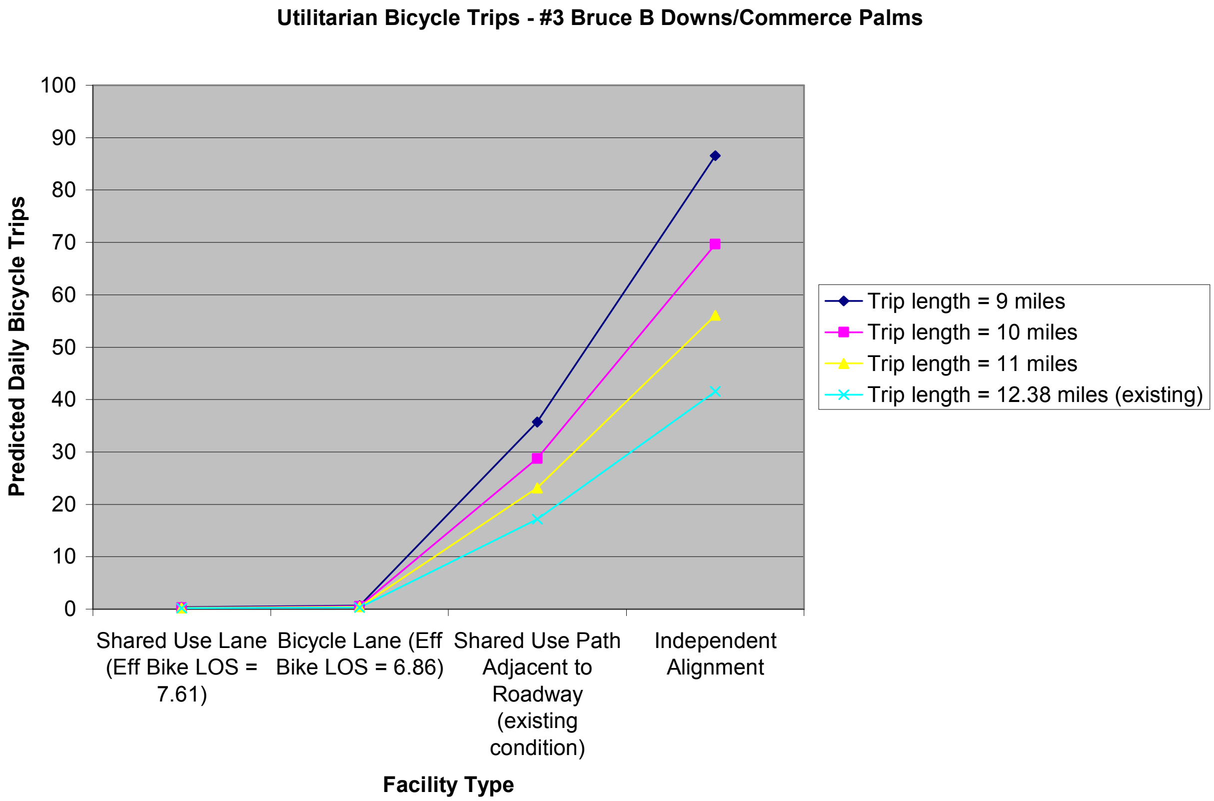

Utilitarian Bicycle Trips - #15 St Marks Trail
Predicted Daily Bicycle Trips
0
5
10
15
20
25
30
35
40
45
50
Shared Use Lane (Eff Bike LOS = 7.78)
Bicycle Lane (Eff Bike LOS = 6.08)
Shared Use Path Adjacent to Roadway
Independent Alignment (existing condition)
Facility Type

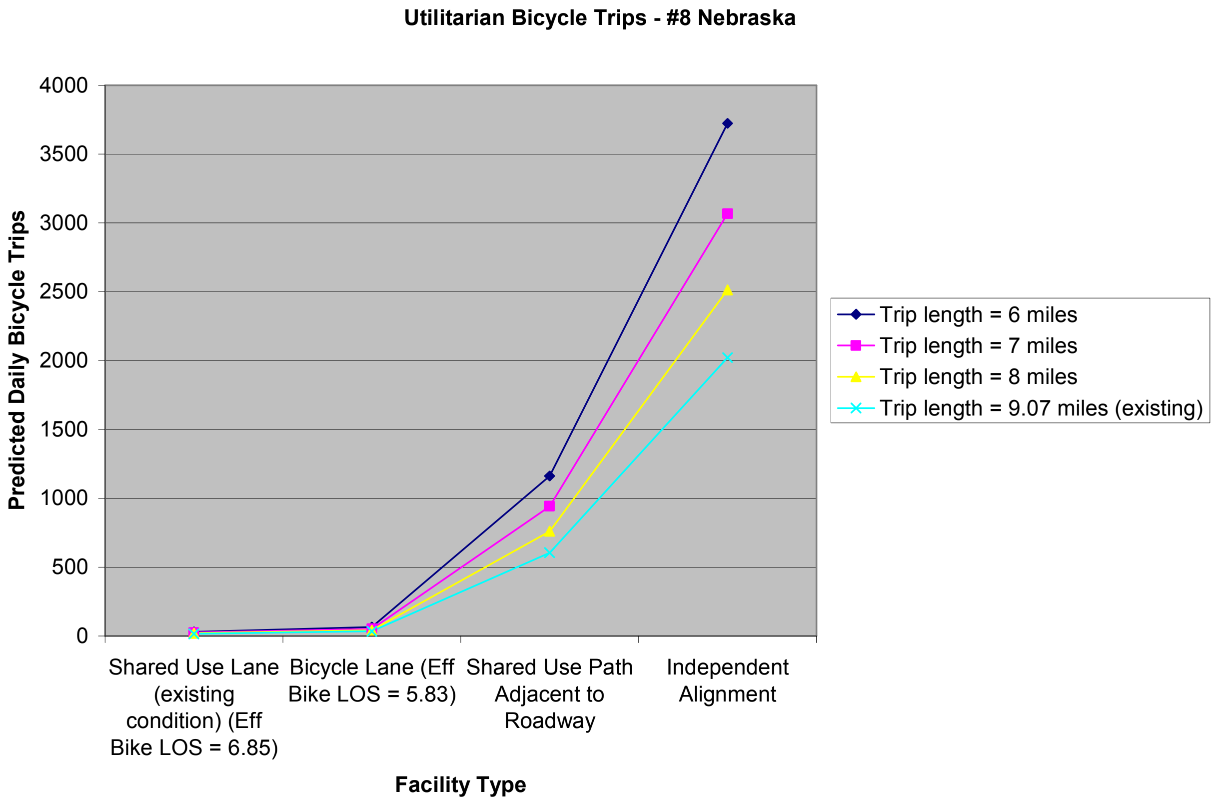

Utilitarian Bicycle Trips - #16 Upper Tampa Bay Trail
Predicted Daily Bicycle Trips
400
350
300
250
200
150
100
50
0
Shared Use Lane (Eff Bike LOS = 7.08)
Bicycle Lane (Eff Bike LOS = 5.88)
Shared Use Path Adjacent to Roadway
Independent Alignment (existing condition)
Facility Type

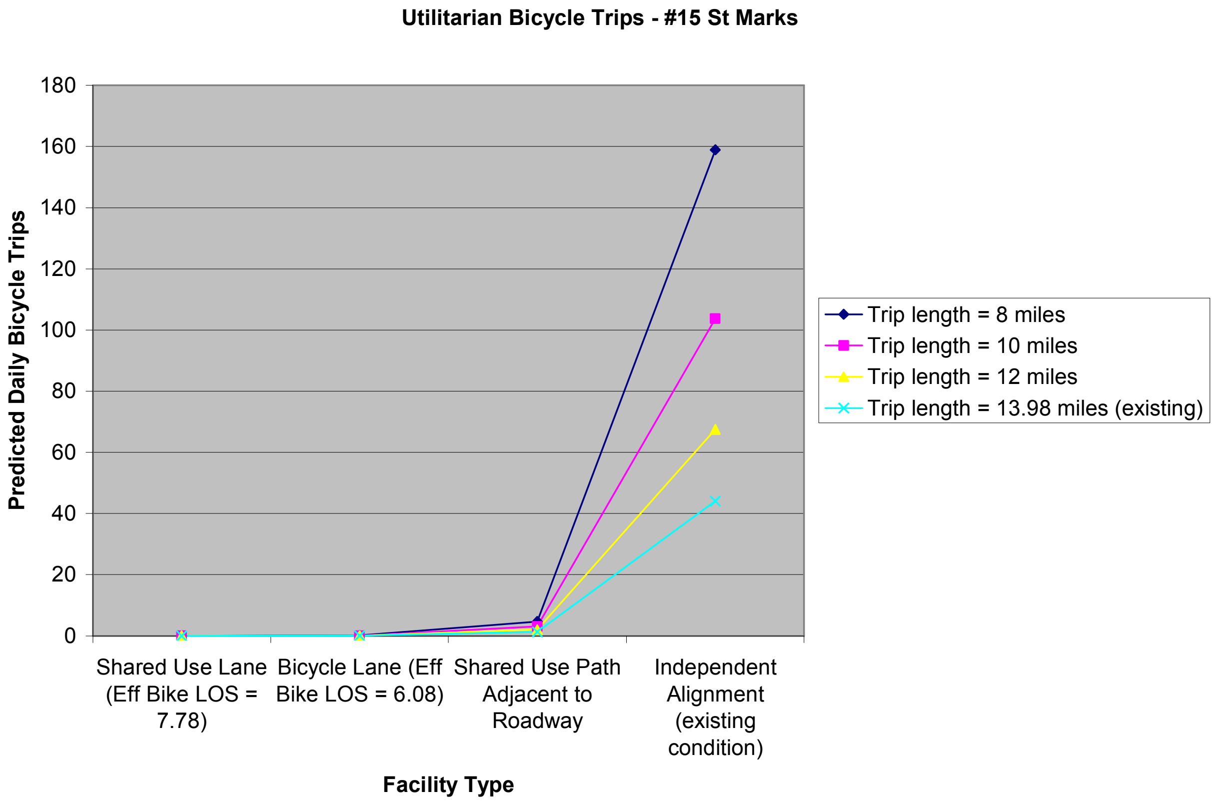

Utilitarian Bicycle Trips - #17 West Orange Trail
Predicted Daily Bicycle Trips
0
1
2
3
4
5
6
Shared Use Lane (Eff Bike LOS = 6.77)
Bicycle Lane (Eff Bike LOS = 6.56)
Shared Use Path Adjacent to Roadway
Independent Alignment (existing condition)
Facility Type

## APPENDIX I Sensitivity Analysis, Mode Shift Model, by Trip Length

The charts in this Appendix illustrate how the predicted numbers of trips on selected corridors vary according to the trip length. For example, the first chart shows the predicted values for Corridor #3, Bruce B. Downs/Commerce Palms. The bottom line shows the predicted number of trips according to facility type (which represents improvements in bicycle LOS and increasing network friendliness values) with the existing average corridor trip length of 12.38 miles. The second line assumes a shorter trip length of 11.00 miles (which may result from more dense development). The third line assumes a trip length of 10.00 miles, and the top line assumes a trip length of 9.00 miles.

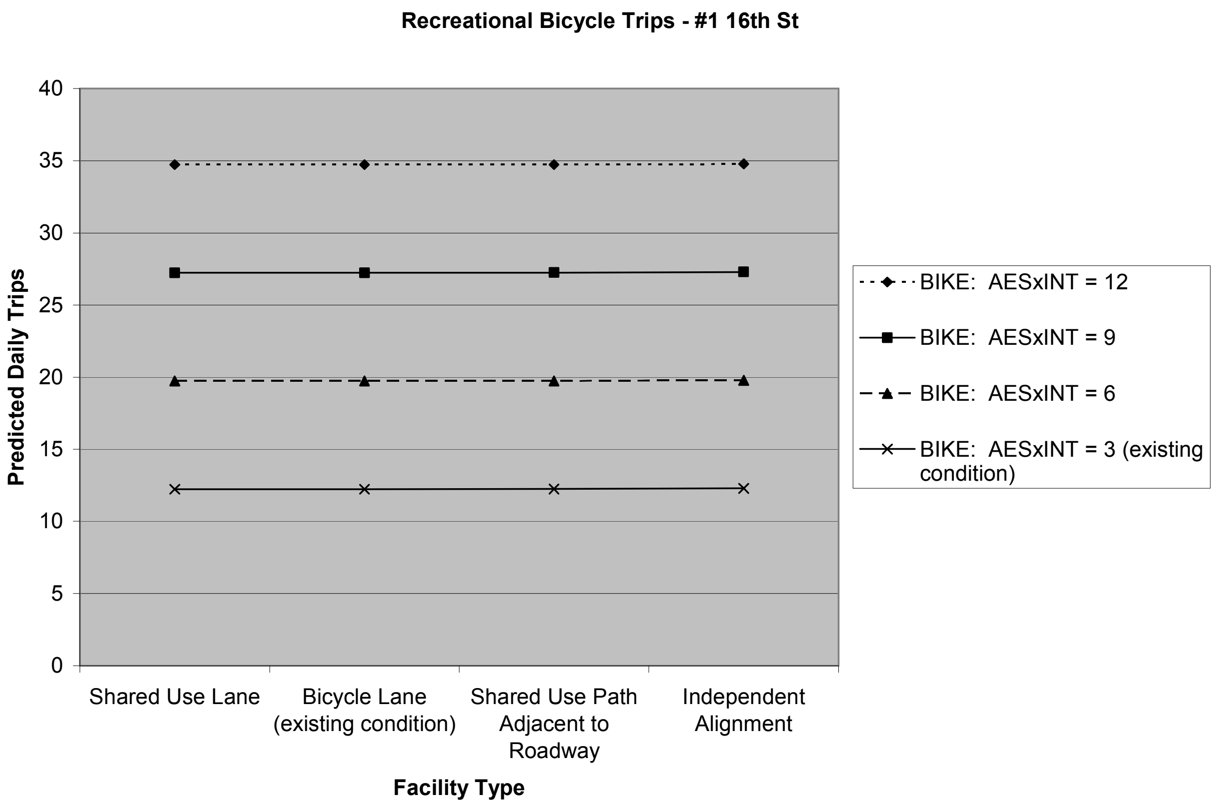

Utilitarian Bicycle Trips - #3 Bruce B Downs/Commerce Palms
Predicted Daily Bicycle Trips
100
90
80
70
60
50
40
30
20
10
0
Shared Use Lane (Eff Bike LOS = 7.61)
Bicycle Lane (Eff Bike LOS = 6.86)
Shared Use Path Adjacent to Roadway (existing condition)
Independent Alignment
Facility Type
Trip length = 9 miles
Trip length = 10 miles
Trip length = 11 miles
Trip length = 12.38 miles (existing)

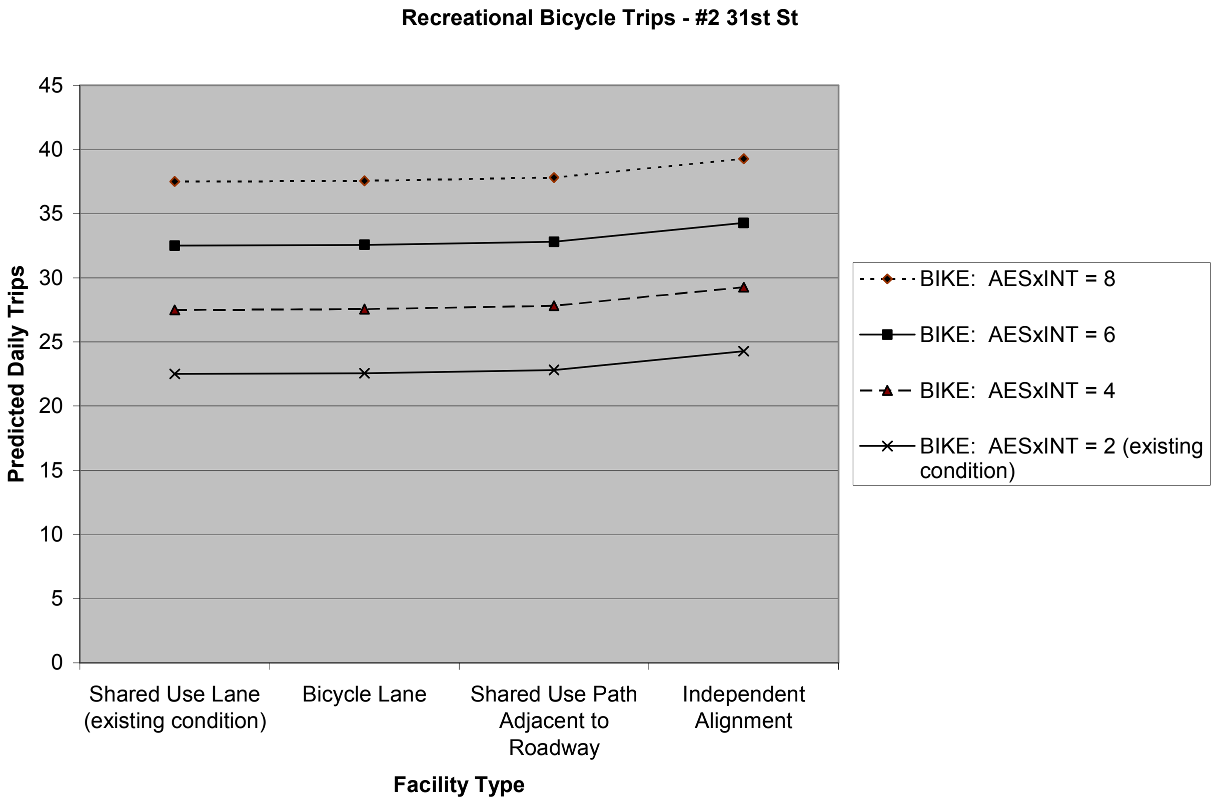

Utilitarian Bicycle Trips - #8 Nebraska
Predicted Daily Bicycle Trips
4000
3500
3000
2500
2000
1500
1000
500
0
Shared Use Lane (existing condition) (Eff Bike LOS = 6.85)
Bicycle Lane (Eff Bike LOS = 5.83)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
Trip length = 6 miles
Trip length = 7 miles
Trip length = 8 miles
Trip length = 9.07 miles (existing)

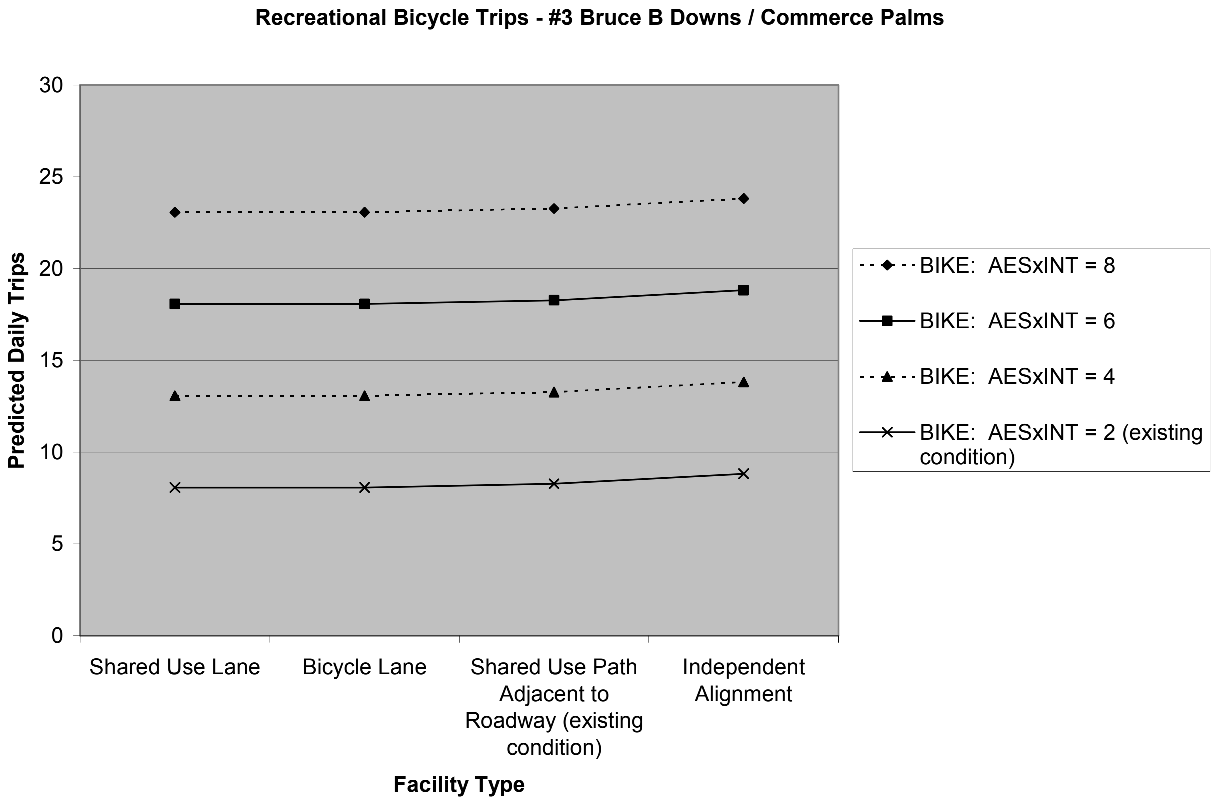

Utilitarian Bicycle Trips - #15 St Marks
Predicted Daily Bicycle Trips
180
160
140
120
100
80
60
40
20
0
Shared Use Lane (Eff Bike LOS = 7.78)
Bicycle Lane (Eff Bike LOS = 6.08)
Shared Use Path Adjacent to Roadway
Independent Alignment (existing condition)
Facility Type
Trip length = 8 miles
Trip length = 10 miles
Trip length = 12 miles
Trip length = 13.98 miles (existing)

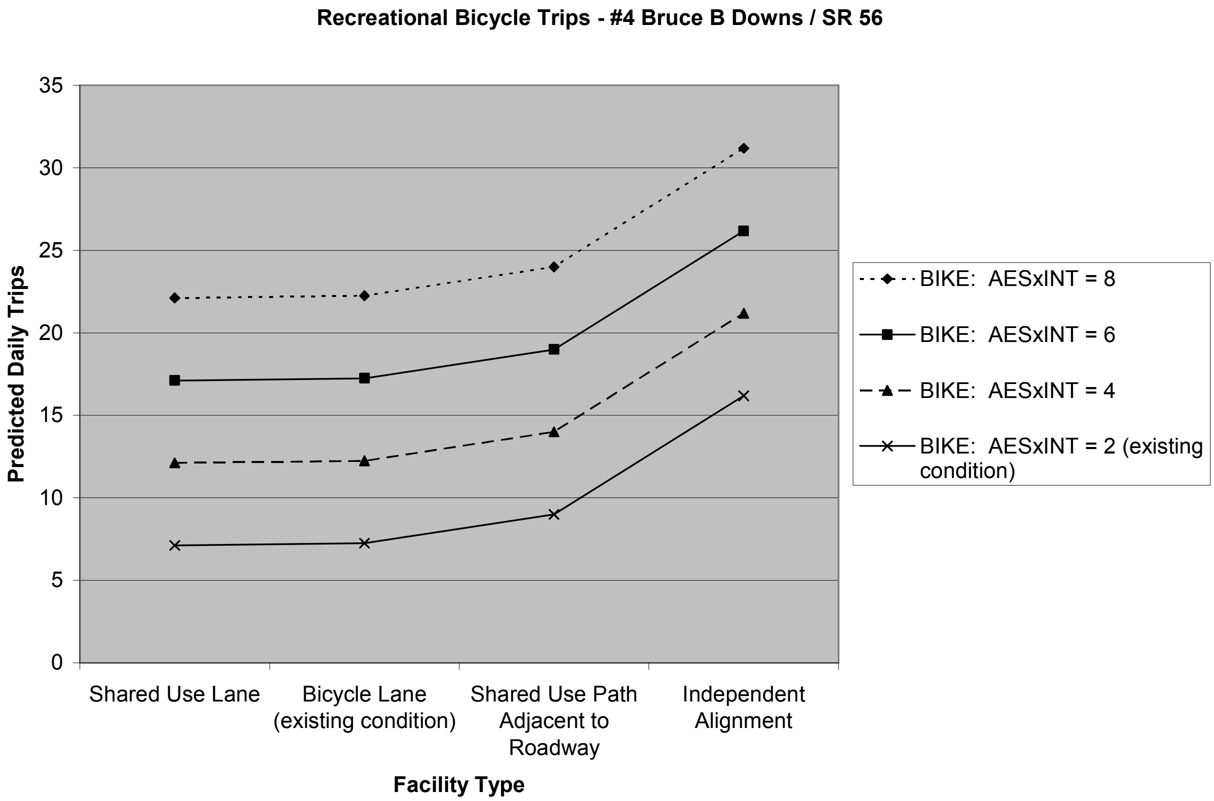
# APPENDIX J Sensitivity Analysis, Induced Recreational Model: Varying Aesthetics, Points of Interest, and Facility Type

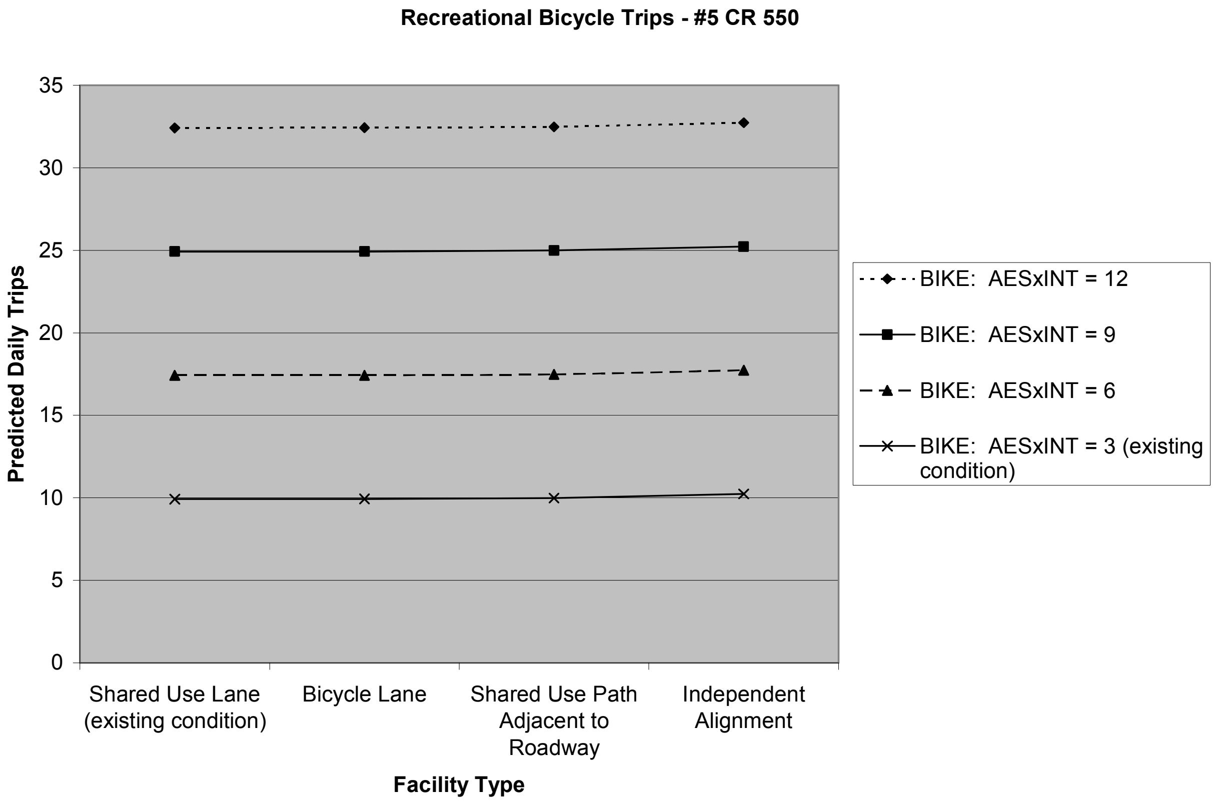
The researchers tested the induced recreational model by varying aesthetics and points of interest (AESxINT) and facility type, while holding population proximity and facility length constant. These charts show how the predicted daily number of recreational bicycle trips increases as aesthetics and points of interest (represented by AESxINT) increase. The predicted number of trips also increases as facility type goes from no bike facilities to bike lane, shared use path adjacent to roadway, and independent alignment, resulting in improved bicycle LOS. The reader is reminded that these charts depict only recreational trips, not utilitarian trips.

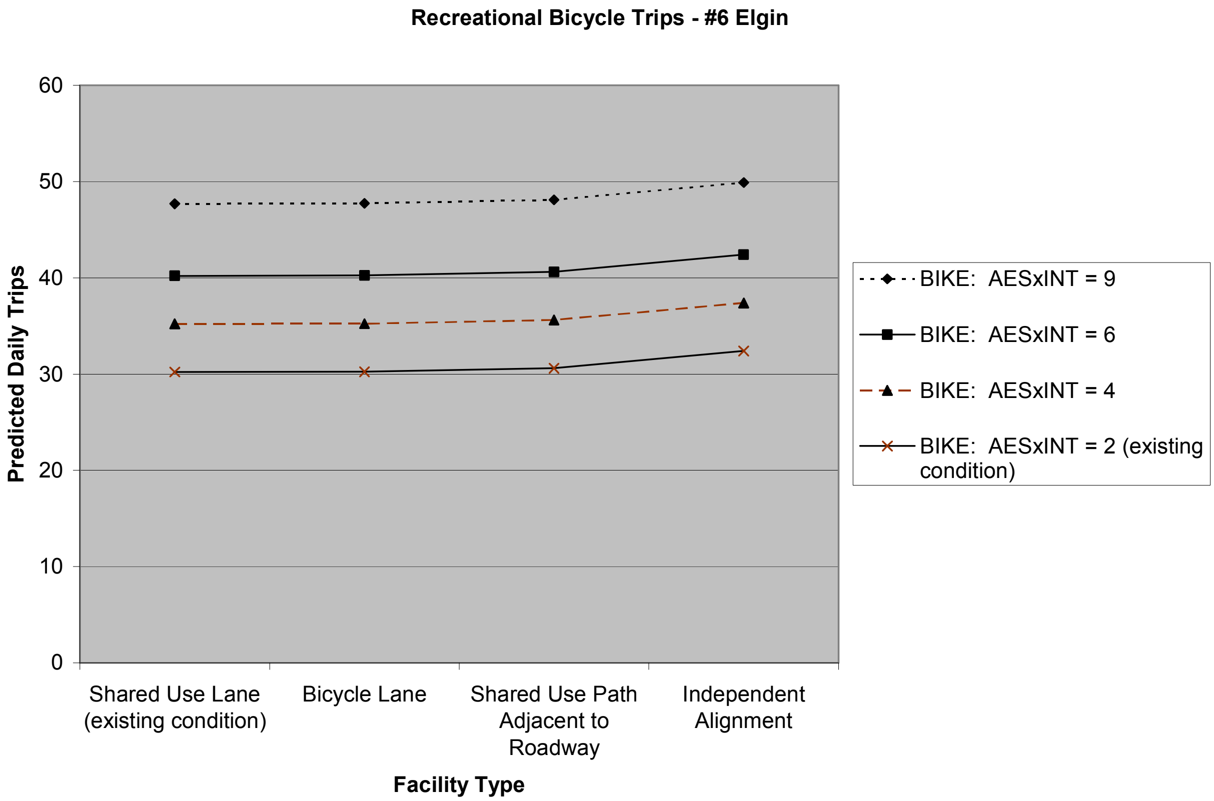

Recreational Bicycle Trips - #1 16th St
Predicted Daily Trips
40
35
30
25
20
15
10
5
0
Shared Use Lane
Bicycle Lane (existing condition)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: AESxINT = 12
BIKE: AESxINT = 9
BIKE: AESxINT = 6
BIKE: AESxINT = 3 (existing condition)

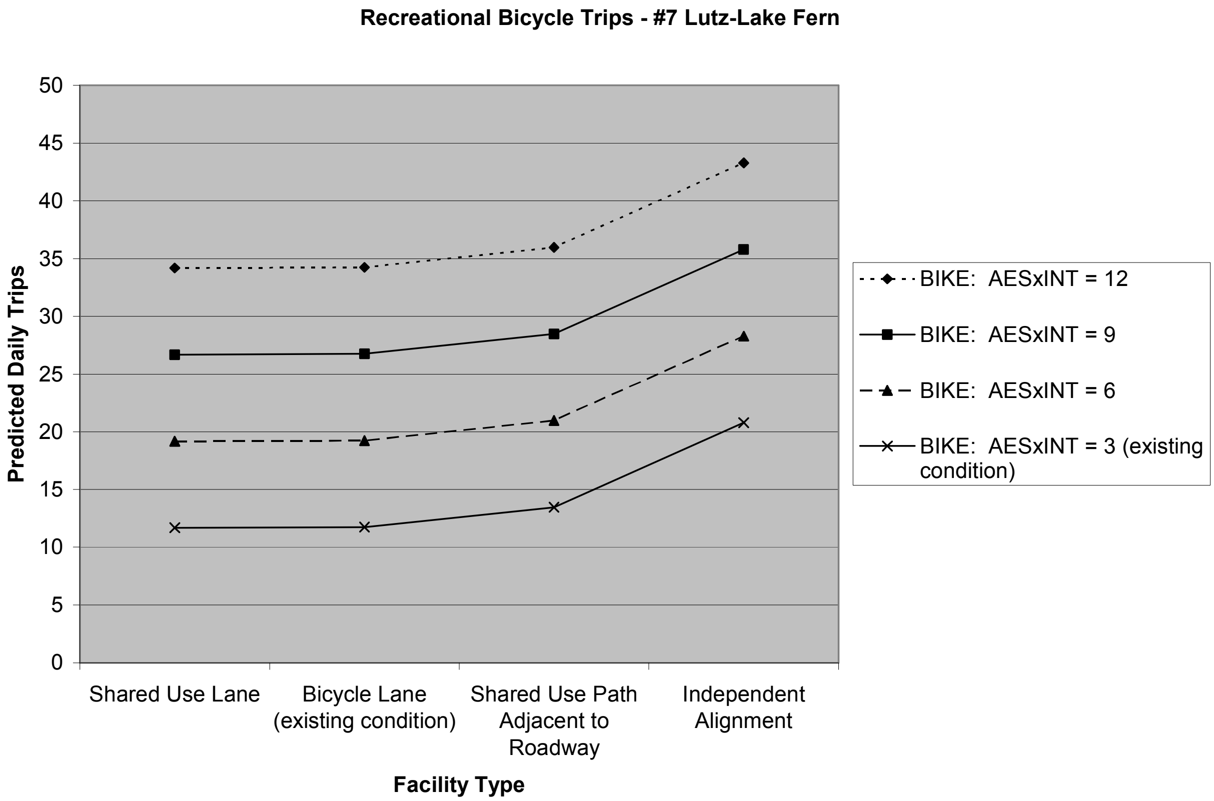

Recreational Bicycle Trips - #2 31st St
45
40
35
30
25
20
15
10
5
0
Predicted Daily Trips
Shared Use Lane (existing condition)
Bicycle Lane
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: AESxINT = 8
BIKE: AESxINT = 6
BIKE: AESxINT = 4
BIKE: AESxINT = 2 (existing condition)

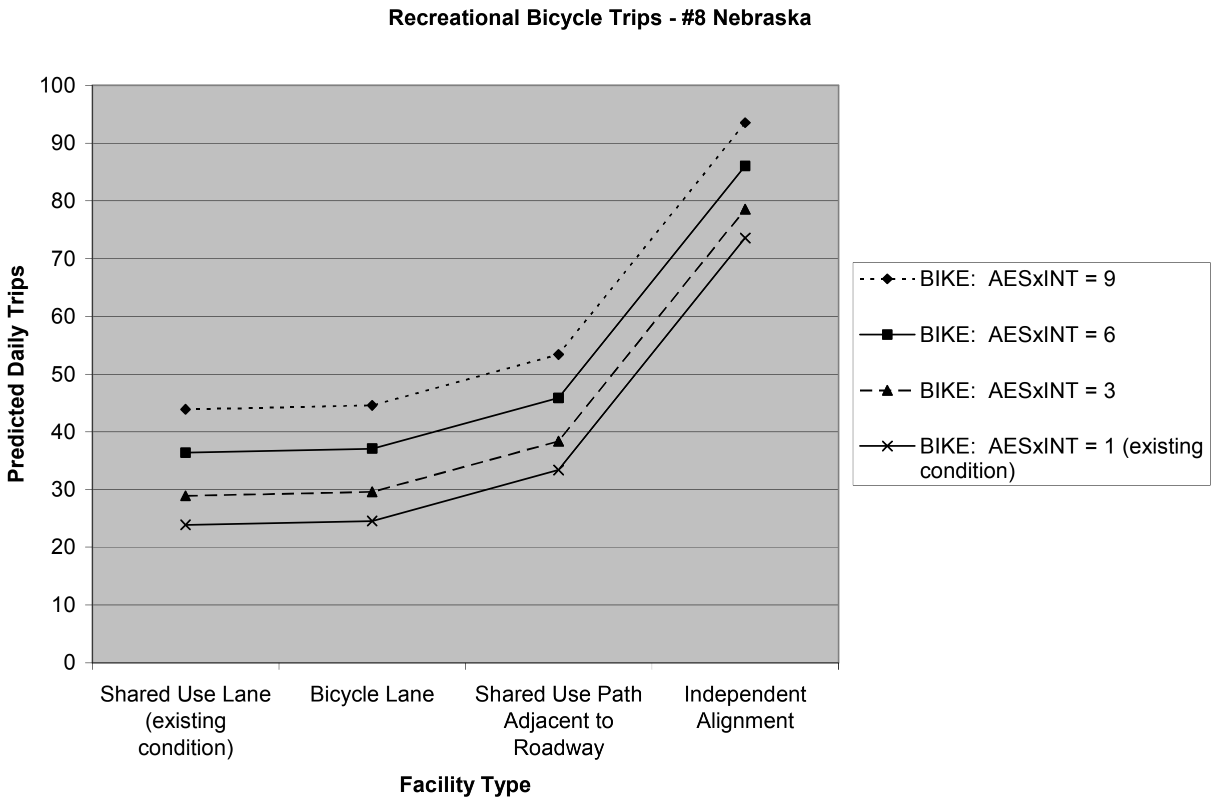

Recreational Bicycle Trips - #3 Bruce B Downs / Commerce Palms
Predicted Daily Trips
30
25
20
15
10
5
0
Shared Use Lane
Bicycle Lane
Shared Use Path Adjacent to Roadway (existing condition)
Independent Alignment
Facility Type
BIKE: AESxINT = 8
BIKE: AESxINT = 6
BIKE: AESxINT = 4
BIKE: AESxINT = 2 (existing condition)

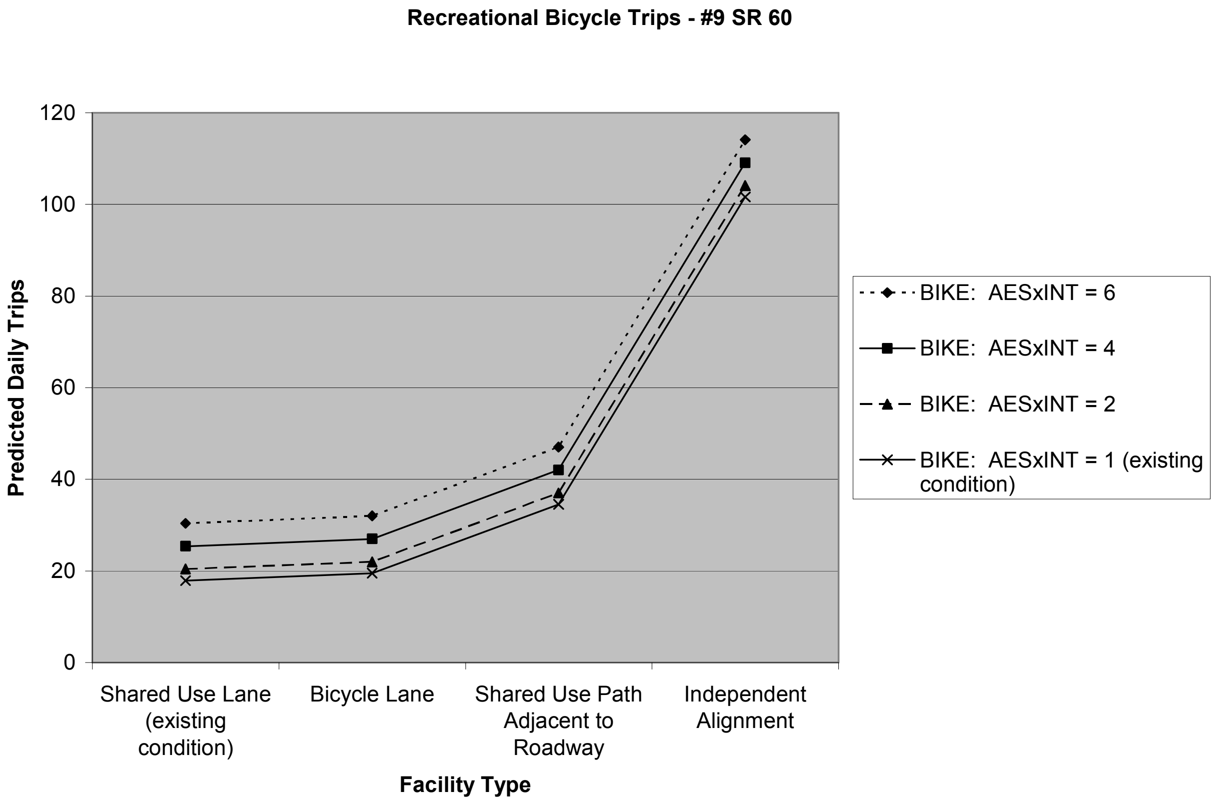

Recreational Bicycle Trips - #4 Bruce B Downs / SR 56
Predicted Daily Trips
35
30
25
20
15
10
5
0
Shared Use Lane
Bicycle Lane (existing condition)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: AESxINT = 8
BIKE: AESxINT = 6
BIKE: AESxINT = 4
BIKE: AESxINT = 2 (existing condition)

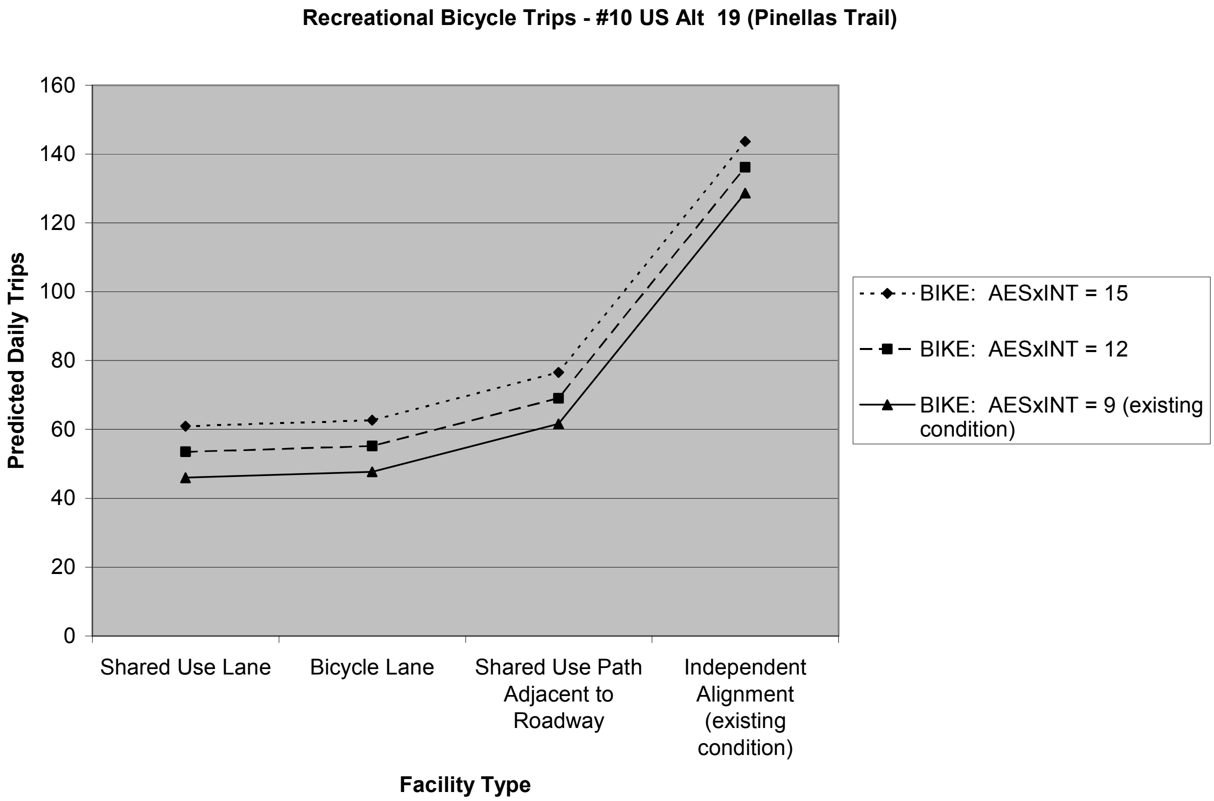

Recreational Bicycle Trips - #5 CR 550
35
30
25
20
15
10
5
0
Predicted Daily Trips
Shared Use Lane (existing condition)
Bicycle Lane
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: AESxINT = 12
BIKE: AESxINT = 9
BIKE: AESxINT = 6
BIKE: AESxINT = 3 (existing condition)

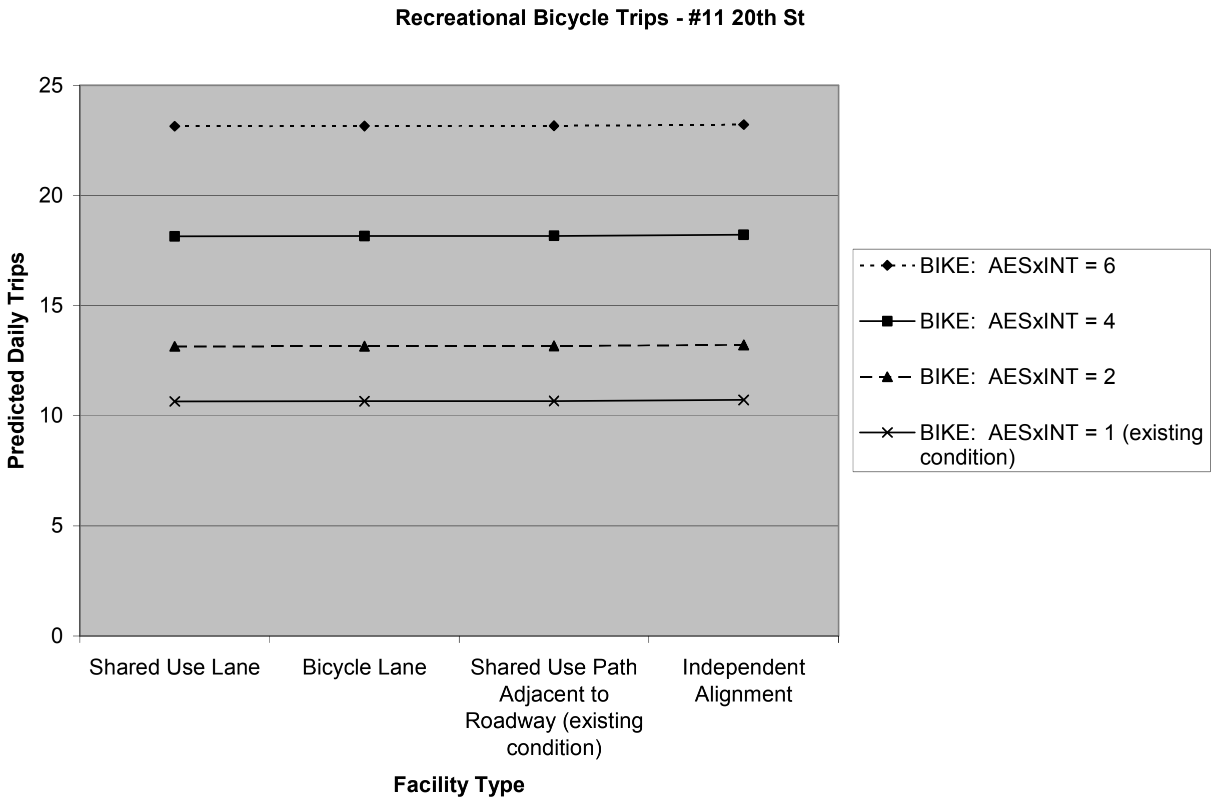

Recreational Bicycle Trips - #6 Elgin
Predicted Daily Trips
0
10
20
30
40
50
60
Shared Use Lane (existing condition)
Bicycle Lane
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: AESxINT = 9
BIKE: AESxINT = 6
BIKE: AESxINT = 4
BIKE: AESxINT = 2 (existing condition)

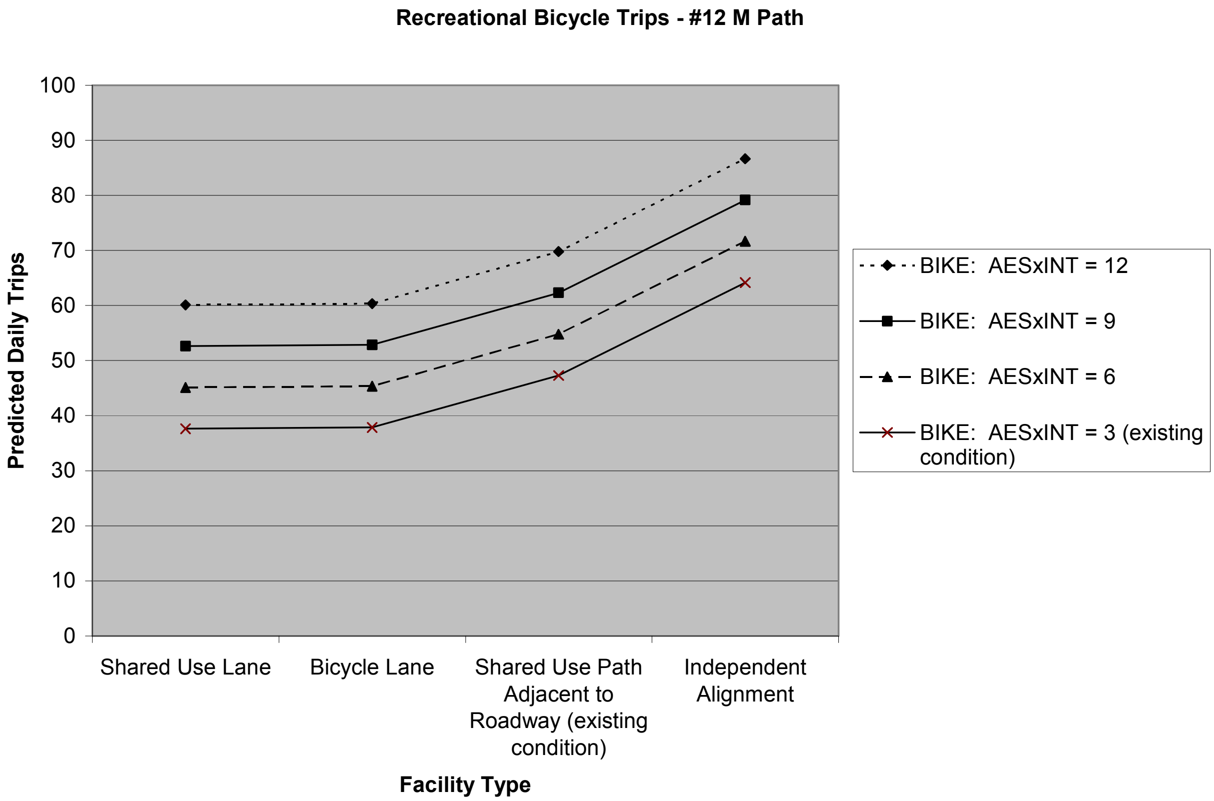

Recreational Bicycle Trips - #7 Lutz-Lake Fern
Predicted Daily Trips
0
5
10
15
20
25
30
35
40
45
50
Shared Use Lane
Bicycle Lane (existing condition)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: AESxINT = 12
BIKE: AESxINT = 9
BIKE: AESxINT = 6
BIKE: AESxINT = 3 (existing condition)

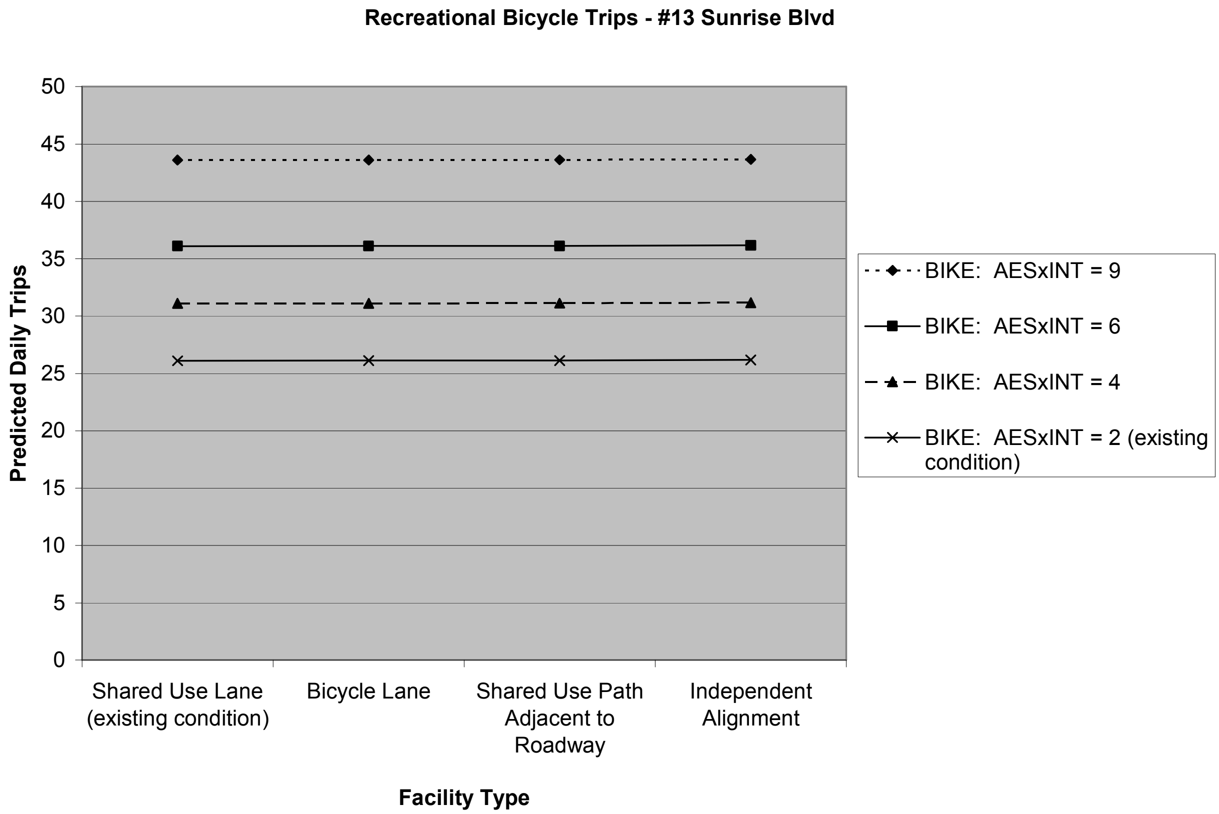

Recreational Bicycle Trips - #8 Nebraska
100
90
80
70
60
50
40
30
20
10
0
Predicted Daily Trips
Shared Use Lane (existing condition)
Bicycle Lane
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: AESxINT = 9
BIKE: AESxINT = 6
BIKE: AESxINT = 3
BIKE: AESxINT = 1 (existing condition)

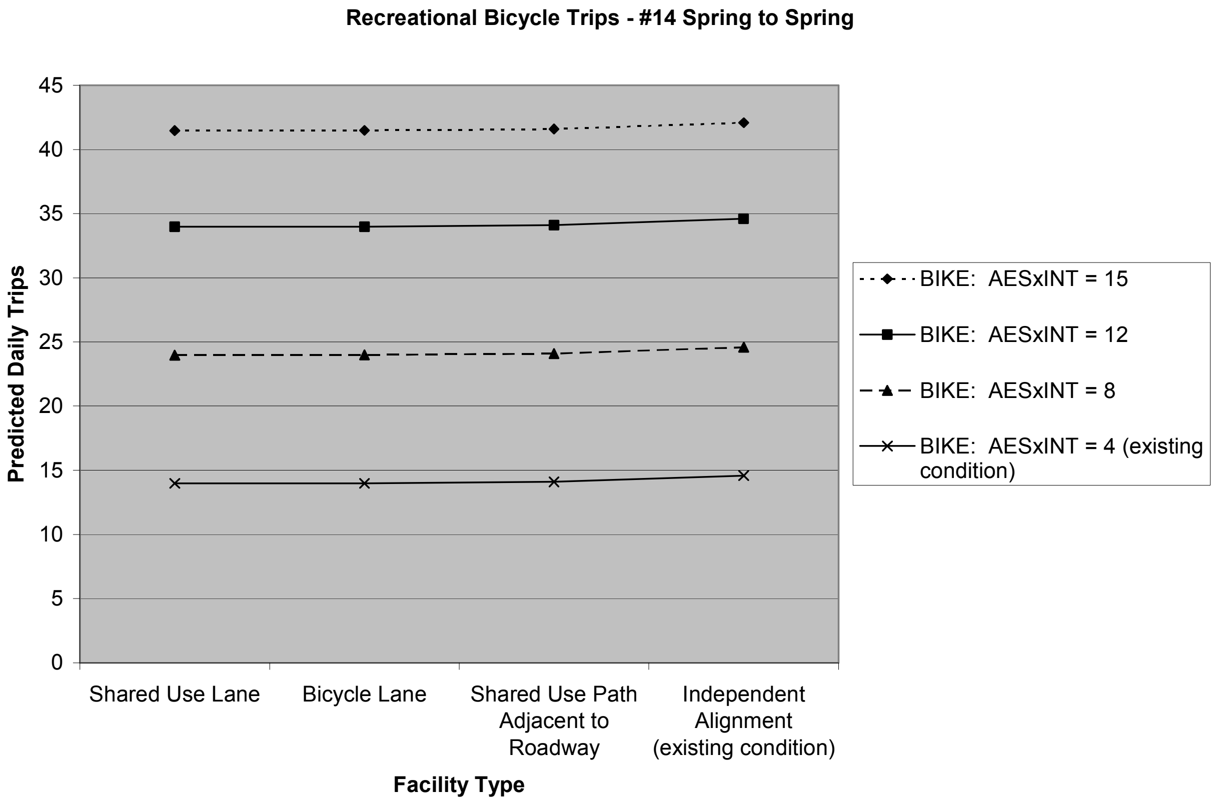

Recreational Bicycle Trips - #9 SR 60
Predicted Daily Trips
120
100
80
60
40
20
0
Shared Use Lane (existing condition)
Bicycle Lane
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: AESxINT = 6
BIKE: AESxINT = 4
BIKE: AESxINT = 2
BIKE: AESxINT = 1 (existing condition)

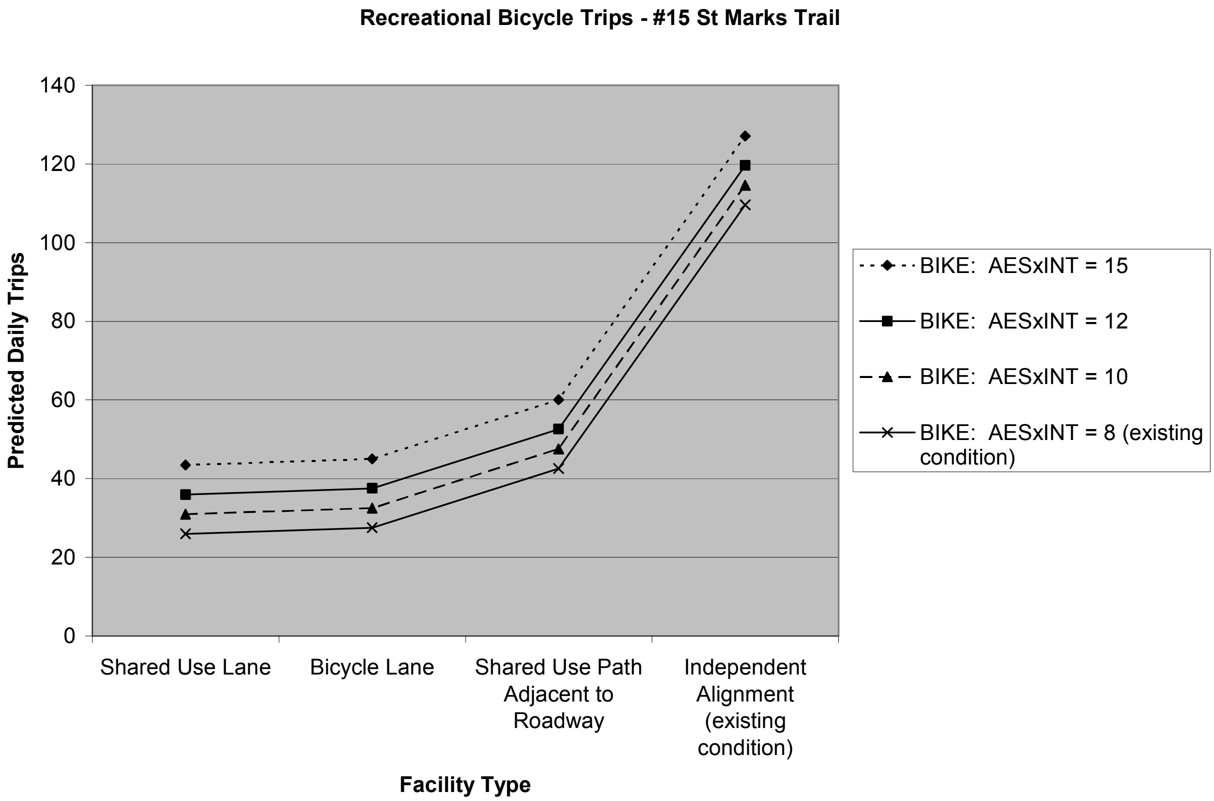

Recreational Bicycle Trips - #10 US Alt 19 (Pinellas Trail)
Predicted Daily Trips
160
140
120
100
80
60
40
20
0
Shared Use Lane
Bicycle Lane
Shared Use Path Adjacent to Roadway
Independent Alignment (existing condition)
Facility Type
BIKE: AESxINT = 15
BIKE: AESxINT = 12
BIKE: AESxINT = 9 (existing condition)

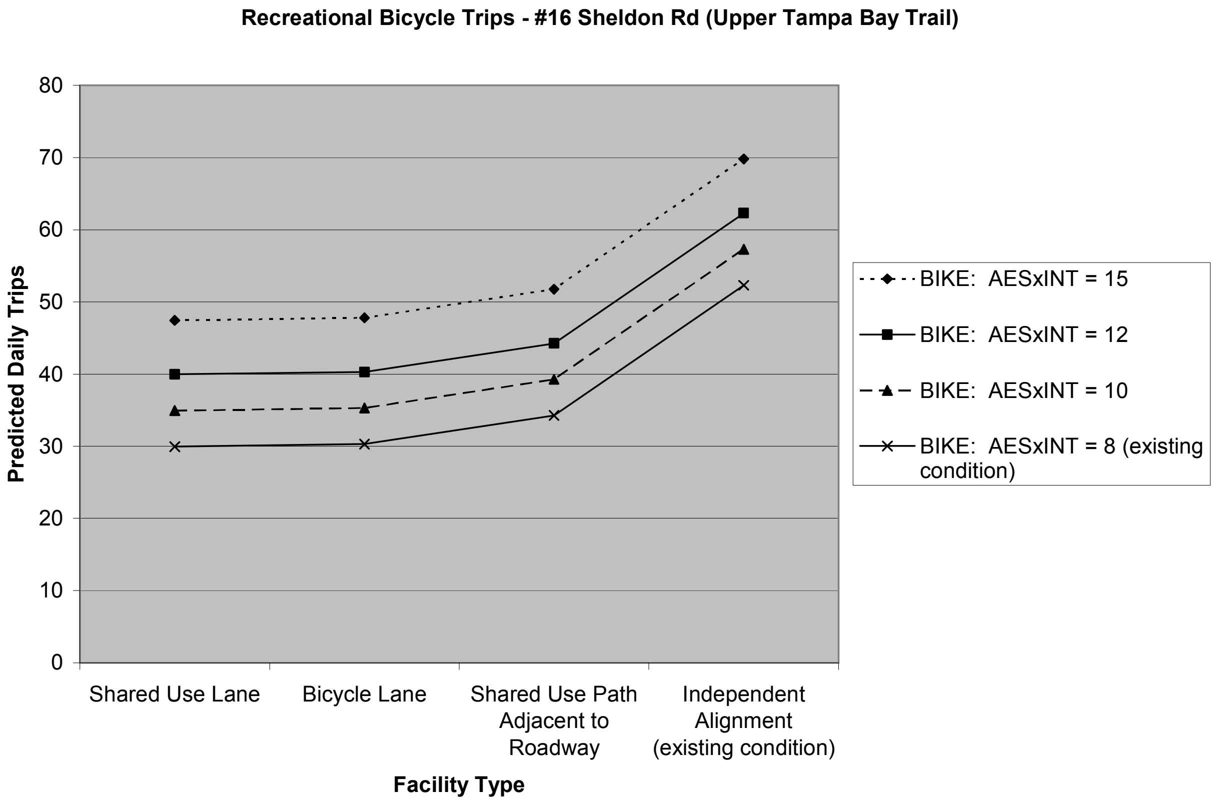

Recreational Bicycle Trips - #11 20th St
Predicted Daily Trips
25
20
15
10
5
0
Shared Use Lane
Bicycle Lane
Shared Use Path Adjacent to Roadway (existing condition)
Independent Alignment
Facility Type
BIKE: AESxINT = 6
BIKE: AESxINT = 4
BIKE: AESxINT = 2
BIKE: AESxINT = 1 (existing condition)

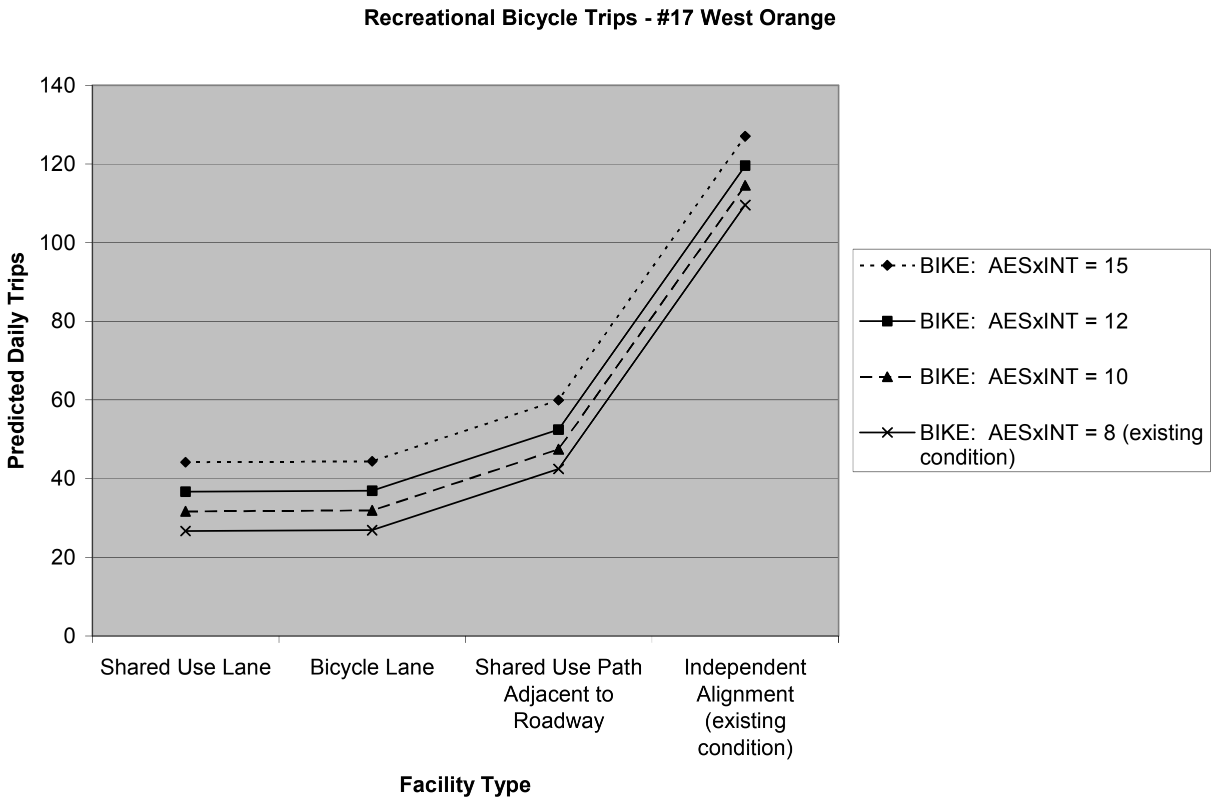

Recreational Bicycle Trips - #12 M Path
Predicted Daily Trips
100
90
80
70
60
50
40
30
20
10
0
Shared Use Lane
Bicycle Lane
Shared Use Path Adjacent to Roadway (existing condition)
Independent Alignment
Facility Type
BIKE: AESxINT = 12
BIKE: AESxINT = 9
BIKE: AESxINT = 6
BIKE: AESxINT = 3 (existing condition)


Recreational Bicycle Trips - #13 Sunrise Blvd
Predicted Daily Trips
50
45
40
35
30
25
20
15
10
5
0
Shared Use Lane (existing condition)
Bicycle Lane
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: AESxINT = 9
BIKE: AESxINT = 6
BIKE: AESxINT = 4
BIKE: AESxINT = 2 (existing condition)


Recreational Bicycle Trips - #14 Spring to Spring
Predicted Daily Trips
45
40
35
30
25
20
15
10
5
0
Shared Use Lane
Bicycle Lane
Shared Use Path Adjacent to Roadway
Independent Alignment (existing condition)
Facility Type
BIKE: AESxINT = 15
BIKE: AESxINT = 12
BIKE: AESxINT = 8
BIKE: AESxINT = 4 (existing condition)

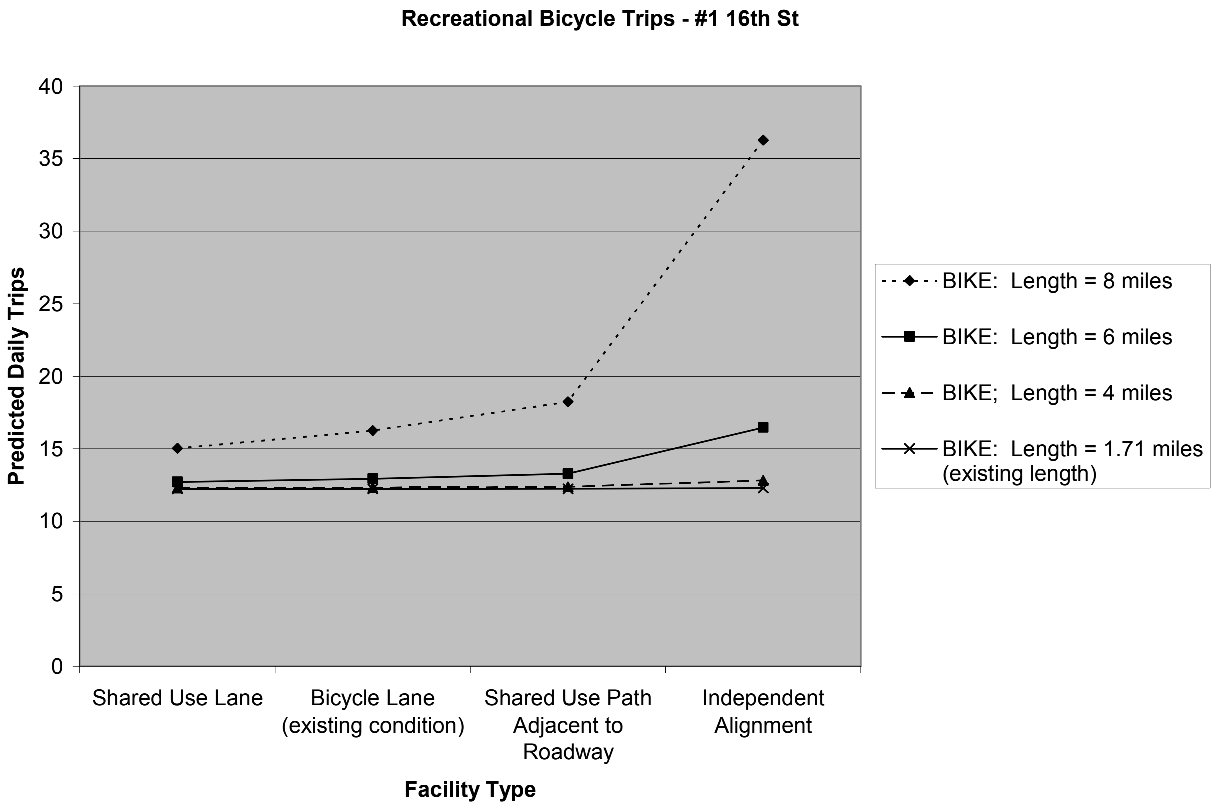

Recreational Bicycle Trips - #15 St Marks Trail
Predicted Daily Trips
0
20
40
60
80
100
120
140
Shared Use Lane
Bicycle Lane
Shared Use Path Adjacent to Roadway
Independent Alignment (existing condition)
Facility Type
BIKE: AESxINT = 15
BIKE: AESxINT = 12
BIKE: AESxINT = 10
BIKE: AESxINT = 8 (existing condition)

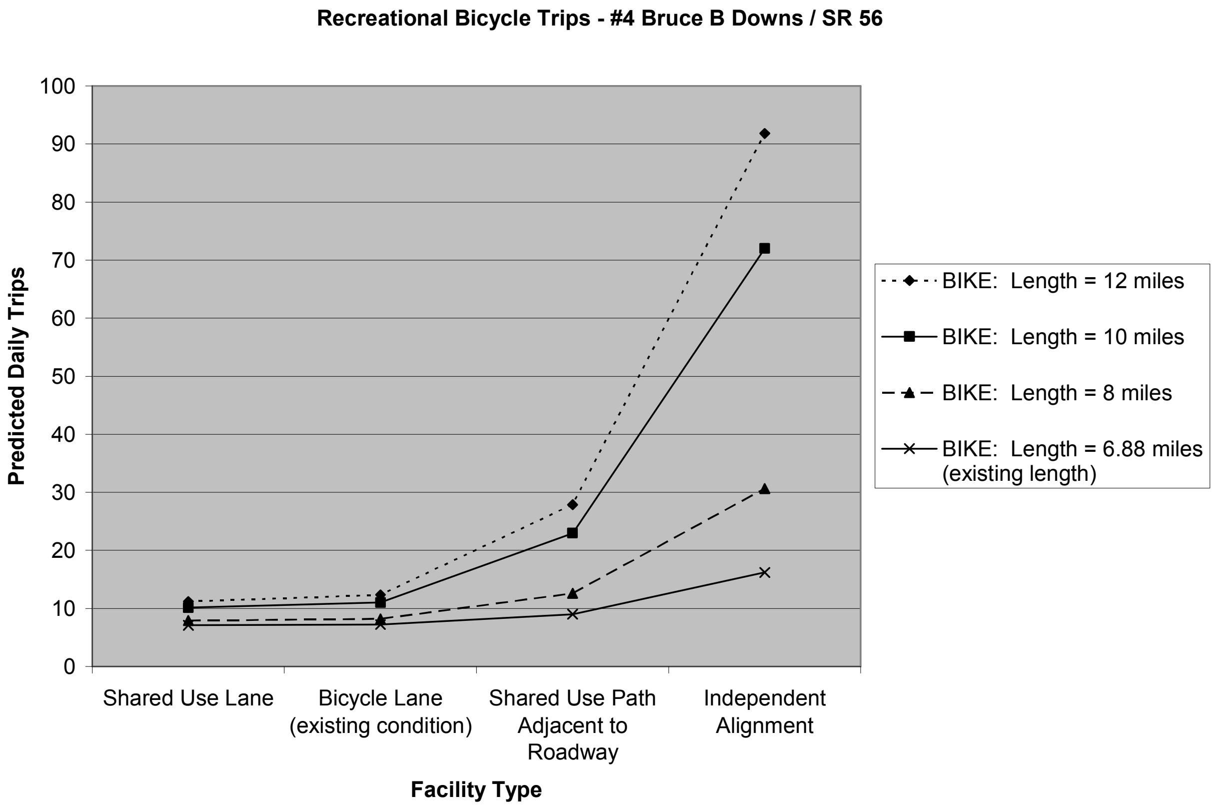

Recreational Bicycle Trips - #16 Sheldon Rd (Upper Tampa Bay Trail)
Predicted Daily Trips
0
10
20
30
40
50
60
70
80
Shared Use Lane
Bicycle Lane
Shared Use Path Adjacent to Roadway
Independent Alignment (existing condition)
Facility Type
BIKE: AESxINT = 15
BIKE: AESxINT = 12
BIKE: AESxINT = 10
BIKE: AESxINT = 8 (existing condition)

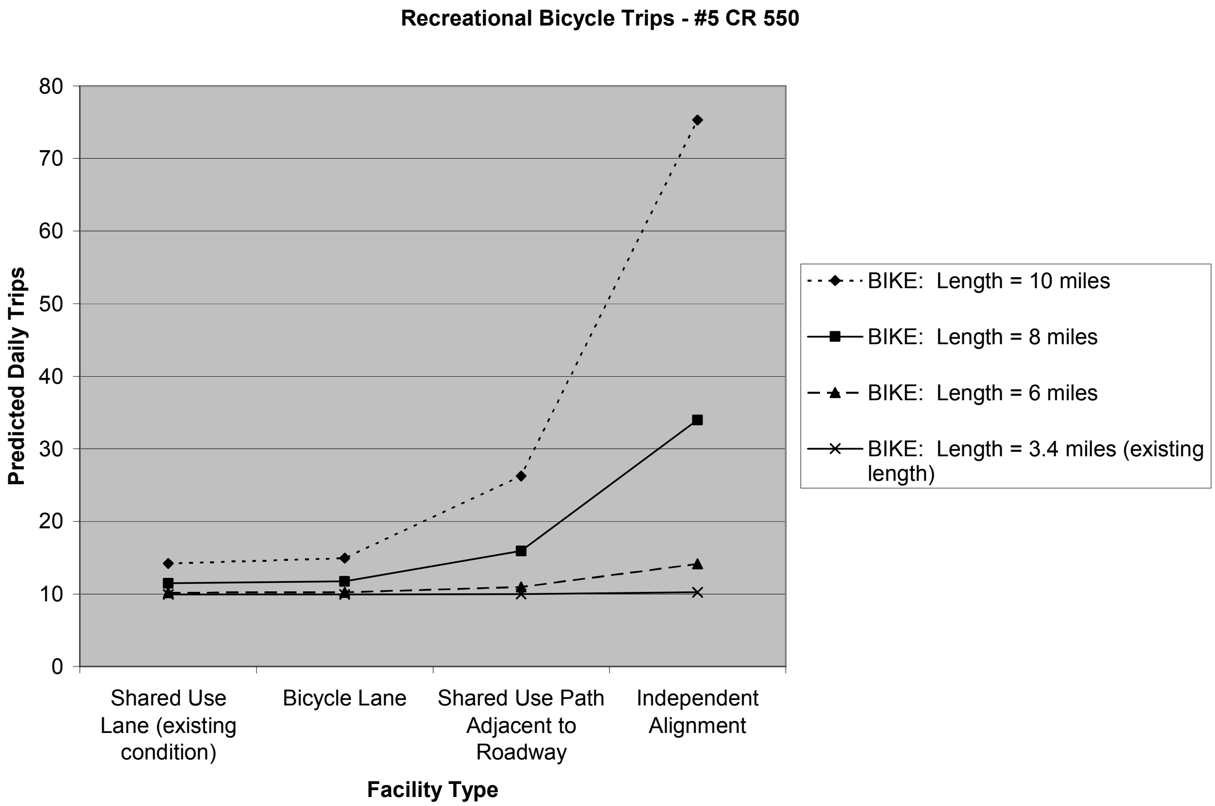

Recreational Bicycle Trips - #17 West Orange
Predicted Daily Trips
0
20
40
60
80
100
120
140
Shared Use Lane
Bicycle Lane
Shared Use Path Adjacent to Roadway
Independent Alignment (existing condition)
Facility Type
BIKE: AESxINT = 15
BIKE: AESxINT = 12
BIKE: AESxINT = 10
BIKE: AESxINT = 8 (existing condition)

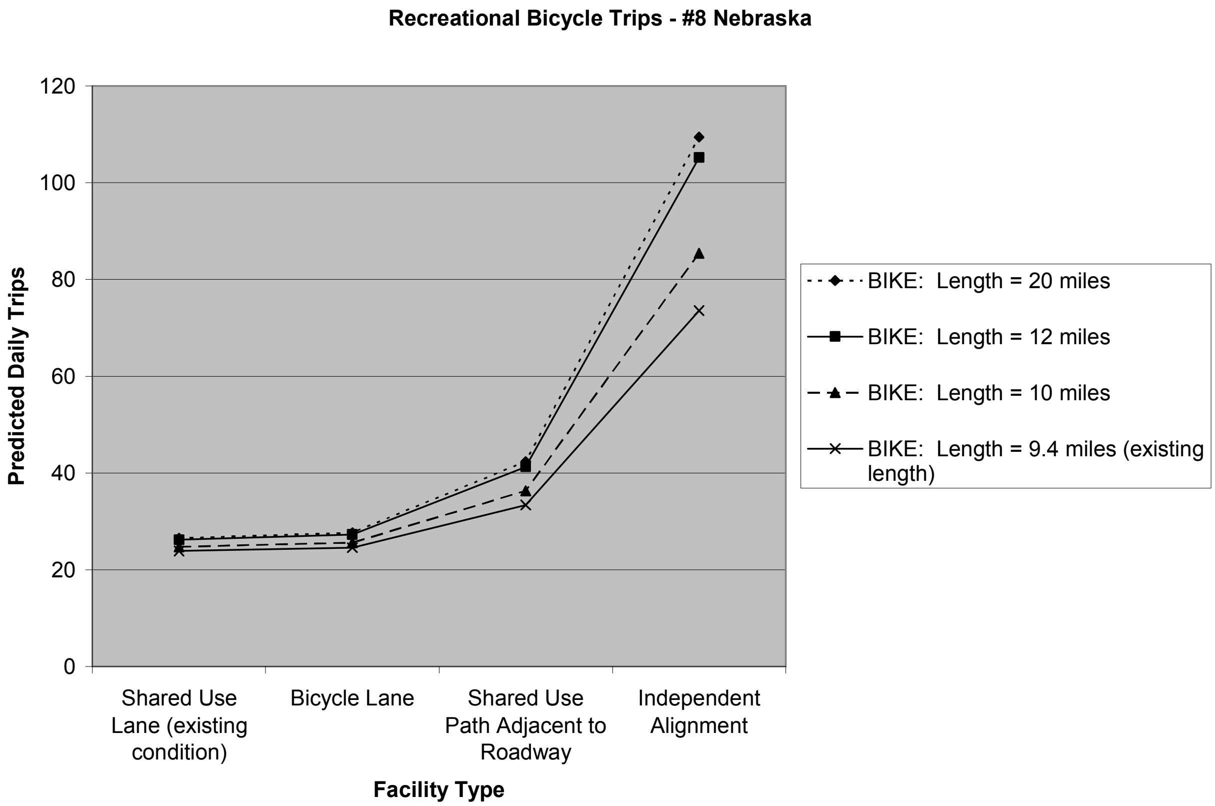
## APPENDIX K Sensitivity Analysis, Induced Recreational Model: Varying Facility Length and Facility Type

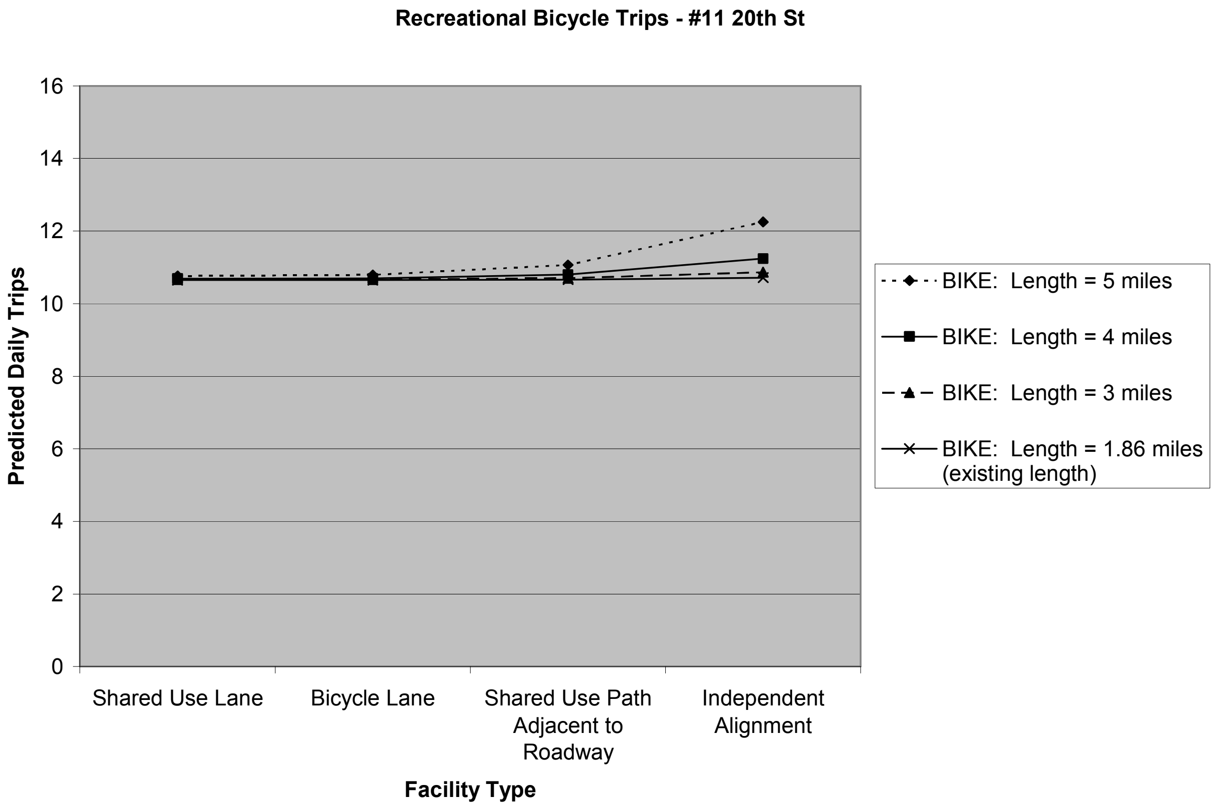
The researchers tested the induced recreational model by varying facility length and facility type, while holding population proximity and facility length constant. These charts show how the predicted daily number of recreational bicycle trips increases as facility length increases. The predicted number of trips also increases as facility type goes from no bike facilities to bike lane, shared use path adjacent to roadway, and independent alignment, resulting in improved bicycle LOS. The reader is reminded that these charts depict only recreational trips, not utilitarian trips.


Recreational Bicycle Trips - #1 16th St
Predicted Daily Trips
40
35
30
25
20
15
10
5
0
Shared Use Lane
Bicycle Lane (existing condition)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: Length = 8 miles
BIKE: Length = 6 miles
BIKE; Length = 4 miles
BIKE: Length = 1.71 miles (existing length)


Recreational Bicycle Trips - #4 Bruce B Downs / SR 56
Predicted Daily Trips
100
90
80
70
60
50
40
30
20
10
0
Shared Use Lane
Bicycle Lane (existing condition)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: Length = 12 miles
BIKE: Length = 10 miles
BIKE: Length = 8 miles
BIKE: Length = 6.88 miles (existing length)

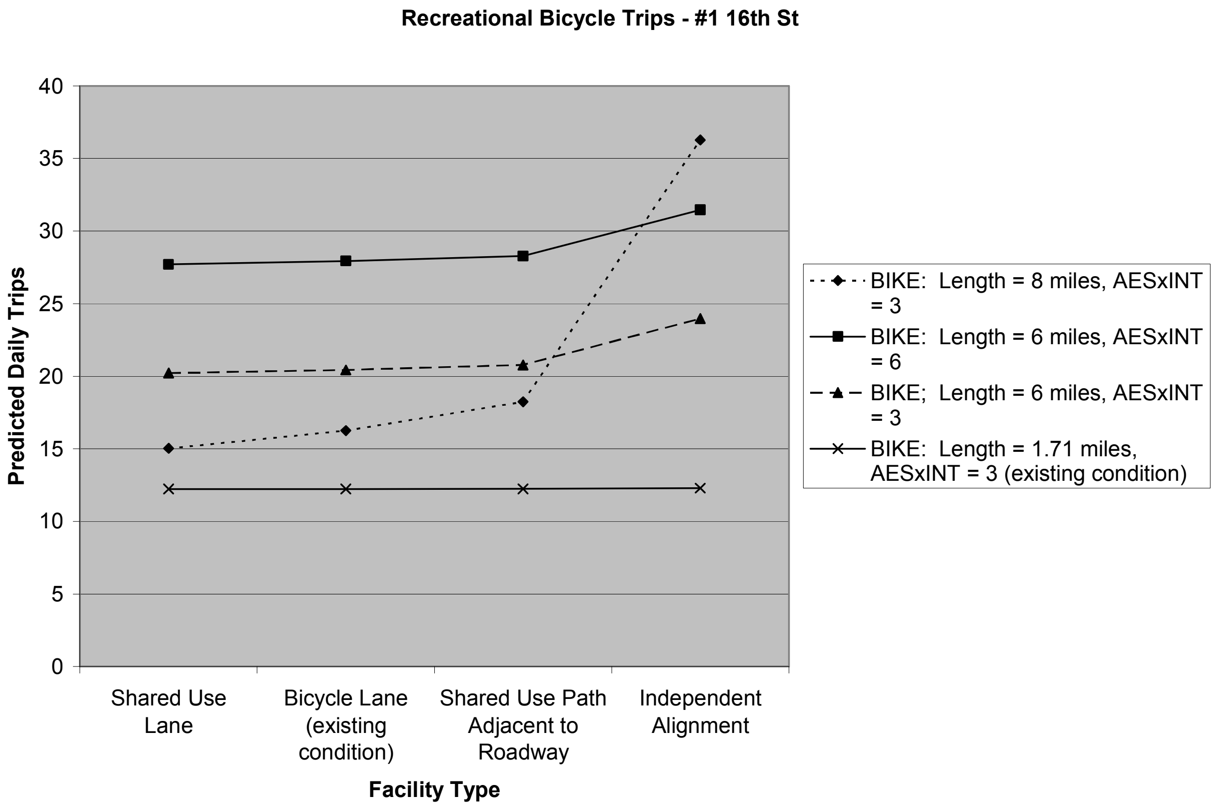

Recreational Bicycle Trips - #5 CR 550
Predicted Daily Trips
80
70
60
50
40
30
20
10
0
Shared Use Lane (existing condition)
Bicycle Lane
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: Length = 10 miles
BIKE: Length = 8 miles
BIKE: Length = 6 miles
BIKE: Length = 3.4 miles (existing length)

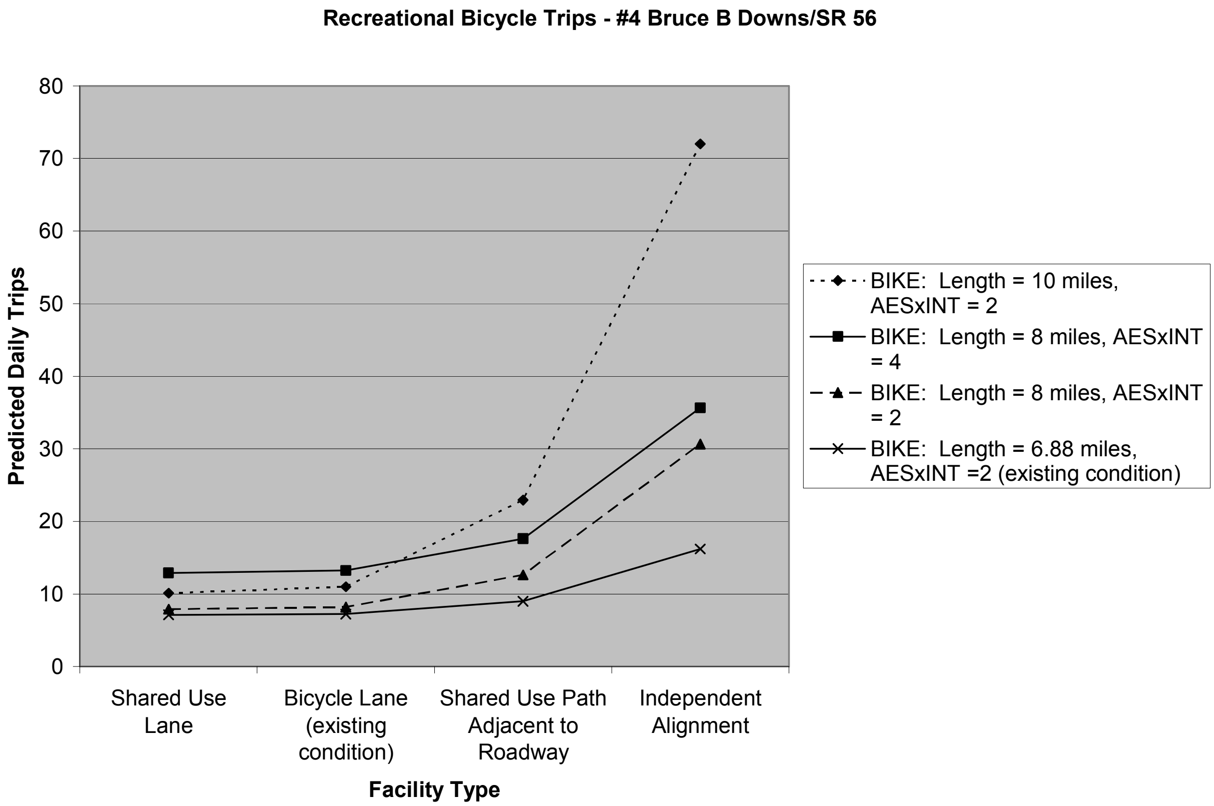

Recreational Bicycle Trips - #8 Nebraska
Predicted Daily Trips
120
100
80
60
40
20
0
Shared Use Lane (existing condition)
Bicycle Lane
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: Length = 20 miles
BIKE: Length = 12 miles
BIKE: Length = 10 miles
BIKE: Length = 9.4 miles (existing length)

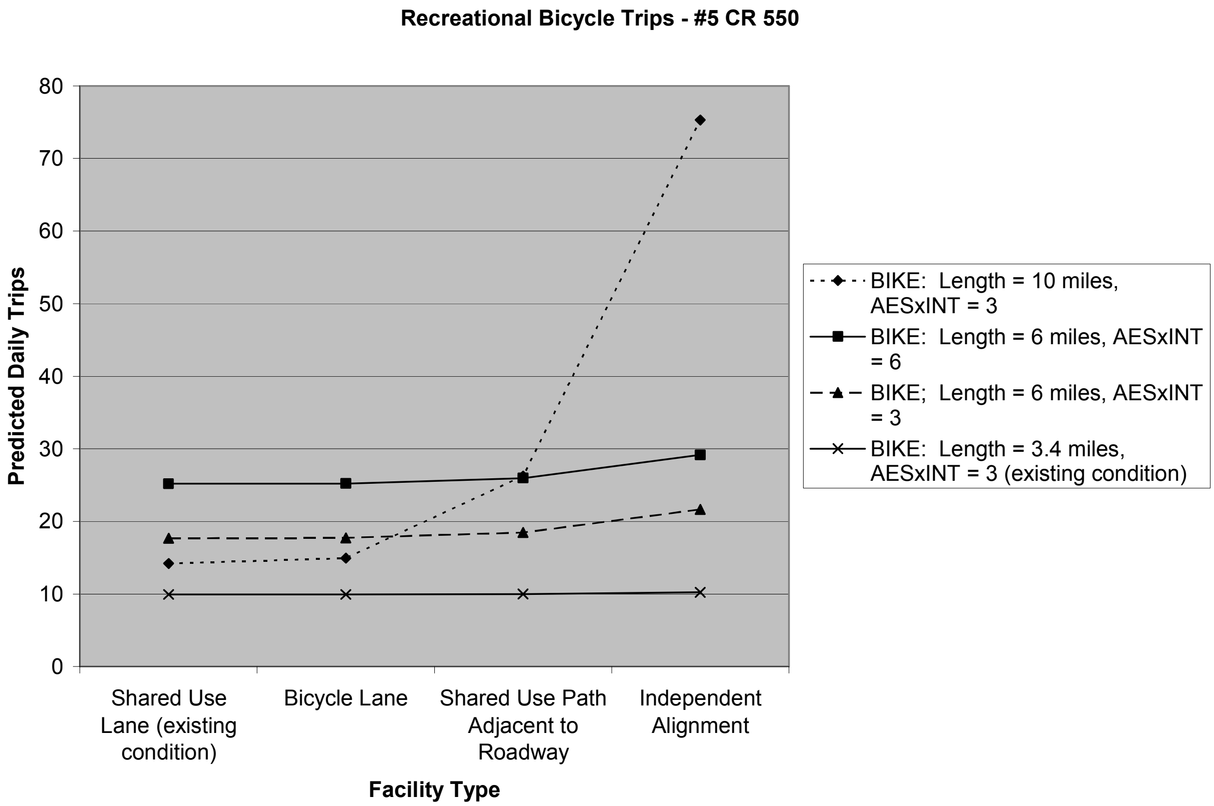

Recreational Bicycle Trips - #11 20th St
Predicted Daily Trips
16
14
12
10
8
6
4
2
0
Shared Use Lane
Bicycle Lane
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: Length = 5 miles
BIKE: Length = 4 miles
BIKE: Length = 3 miles
BIKE: Length = 1.86 miles (existing length)

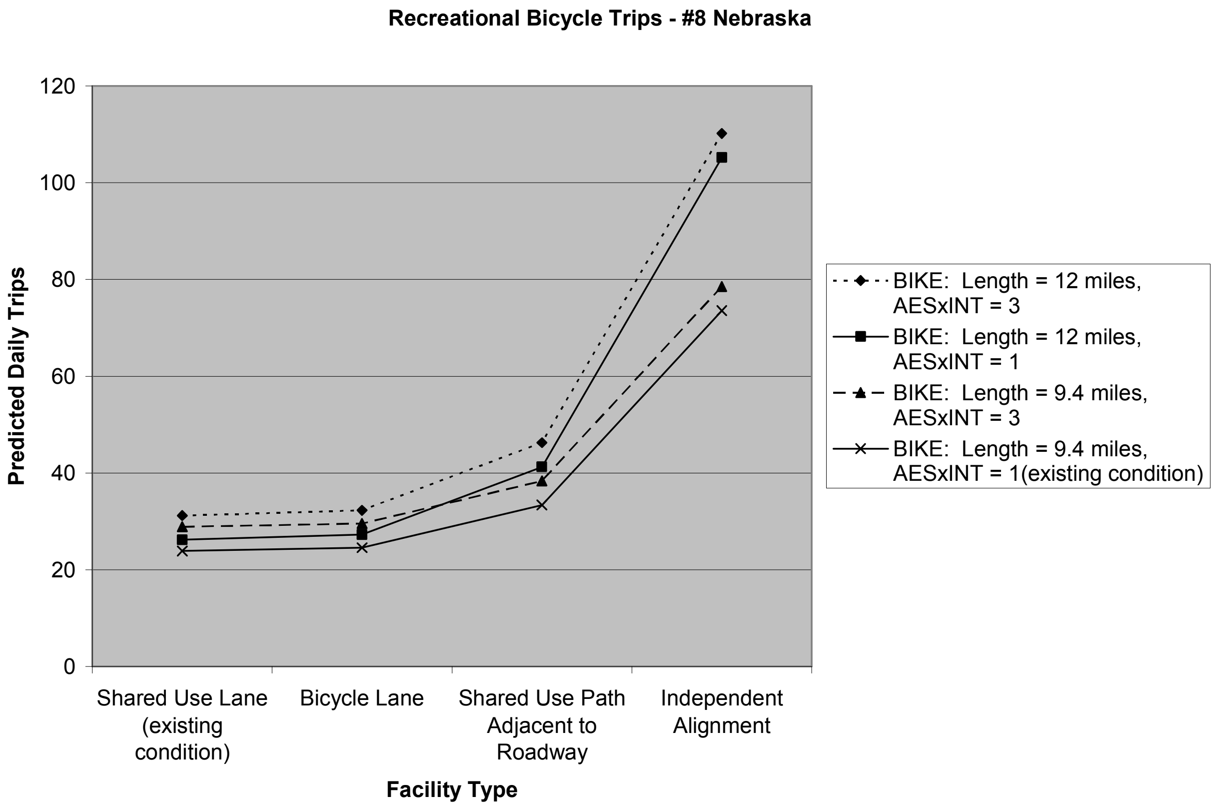
## APPENDIX L Sensitivity Analysis, Induced Recreational Model: Varying Aesthetics, Points of Interest, Facility Length, and Facility Type

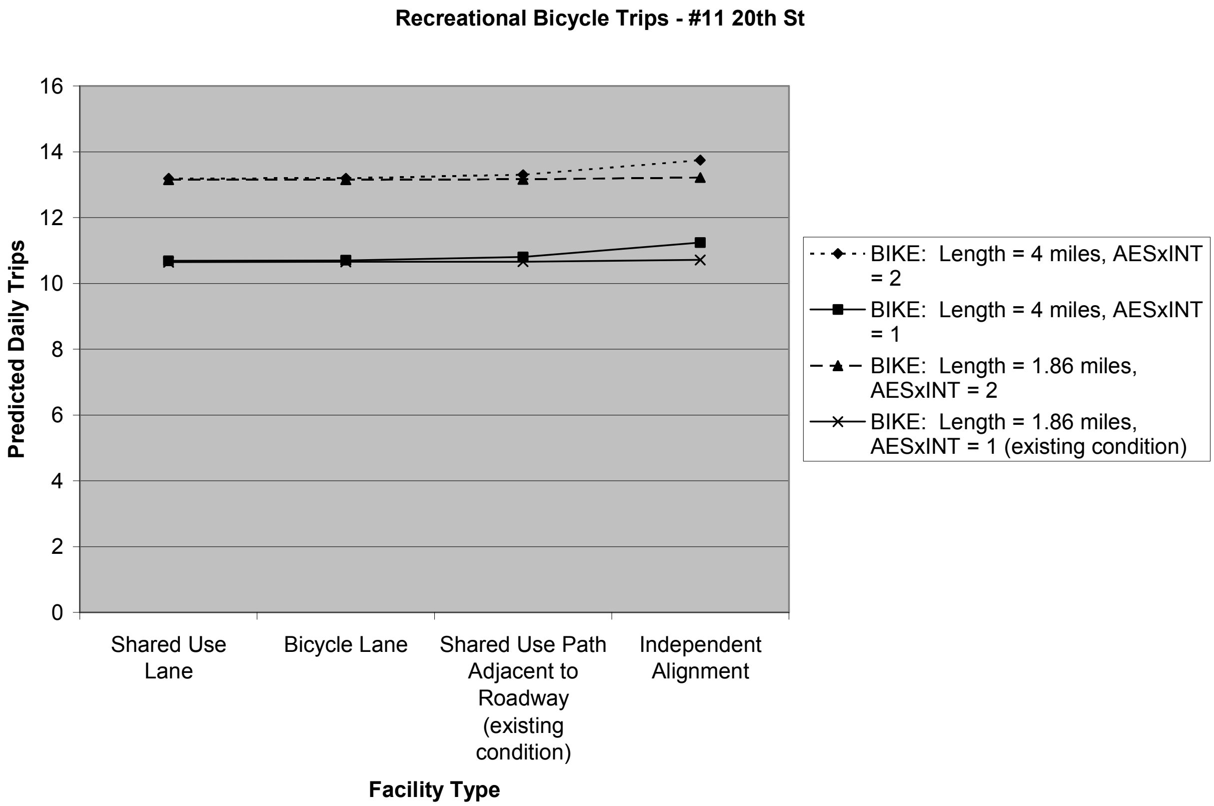
The researchers tested the induced recreational model by varying aesthetics and points of interest (AESxINT), facility length, and facility type, while holding population proximity constant. These charts show how the predicted daily number of recreational bicycle trips increases as AESxINT and facility length increase. The predicted number of trips also increases as facility type goes from no bike facilities to bike lane, shared use path adjacent to roadway, and independent alignment, resulting in improved bicycle LOS. The reader is reminded that these charts depict only <u>recreational</u> trips, not utilitarian trips.


Recreational Bicycle Trips - #1 16th St
Predicted Daily Trips
40
35
30
25
20
15
10
5
0
Shared Use Lane
Bicycle Lane (existing condition)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: Length = 8 miles, AESxINT = 3
BIKE: Length = 6 miles, AESxINT = 6
BIKE; Length = 6 miles, AESxINT = 3
BIKE: Length = 1.71 miles, AESxINT = 3 (existing condition)


Recreational Bicycle Trips - #4 Bruce B Downs/SR 56
Predicted Daily Trips
0
10
20
30
40
50
60
70
80
Shared Use Lane
Bicycle Lane (existing condition)
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: Length = 10 miles, AESxINT = 2
BIKE: Length = 8 miles, AESxINT = 4
BIKE: Length = 8 miles, AESxINT = 2
BIKE: Length = 6.88 miles, AESxINT =2 (existing condition)


Recreational Bicycle Trips - #5 CR 550
Predicted Daily Trips
0
10
20
30
40
50
60
70
80
Shared Use Lane (existing condition)
Bicycle Lane
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: Length = 10 miles, AESxINT = 3
BIKE: Length = 6 miles, AESxINT = 6
BIKE; Length = 6 miles, AESxINT = 3
BIKE: Length = 3.4 miles, AESxINT = 3 (existing condition)


Recreational Bicycle Trips - #8 Nebraska
120
100
80
60
40
20
0
Predicted Daily Trips
Shared Use Lane (existing condition)
Bicycle Lane
Shared Use Path Adjacent to Roadway
Independent Alignment
Facility Type
BIKE: Length = 12 miles, AESxINT = 3
BIKE: Length = 12 miles, AESxINT = 1
BIKE: Length = 9.4 miles, AESxINT = 3
BIKE: Length = 9.4 miles, AESxINT = 1(existing condition)


Recreational Bicycle Trips - #11 20th St
Predicted Daily Trips
16
14
12
10
8
6
4
2
0
Shared Use Lane
Bicycle Lane
Shared Use Path Adjacent to Roadway (existing condition)
Independent Alignment
Facility Type
BIKE: Length = 4 miles, AESxINT = 2
BIKE: Length = 4 miles, AESxINT = 1
BIKE: Length = 1.86 miles, AESxINT = 2
BIKE: Length = 1.86 miles, AESxINT = 1 (existing condition)

## APPENDIX M Health Benefits and Energy Savings Worksheet

The researchers developed an Excel worksheet that enables the user to compare the health benefits and energy savings for different bicycle improvements. This worksheet and detailed descriptions of the items in the worksheet appear on the following pages. Many of the cells in this worksheet are linked to another worksheet (not shown) that serves as the calculation engine.

In this example worksheet, Column C (shared use lane) is the baseline condition. Three improvements are shown – a bicycle lane (Column D), a shared use path adjacent to a roadway (Column E), and an independent alignment (Column F).

Input values appear in the yellow-shaded area of the worksheet. These input values represent the operational and demographic characteristics of the corridor in the baseline condition and with bicycle facility improvements. The input values are needed for calculating the predicted number of utilitarian and recreational users and for calculating the predicted health benefits and energy savings that would result from increased bicycling activity.

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | **Health Benefits and Energy Savings** | | | | | |
| 3 | | | Scenario | | | |
| 4 | | Values common to all scenarios | Baseline - Shared Use Lane | Bicycle Lane/Paved Shoulder | Shared Use Path Adjacent to Roadway | Independent Alignment |
| 5 | **Inputs for Both Models** | | | | | |
| 6 | Facility Type (1=Shared use lane, 2=bike lane, 3=Shared use path adjacent to roadway, 4=Independent alignment) | | 1 | 2 | 3 | 4 |
| 7 | Distance between Shared Use Path Adjacent to Roadway and Roadway (feet) (Enter 0 if not a shared use path adjacent to roadway) | | 0 | 0 | 0 | 0 |
| 8 | Speed Limit (MPH) | 45 | | | | |
| 9 | On-Street Recycling Conditions (Bicycle LOS for typical segment) (Enter 0.5 for independent alignment) | | 4.88 | 3.63 | 3.63 | 0.5 |
| 10 | | | | | | |
| 11 | | | | | | |
| 12 | **Inputs for Utilitarian Model Only** | | | | | |
| 13 | Trip Length of Travelers in Corridor for all modes (miles) | 6.07 | | | | |
| 14 | Average Utilitarian Bike Trip Length (miles) | 3 | | | | |
| 15 | Motor Vehicle Facility LOS (from FDOT Q/LOS Handbook) | C | | | | |
| 16 | Bus Frequency during PM Peak (buses per hour) - enter 0 if no bus service | 4 | | | | |
| 17 | Rapid Transit Frequency during PM Peak (trains or bus rapid transit per hour) - enter 0 if no rail service) | 0 | | | | |
| 18 | Walking Conditions (Pedestrian LOS for typical segment) (Enter 0.5 for independent alignment) | | 3.37 | 3.78 | 3.76 | 0.5 |
| 19 | Population in Network Analysis Zone | 17587 | | | | |
| 20 | Employment in Network Analysis Zone | 10106 | | | | |
| 21 | Area of Network Analysis Zone (square miles) | 6.66 | | | | |
| 22 | Bike Network Friendliness | | 0.44 | 0.45 | 0.48 | 0.51 |
| 23 | Pedestrian Network Friendliness | | 0.46 | 0.48 | 0.49 | 0.55 |
| 24 | | | | | | |

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 4 | | Values common to all scenarios | Baseline - Shared Use Lane | Bicycle Lane/Paved Shoulder | Shared Use Path Adjacent to Roadway | Independent Alignment |
| 25 | **Inputs for Recreational Model Only** | | | | | |
| 26 | Distance weighted population within 10 miles | 79963 | | | | |
| 27 | Aesthetics (1=Lowest, 3=Highest) | 1 | | | | |
| 28 | Points of Interest (1=Least, 3=Most) | 1 | | | | |
| 29 | Facility Length (miles) | 9.4 | | | | |
| 30 | Average Recreational Bike Trip Length (miles) | 5 | | | | |
| 31 | | | | | | |
| 32 | **Trips passing a cut line** | | | | | |
| 33 | Total People passing a cut line per weekday, all modes | 32000 | | | | |
| 34 | Utilitarian Bicycle Trips (passing a cut line per weekday) | | 15 | 33 | 916 | 2023 |
| 35 | Day to Week Adjustment Factor - Util (day as percent of week) | 17% | | | | |
| 36 | Utilitarian Bicycle Trips (passing a cut line per year) | | 4534 | 10019 | 189441 | 820391 |
| 37 | | | | | | |
| 38 | Peak-to-Day Adjustment Factor - Rec (PM peak as fraction of day) | 25% | | | | |
| 39 | | | | | | |
| 40 | Recreation Bicycle Trips (passing a cut line per day) | | 24 | 26 | 33 | 71 |
| 41 | Day to Week Adjustment Factor - Rec (day as percent of week) | 13% | | | | |
| 42 | Recreation Bicycle Trips (passing a cut line per year) | | 9541 | 9955 | 13363 | 29495 |
| 43 | | | | | | |
| 44 | **Trips on Facility** | | | | | |
| 48 | Adjusted Facility Length (utilitarian) (miles) | 6 | | | | |
| 49 | Adjusted Facility Length (recreational) (miles) | 5.36 | | | | |
| 50 | Utilitarian Bicycle Trips/Year (on facility) | | 9068 | 20037 | 390082 | 1240762 |
| 51 | Mode Shift (# of utilitarian bicycle trips/year on facility) (relative to baseline) | | | 10970 | 381014 | 1231695 |
| 52 | | | | | | |
| 53 | Recreational Bicycle Trips/year (on facility) | | 18019 | 18478 | 22377 | 49319 |
| 54 | Induced Recreation (# of recreational bicycle trips/year on facility) (relative to baseline) | | | 459 | 4358 | 33268 |

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 4 | | Values common to all scenarios | Baseline - Shared Use Lane | Bicycle Lane/Paved Shoulder | Shared Use Path Adjacent to Roadway | Independent Alignment |
| 55 | | | | | | |
| 56 | **Health Benefits** | | | | | |
| 58 | Health Benefit of Being Physically Active ($/trip) | $0.43 | | | | |
| 59 | Annual Health Benefit of Being Physically Active (relative to baseline) | | | $5,526 | $181,254 | $622,765 |
| 61 | | | | | | |
| 62 | **Energy Savings** | | | | | |
| 63 | Car Occupancy | 1.43 | | | | |
| 64 | Price per Gallon of Gas ($) | $3.00 | | | | |
| 65 | Fuel Savings (miles per gallon) | 20 | | | | |
| 66 | | | | | | |
| 67 | Energy Savings ($/year) (relative to baseline) | | | $3,452 | $113,858 | $387,596 |
| 68 | | | | | | |
| 69 | **Combined Health & Energy Benefits ($/year) (relative to baseline)** | | | | | |
| 70 | Combined Benefits ($/year) (relative to baseline) | | | $8,978 | $295,112 | $1,010,361 |
| 71 | Benefits per Mile of Facility ($/year) (relative to baseline) | | | $998 | $31,352 | $107,485 |

The specific input and output values are described below.

- Row 6, Facility Type – Enter 1 for shared use lane, 2 for bike lane, 3 for shared use path adjacent to roadway, and 4 for independent alignment.
- Row 7, Distance between Shared Use Path Adjacent to Roadway and Roadway – Enter the distance (feet) separating the shared use path from the roadway. If the facility is not a shared use path adjacent to roadway, enter 0. This value is needed to calculate the bicycle LOS and pedestrian LOS for shared use paths adjacent to roadways.
- Row 8, Speed Limit – Enter the speed limit (MPH). This value is needed to calculate the bicycle LOS and pedestrian LOS for shared use paths adjacent to roadways.
- Row 9, On-Street Bicycling Conditions – Enter the bicycle LOS for a typical shared use lane segment. Enter the bicycle LOS for a typical bicycle lane/paved shoulder segment. Enter the same bicycle LOS for a typical shared use path adjacent to roadway segment. Enter 0.5 for a typical independent alignment segment. The bicycle LOS is a measure of the bicyclist's perceived stress level. A higher value denotes a higher perceived stress level. The bicycle LOS is used in both the utilitarian and recreational models. The calculation engine will adjust the bicycle LOS for shared use paths adjacent to roadways using the distance between the shared use path and the roadway and the speed limit. The values range from 0.75 to 2. In other words, bicyclists perceive less stress on shared use paths adjacent to roadways than on bike lanes or in shared use lanes.
- Row 13, Trip Length of Travelers in Corridor – Enter the average trip length (miles) for all trips in the corridor. This value is used in the utilitarian model. The average trip length can be obtained by conducting an intercept survey of corridor users. The average trip length can also be approximated by the following equation ($R^2 = 0.878$)[1]:

Avg. trip length = -3.784 + 0.364 * speed limit – 0.975 * signals per mile

- Row 14, Average Utilitarian Bike Trip Length - The average length of a utilitarian bicycle trip is assumed to be 3 miles.[2] This value is used to calculate annual utilitarian trips, which in turn is used to calculate energy savings and health benefits associated with additional utilitarian bicycling.

[1] This model was developed by staff at Sprinkle Consulting, Inc. using average trip lengths from intercept surveys.

[2] Center for Urban Transportation Research and NuStats, Inc. *Bicycle and Pedestrian Travel: Exploration of Collision Exposure in Florida*. Final Report. University of South Florida, Tampa, September 2002.

- Row 15, Motor Vehicle Facility LOS – Enter the motor vehicle facility LOS, as defined in the FDOT Q/LOS Handbook.[3] The possible values are A, B, C, D, E, and F. This value is used in the utilitarian model.
- Row 16, Bus Frequency during PM Peak – Enter the number of buses per hour that stop within 0.25 mile of the cut line during the PM peak. Enter 0 if there is no bus transit in the corridor or if there are no bus stops within 0.25 mile of the cut line. The calculation engine translates the combined frequency of buses and trains (see also Row 15) into a transit QOS value, as defined in the FDOT Q/LOS Handbook.[4] The transit QOS value is used in the utilitarian model.
- Row 17, Rapid Transit Frequency during PM Peak – Enter the number of trains or bus rapid transit buses per hour that stop within 0.50 mile of the cut line during the PM peak. Enter 0 if there is no rapid transit in the corridor or if there are no rapid transit stops within 0.50 mile of the cut line. Since buses generally share the roadway with cars, the utility of conventional bus transit depends in part on the motor vehicle facility LOS. Rapid transit lines (such as Miami's Metrorail) often do not share the roadway with cars. In that case, the utility of rapid transit does not depend on the motor vehicle facility LOS. If a value greater than 0 is entered, then the corridor has rapid transit, and the calculation engine sets the motor vehicle facility LOS to A for the purpose of estimating the transit mode share.
- Row 18, Walking Conditions – Enter the pedestrian LOS for a typical shared use lane segment. Enter the pedestrian LOS for a typical bicycle lane/paved shoulder segment. Enter the pedestrian LOS for a typical shared use path adjacent to roadway segment. Enter 0.5 for a typical independent alignment segment. In other words, pedestrians perceive less stress on independent alignments than on any other facility type. The pedestrian LOS is a measure of the pedestrian's perceived stress level. A higher value denotes a higher perceived stress level. The pedestrian LOS is used in the utilitarian model.

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[3] FDOT, *2002 Quality/Level of Service Handbook*. Florida Department of Transportation, Tallahassee, FL, 2002.
[4] *Ibid*.

- Row 19, Population in Network Analysis Zone – Enter the population within the corridor's network analysis zone.[5]
- Row 20, Employment in Network Analysis Zone – Enter the number of employees within the corridor's network analysis zone.
- Row 21, Area of Network Analysis Zone – Enter the area of the network analysis zone, in square miles. The calculation engine multiplies the population by the employment and divides by the area to obtain population * employment density, which is used in the utilitarian model.
- Row 22, Bike Network Friendliness – Enter the bicycle network friendliness, to two decimal places. The bicycle network friendliness is a weighted average of bicycling conditions on arterials and collectors within the network analysis zone. It measures the quality of the surrounding roadway network as it accommodates bicycling. The minimum value is 0.00 and the maximum value is 1.00.[6] This value is used in the utilitarian model.
- Row 23, Ped Network Friendliness – Enter the pedestrian network friendliness, to two decimal places. The pedestrian network friendliness is a weighted average of walking conditions on arterials and collectors within the network analysis zone. It measures the quality of the surrounding roadway network as it accommodates walking. The minimum value is 0.00 and the maximum value is 1.00. This value is used in the utilitarian model.
- Row 26, Distance-Weighted Population within 10 Miles – The distance-weighted population is a measure of how many people live in the area surrounding the cut line, weighted by how close they live.[7] This value is used in the recreational model.
  The distance-weighted population within 10 miles is calculated by the equation:

[5] A detailed explanation of network analysis zones appears in the report, *Conserve by Bicycle Program Study: Bicycle Mode Shift and Induced Travel Models*.

[6] Detailed explanations of bicycle network friendliness and pedestrian network friendliness appear in the report, *Conserve by Bicycle Program Study: Bicycle Mode Shift and Induced Travel Models*.

[7] A detailed explanation of distance-weighted population appears in the report, *Conserve by Bicycle Program Study: Bicycle Mode Shift and Induced Travel Models*.

$$Pop\_10 = \sum_{i=1}^{n} \frac{pop_i}{d_i^2}$$

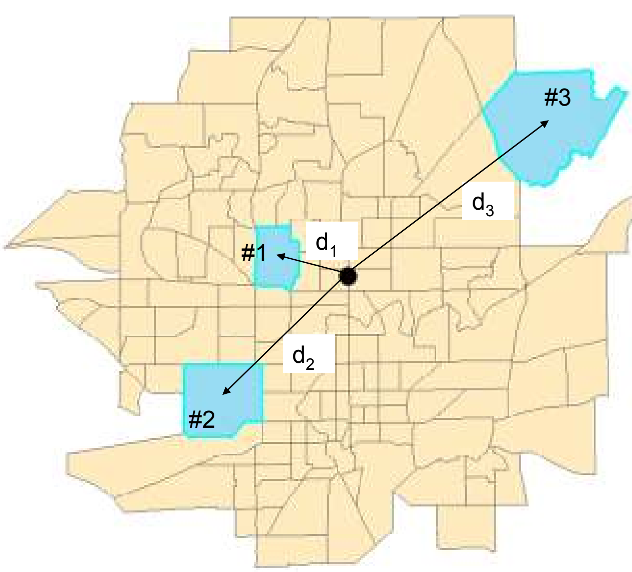
where

$pop_i$ = Population of the i-th Census tract

$d_i^2$ = Distance (in miles) of the i-th Census tract from the cut line, squared

n = Total number of Census tracts whose centroids are within a specified distance (in this case, 10 miles) of the cut line

The figure below shows a cut line (represented by a black circle) surrounded by numerous Census tracts that are within 10 miles. Census Tracts 1, 2, and 3 are highlighted in blue. These tracts are located at distances $d_1$, $d_2$, and $d_3$ from the cut line. The population of Tract 1 is divided by the square of its distance from the cut line to obtain a distance-weighted population for Tract 1. The process is repeated for Tracts 2, 3, etc., until distance-weighted populations have been obtained for all of the tracts. The distance-weighted populations are then added together to obtain the distance-weighted population within 10 miles.




- Row 27, Aesthetics – Enter a value of 1 (lowest), 2, 3, 4, or 5 (highest). This value is used in the recreational model.

- Row 28, Points of Interest – Enter a value of 1 (least), 2, or 3 (most). This value is used in the recreational model.
- Row 29, Facility Length – Enter the facility length (miles). The facility length is the length of the continuous cross section. Facility length is used in the recreational model.
- Row 30, Average Recreational Bike Trip Length - The average length of a recreational bicycle trip is assumed to be 5 miles.[8] This value is used to calculate annual recreational trips, which in turn is converted to annual recreational users and then to health benefits of induced recreational bicycling.
- Row 33, Total People passing a cut line per weekday, all modes – Enter the total number of people passing the corridor cut line per weekday for utilitarian purposes. This value is used to estimate the number of utilitarian trips by each mode.
- Row 34, Utilitarian Trips (passing a cut line per day) – The utilitarian model is used to predict the daily number of utilitarian trips passing a cut line.
- Row 35, Day-to-Week Adjustment Factor (Util) – It is assumed that one weekday accounts for 17 percent of utilitarian bicycle trips during a week.[9] The utilitarian model predicts daily trips for each mode. This factor expands weekday trips to weekly trips.
- Row 36, Utilitarian Trips (passing a cut line per year) – The calculation engine expands daily trips to annual trips. The calculation engine first expands weekday trips to weekly trips, and then multiplies the weekly value by 52.14 (weeks in a year) to obtain the annual number of utilitarian trips passing a cut line in the corridor.
- Row 38, Peak-to-Day Adjustment Factor (Rec) – This factor, which has a value of 0.25, expands PM peak trips to weekday daily trips. It is based on average of data from the National Bicycle & Pedestrian Documentation Project, which found that 24% of daily bicycle counts on commuter facilities occur between 3 PM and 6 PM, while 25.5% of daily bicycle counts on recreational facilities occur between 3 PM and 6 PM.[10]

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[8] Feeney, Stephen J. *The Mohawk-Hudson Bike-Hike Trail*. Schenectady County Department of Planning, Schenectady, NY, November 1998.

[9] This value is based on data from the National Bicycle & Pedestrian Documentation Project.

[10] Jones, Michael and Lauren Buckland. National Bicycle & Pedestrian Documentation Project. Presentation given to the Transportation Research Board, January 2006.

- Row 40, Recreation Bicycle Trips (passing a cut line per weekday) – The recreational model is used to predict the number of recreational trips passing a cut line between 3 PM and 6 PM. These PM peak trips are then expanded to daily trips.
- Row 41, Day-to-Week Adjustment Factor (Rec) – It is assumed that one weekday accounts for 13 percent of recreational bicycle trips during a week.[11] This factor expands weekday trips to weekly trips.
- Row 42, Recreation Trips (passing a cut line per year) – The calculation engine expands daily trips to annual trips. The calculation engine first expands weekday trips to weekly trips, and then multiplies the weekly value by 52.14 (weeks in a year) to obtain the annual number of recreational trips passing a cut line in the corridor.
- Row 46, Average Utilitarian Bike Trip Length – The value entered in Row 14 is repeated here.
- Row 47, Average Recreational Bike Trip Length – The value entered in Row 30 is repeated here.
- Row 48, Adjusted Facility Length (utilitarian) – The adjusted facility length for utilitarian bicycle trips has a maximum value of 6 miles. The length of a utilitarian bicycle trip is 3 miles, so 3 miles on either side of a cut line is 6 miles total. The adjusted facility length is less than 6 miles if the cut line is within 3 miles of a facility end point.
- Row 49, Adjusted Facility Length (recreational) – The adjusted facility length for recreational trips has a maximum value of 10 miles. The length of a recreational bicycle trip is 5 miles, so 5 miles on either side of a cut line is 10 miles. The adjusted facility length is less than 6 miles if the cut line is within 5 miles of a facility end point.
- Row 50, Utilitarian Bicycle Trips/Year (on facility) – The calculation engine expands the number of utilitarian bicycle trips passing a cut line per year (Row 36) to the number of utilitarian bicycle trips on the facility by multiplying by the ratio of the adjusted facility length (Row 48) and average utilitarian bike trip length (Row 46). If the ratio is less than one, then the number of trips on the facility (Row 50) is set equal to the number of trips passing the cut line (Row 36).

[11] *Ibid*.

- Row 51, Mode Shift (# of utilitarian bicycle trips/year on facility) (relative to baseline) – The mode shift is the number of additional utilitarian trips for the bicycle lane/paved shoulder, shared use path adjacent to roadway, and independent alignment conditions (relative to the baseline condition).
- Row 53, Recreational Bicycle Trips/Year (on facility) – The calculation engine expands the number of recreational bicycle trips passing a cut line per year (Row 42) to the number of recreational bicycle trips on the facility by multiplying by the ratio of the adjusted facility length (Row 49) and average recreational bike trip length (Row 47). If the ratio is less than one, then the number of trips on the facility (Row 53) is set equal to the number of trips passing the cut line (Row 42).
- Row 54, Induced Recreation (# of recreational bicycle trips/year on facility) (relative to baseline) – The induced recreation is the number of additional recreational trips for the bicycle lane/paved shoulder, shared use path adjacent to roadway, and independent alignment conditions (relative to the baseline condition).
- Row 58, Health Benefit of Being Physically Active – This value is about 49 cents per trip. The research[12] defines physically active as 30 minutes of physical activity, 5 times a week and identifies an average health benefit of $128 per person per year. Five times a week translates into 260 times (*i.e.*, trips) a year, so the average health benefit of $128 per person per year is divided by 260 trips per person per year to obtain a benefit of about 49 cents per trip.
- Row 59, Annual Health Benefit – This value assumes that the health benefit for each additional trip (not unique user) is about 49 cents. The benefits are for each improvement (bicycle lane/paved shoulder, shared use path adjacent to roadway, independent alignment) relative to the baseline.
- Row 63, Car Occupancy – It is assumed that the average car has 1.43 occupants, based on data from the Center for Urban Transportation Research.[13] This factor is used in estimating energy savings.

[12] Krizek, Kevin J., *et al.* *Guidelines for Analysis of Investments in Bicycle Facilities*. NCHRP Report 552. TRB, National Research Council, Washington, DC, 2006.

[13] E-mail from Sara Hendricks, Center for Urban Transportation Research, to Herman Huang, Sprinkle Consulting, Inc.

- Row 64, Price per Gallon of Gas – Enter the prevailing price of a gallon of gas, in dollars and cents. This value is used to calculate energy savings.
- Row 65, Fuel Savings – It is assumed that for every 20 miles of motor vehicle travel that are mode shifted to bicycling, one gallon of gas is saved.[14] This value is used to calculate energy savings.
- Row 67, Energy Savings – The energy savings is calculated by multiplying the average utilitarian bicycle trip length (Row 46), the annual number of utilitarian trips along the facility (Row 50), and the price per gallon of gas (Row 64), then dividing by fuel savings (Row 65) and the average car occupancy (Row 63). It is assumed that there are no energy savings associated with induced recreational bicycling because those trips are not mode-shifted from the motor vehicle mode.
- Row 70, Combined Health & Energy Benefits – This is the sum of the annual health benefit (Row 59) and the annual energy savings (Row 67). This value represents the annual combined health and energy benefits relative to the baseline.
- Row 74, Benefits per Mile of Facility – This is the combined health and energy benefits (Row 70) divided by the length of the facility improvement (Row 29). This value represents the annual health and energy benefits per mile of facility improvement.

The spreadsheet on the following two pages lists each of the 17 study corridors. For purposes of comparison, the baseline condition is assumed to be "Shared Use Lane." Thus, the additional trips and benefits shown compare each improvement (bicycle lane, shared use path adjacent to roadway, independent alignment) with "No bike facilities." The same process as described above was used to obtain the predicted trips and benefits.

[14] Davis, Stacy C. and Susan W. Diegel. *Transportation Energy Data Book: Edition 25*. Report No. ORNL-6974. Oak Ridge National Laboratory, Oak Ridge, TN, 2006.

Health Benefits and Energy Savings per Facility

| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | ID | CORRIDOR | FACILITY TYPE | ADDL UTIL TRIPS/YR (Commute) | UTIL HEALTH BENEFIT ($/YR) | UTIL ENERGY BENEFIT ($/YR) | | ADDL REC TRIPS/YR (Recreat.) | REC HEALTH BENEFIT ($/YR) | COMBINED BENEFITS ($/YR) | BENEFITS PER MILE ($/YR) |
| 4 | 1 | 18th St S | Shared Use Lane | | | | | | | | |
| 5 | 1 | 18th St S | Bicycle Lane | 1332 | $341 | $234 | | 1 | $0 | $575 | $312 |
| 6 | 1 | 18th St S | Shared Use Path Adjacent to Roadway | 3516 | $1,252 | $801 | | 3 | $1 | $2,054 | $1,353 |
| 7 | 1 | 18th St S | Independent Alignment | 11858 | $3,854 | $3,152 | | 25 | $11 | $7,004 | $3,676 |
| 8 | 2 | 31st St N | Shared Use Lane | | | | | | | | |
| 9 | 2 | 31st St N | Bicycle Lane | 3028 | $1,407 | $930 | | 25 | $12 | $2,449 | $472 |
| 10 | 2 | 31st St N | Shared Use Path Adjacent to Roadway | 10823 | $9,805 | $6,258 | | 125 | $82 | $16,145 | $1,110 |
| 11 | 2 | 31st St N | Independent Alignment | 60257 | $25,880 | $15,151 | | 708 | $345 | $41,480 | $8,590 |
| 12 | 3 | Bruce B Downs / Commerce Palms | Shared Use Lane | | | | | | | | |
| 13 | 3 | Bruce B Downs / Commerce Palms | Bicycle Lane | 44 | $22 | $20 | | 2 | $1 | $43 | $10 |
| 14 | 3 | Bruce B Downs / Commerce Palms | Shared Use Path Adjacent to Roadway | 7203 | $2,504 | $2,343 | | 85 | $40 | $4,853 | $1,152 |
| 15 | 3 | Bruce B Downs / Commerce Palms | Independent Alignment | 12791 | $6,253 | $5,720 | | 224 | $142 | $12,125 | $2,921 |
| 16 | 4 | Bruce B Downs / SR 56 | Shared Use Lane | | | | | | | | |
| 17 | 4 | Bruce B Downs / SR 56 | Bicycle Lane | 5 | $2 | $2 | | 61 | $40 | $44 | $5 |
| 18 | 4 | Bruce B Downs / SR 56 | Shared Use Path Adjacent to Roadway | 439 | $218 | $138 | | 808 | $445 | $799 | $118 |
| 19 | 4 | Bruce B Downs / SR 56 | Independent Alignment | 1686 | $806 | $615 | | 4380 | $2,145 | $3,466 | $504 |
| 20 | 5 | CR 550 | Shared Use Lane | | | | | | | | |
| 21 | 5 | CR 550 | Bicycle Lane | 10 | $5 | $3 | | 2 | $1 | $9 | $3 |
| 22 | 5 | CR 550 | Shared Use Path Adjacent to Roadway | 432 | $219 | $150 | | 24 | $12 | $381 | $106 |
| 23 | 5 | CR 550 | Independent Alignment | 1281 | $639 | $406 | | 124 | $61 | $1,106 | $334 |
| 24 | 6 | Elgin | Shared Use Lane | | | | | | | | |
| 25 | 6 | Elgin | Bicycle Lane | [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] |
| 26 | 6 | Elgin | Shared Use Path Adjacent to Roadway | 1144 | [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] |
| 27 | 6 | Elgin | Independent Alignment | [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] |
| 28 | 7 | Lutz-Lake Fern | Shared Use Lane | | | | | | | | |
| 29 | 7 | Lutz-Lake Fern | Bicycle Lane | 4 | $2 | $1 | | 80 | $15 | $16 | $3 |
| 30 | 7 | Lutz-Lake Fern | Shared Use Path Adjacent to Roadway | 340 | $187 | $137 | | 860 | $416 | $690 | $102 |
| 31 | 7 | Lutz-Lake Fern | Independent Alignment | 1018 | $501 | $326 | | 4232 | $2,132 | $2,454 | $422 |
| 32 | 8 | Nebraska | Shared Use Lane | | | | | | | | |
| 33 | 8 | Nebraska | Bicycle Lane | 10840 | $5,401 | $3,452 | | 458 | $226 | $9,079 | $906 |
| 34 | 8 | Nebraska | Shared Use Path Adjacent to Roadway | 351819 | $170,198 | $113,858 | | 6056 | $3,130 | $285,118 | $31,295 |
| 35 | 8 | Nebraska | Independent Alignment | 1251711 | $609,891 | $387,601 | | 32295 | $16,382 | $1,010,374 | $107,487 |

| | A | B | C | G | I | K | L | N | O | Q | R | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | ID | CORRIDOR | FACILITY TYPE | ADD'L UTIL. BI. DAYS (annual) | UTIL. HEALTH BENEFIT (NPV) | UTIL. ENERGY BENEFIT (NPV) | | ADD'L REC. TRIPS (annual) | REC HEALTH BENEFIT (NPV) | | COMBINED BENEFITS (NPV) | BENEFITS PER MILE (NPV) |
| 36 | 9 | SR 60 | Shared Use Lane | | | | | | | | | |
| 37 | 9 | SR 60 | Bicycle Lane | 185 | $91 | $3 | | 641 | $316 | | $410 | $19 |
| 38 | 9 | SR 60 | Shared Use Path Adjacent to Roadway | 7278 | $3,531 | $775 | | 9870 | $3,234 | | $7,842 | $335 |
| 39 | 9 | SR 60 | Independent Alignment | 218410 | $103,380 | $22,512 | | 35542 | $16,533 | | $142,891 | $6,694 |
| 40 | 10 | US 441 | Shared Use Lane | | | | | | | | | |
| 41 | 10 | US 441 | Bicycle Lane | [illegible] | [illegible] | [illegible] | | 1575 | [illegible] | | [illegible] | [illegible] |
| 42 | 10 | US 441 | Shared Use Path Adjacent to Roadway | 2227 | [illegible] | [illegible] | | 12607 | [illegible] | | [illegible] | [illegible] |
| 43 | 10 | US 441 | Independent Alignment | 7044 | [illegible] | [illegible] | | [illegible] | [illegible] | | [illegible] | [illegible] |
| 44 | 11 | 20th St | Shared Use Lane | | | | | | | | | |
| 45 | 11 | 20th St | Bicycle Lane | 14 | $7 | $3 | | 0 | $0 | | $10 | $5 |
| 46 | 11 | 20th St | Shared Use Path Adjacent to Roadway | 253 | $146 | $57 | | 5 | $2 | | $202 | $103 |
| 47 | 11 | 20th St | Independent Alignment | 892 | $428 | $190 | | 29 | $13 | | $310 | $326 |
| 48 | 12 | US 1 (M Pier) | Shared Use Lane | | | | | | | | | |
| 49 | 12 | US 1 (M Pier) | Bicycle Lane | 7080 | $3,575 | $7,611 | | 131 | $64 | | $8,604 | $711 |
| 50 | 12 | US 1 (M Pier) | Shared Use Path Adjacent to Roadway | 1250254 | $325,654 | $585,834 | | 2210 | $2,040 | | $382,158 | $120,010 |
| 51 | 12 | US 1 (M Pier) | Independent Alignment | [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | | [illegible] | [illegible] |
| 52 | 13 | Sunrise | Shared Use Lane | | | | | | | | | |
| 53 | 13 | Sunrise | Bicycle Lane | 634 | $312 | $120 | | 0 | $0 | | $432 | $240 |
| 54 | 13 | Sunrise | Shared Use Path Adjacent to Roadway | 15022 | $8,672 | $3,403 | | 5 | $2 | | $12,276 | $6,821 |
| 55 | 13 | Sunrise | Independent Alignment | 57070 | $36,098 | $13,778 | | 23 | $12 | | $59,864 | $21,305 |
| 56 | 14 | [illegible] | Shared Use Lane | | | | | | | | | |
| 57 | 14 | [illegible] | Bicycle Lane | 405 | [illegible] | [illegible] | | [illegible] | [illegible] | | [illegible] | [illegible] |
| 58 | 14 | [illegible] | Shared Use Path Adjacent to Roadway | 13738 | [illegible] | [illegible] | | [illegible] | [illegible] | | [illegible] | [illegible] |
| 59 | 14 | [illegible] | Independent Alignment | 124075 | [illegible] | [illegible] | | [illegible] | [illegible] | | [illegible] | [illegible] |
| 60 | 15 | St Marks | Shared Use Lane | | | | | | | | | |
| 61 | 15 | St Marks | Bicycle Lane | 17 | $8 | $6 | | 1280 | $635 | | $649 | $24 |
| 62 | 15 | St Marks | Shared Use Path Adjacent to Roadway | 787 | $357 | $248 | | 13229 | $6,492 | | $7,197 | $257 |
| 63 | 15 | St Marks | Independent Alignment | 27028 | $13,511 | $1,530 | | 47153 | $22,039 | | $54,079 | $3,572 |
| 64 | 16 | Sheldon (Upper Tampa Bay) | Shared Use Lane | | | | | | | | | |
| 65 | 16 | Sheldon (Upper Tampa Bay) | Bicycle Lane | [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | | [illegible] | [illegible] |
| 66 | 16 | Sheldon (Upper Tampa Bay) | Shared Use Path Adjacent to Roadway | [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | | [illegible] | [illegible] |
| 67 | 16 | Sheldon (Upper Tampa Bay) | Independent Alignment | [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | | [illegible] | [illegible] |
| 68 | 17 | West Orange | Shared Use Lane | | | | | | | | | |
| 69 | 17 | West Orange | Bicycle Lane | 6 | $3 | $5 | | 135 | $34 | | $33 | $5 |
| 70 | 17 | West Orange | Shared Use Path Adjacent to Roadway | 1037 | $538 | $562 | | 12549 | $5,723 | | $7,100 | $374 |
| 71 | 17 | West Orange | Independent Alignment | 5365 | $1,613 | $1,622 | | 54461 | $32,713 | | $35,958 | $1,861 |

## APPENDIX N Supplemental Figures

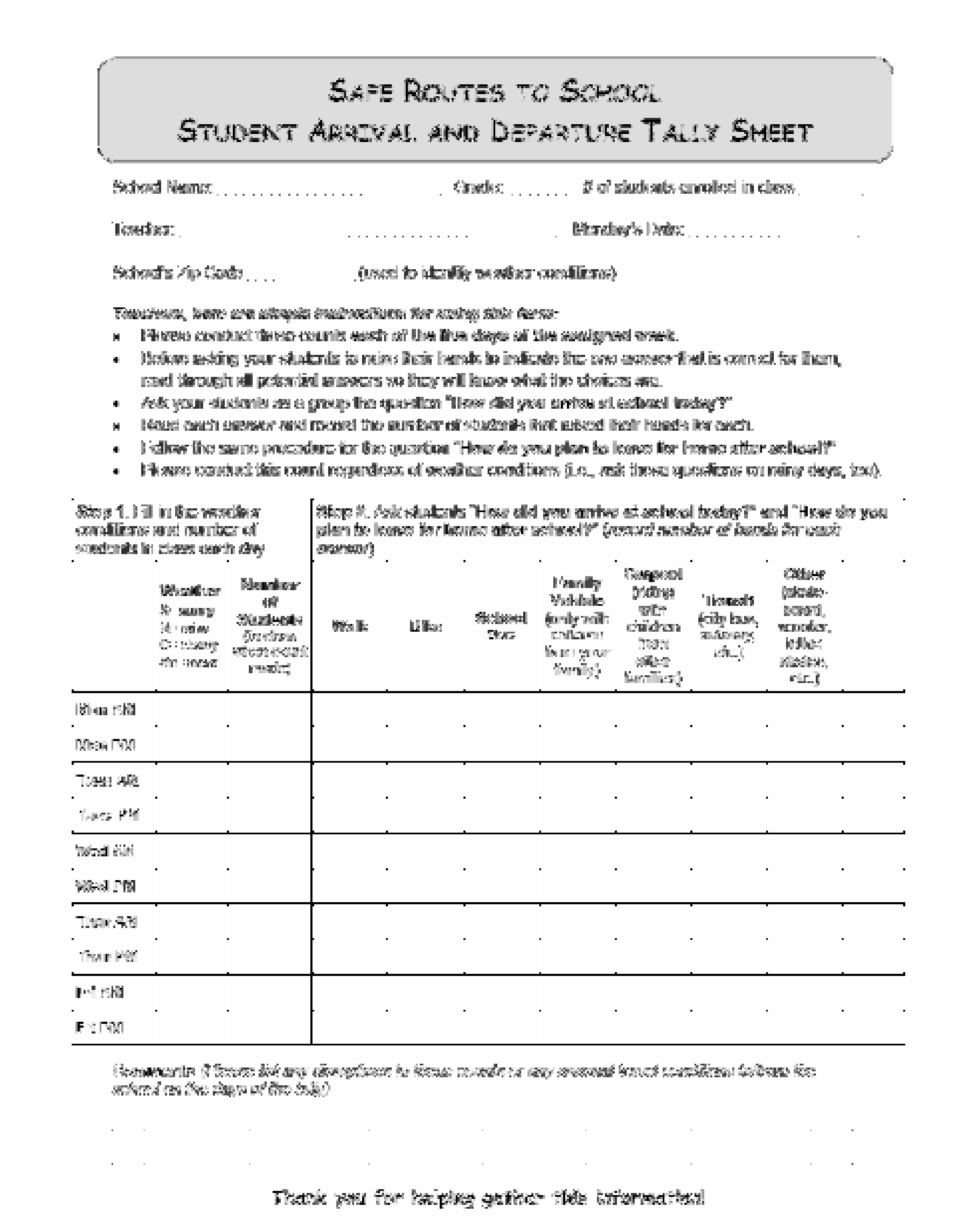



Figure N-1 Student survey for FDOT Safe Routes to School (Source: National Center for Safe Routes to School)

## SURVEY ABOUT WALKING AND BIKING TO SCHOOL
## - FOR PARENTS -

**Dear Parent or Caregiver,**

Your child's school wants to learn your thoughts about children walking and biking to school. This survey will take about 10 - 15 minutes to complete. We ask that each family complete only one survey per school your children attend. If more than one child from a school brings a survey home, please fill out the survey for the child with the next birthday from today's date.

After you have completed this survey, send it back to the school with your child or give it to the teacher. Your responses will be kept confidential and neither your name nor your child's name will be associated with any results. **Thank you for participating in this survey!**

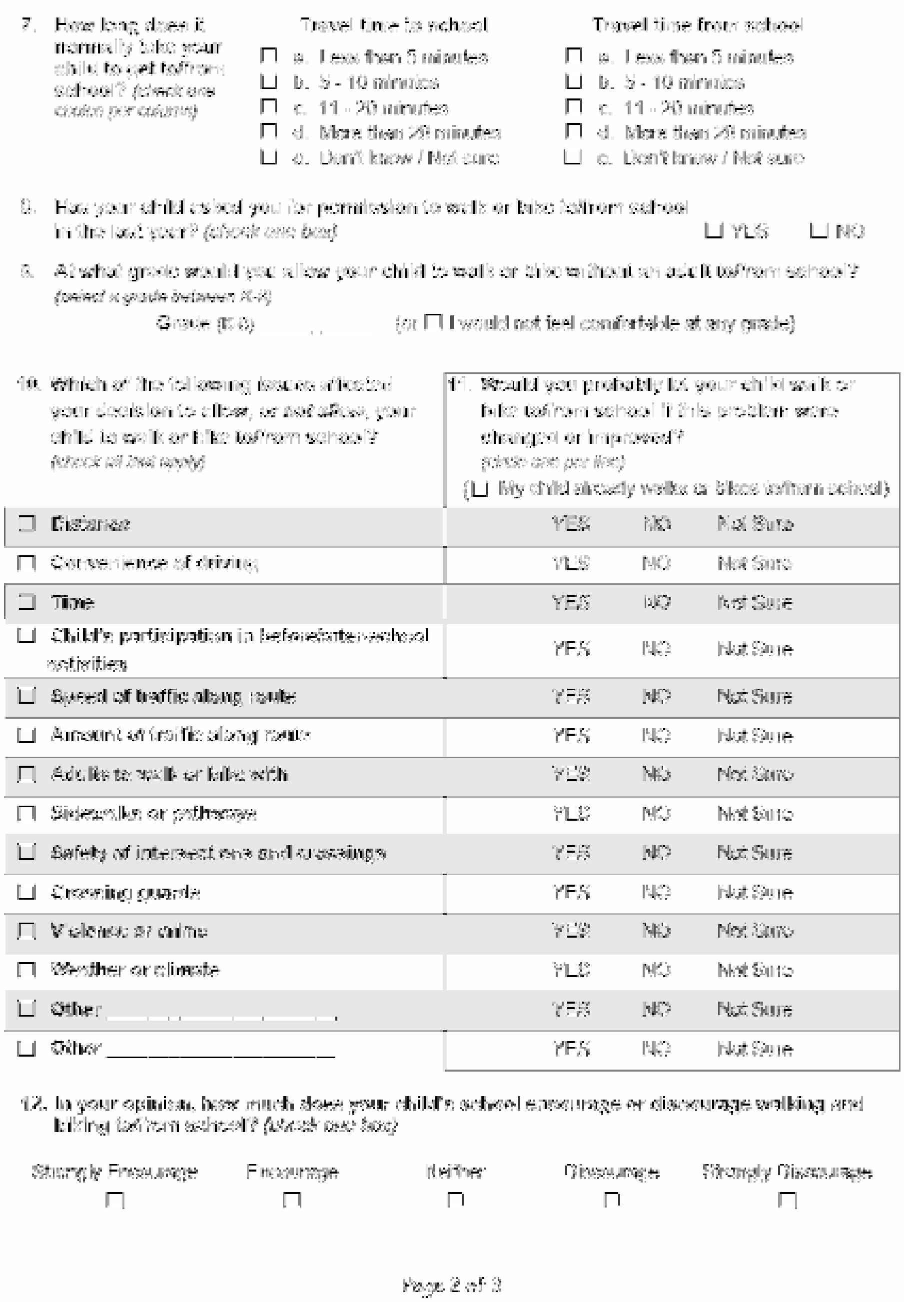
***These first few questions gather some general and background information.***
*Remember, all information will be confidential, and no identifying information will be released.*

1. What is the grade of the child who brought home this survey? (K – 8) ________ grade
2. Is the child who brought home this survey male or female? ☐ MALE ☐ FEMALE
3. How many children do you have in Kindergarten through 8th grade? _______ children
4. What is your ZIP Code? *(please provide ZIP+4 if known)* _________ ZIP code *(note: many utility bills will show your ZIP+4)*
5. How far does your child live from school? *(choose one)*
   - ☐ a. Less than 1/4 mile
   - ☐ b. 1/4 mile up to 1/2 mile
   - ☐ c. 1/2 mile up to 1 mile
   - ☐ d. 1 mile up to 2 miles
   - ☐ e. More than 2 miles
   - ☐ f. Don't know
6. On most days, how does your child arrive at school and leave for home after school? *(circle one choice per column)*

| Arrive at school | Leave for home |
|---|---|
| a. Walk | a. Walk |
| b. Bike | b. Bike |
| c. School bus | c. School bus |
| d. Family vehicle (only with children from your family) | d. Family vehicle (only with children from your family) |
| e. Carpool (riding with children from other families) | e. Carpool (riding with children from other families) |
| f. Transit (city bus, subway, etc.) | f. Transit (city bus, subway, etc.) |
| g. Other (skateboard, scooter, inline skates, etc.) | g. Other (skateboard, scooter, inline skates, etc.) |

Page 1 of 3

Figure N-2 Parent survey, FDOT Safe Routes to School, page 1 (Source: National Center for Safe Routes to School)



7. How long does it normally take your child to get to/from school? *(check one choice per column)*

| Travel time to school | Travel time from school |
|---|---|
| ☐ a. Less than 5 minutes | ☐ a. Less than 5 minutes |
| ☐ b. 5 - 10 minutes | ☐ b. 5 - 10 minutes |
| ☐ c. 11 - 20 minutes | ☐ c. 11 - 20 minutes |
| ☐ d. More than 20 minutes | ☐ d. More than 20 minutes |
| ☐ e. Don't know / Not sure | ☐ e. Don't know / Not sure |

8. Has your child asked you for permission to walk or bike to/from school in the last year? *(check one box)* ☐ YES ☐ NO

9. At what grade would you allow your child to walk or bike without an adult to/from school? *(select a grade between K-8)*

Grade (K-8) ________ (or ☐ I would not feel comfortable at any grade)

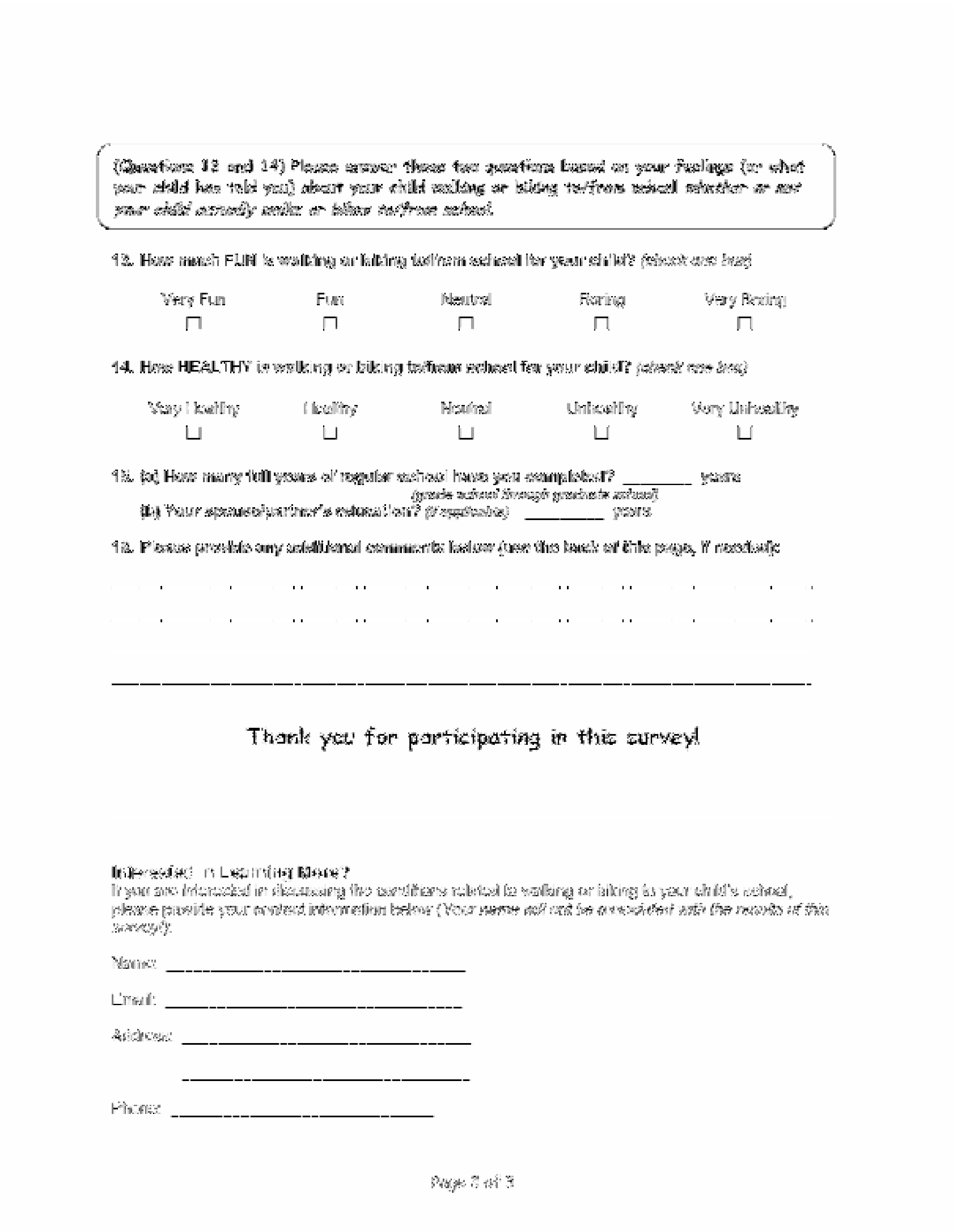
| 10. Which of the following issues affected your decision to allow, or not allow, your child to walk or bike to/from school? *(check all that apply)* | 11. Would you probably let your child walk or bike to/from school if this problem were changed or improved? *(circle one per line)* (☐ My child already walks or bikes to/from school) | | |
|---|---|---|---|
| ☐ Distance | YES | NO | Not Sure |
| ☐ Convenience of driving | YES | NO | Not Sure |
| ☐ Time | YES | NO | Not Sure |
| ☐ Child's participation in before/after-school activities | YES | NO | Not Sure |
| ☐ Speed of traffic along route | YES | NO | Not Sure |
| ☐ Amount of traffic along route | YES | NO | Not Sure |
| ☐ Adults to walk or bike with | YES | NO | Not Sure |
| ☐ Sidewalks or pathways | YES | NO | Not Sure |
| ☐ Safety of intersections and crossings | YES | NO | Not Sure |
| ☐ Crossing guards | YES | NO | Not Sure |
| ☐ Violence or crime | YES | NO | Not Sure |
| ☐ Weather or climate | YES | NO | Not Sure |
| ☐ Other ____________ | YES | NO | Not Sure |
| ☐ Other ____________ | YES | NO | Not Sure |

12. In your opinion, how much does your child's school encourage or discourage walking and biking to/from school? *(check one box)*

| Strongly Encourage | Encourage | Neither | Discourage | Strongly Discourage |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

Page 2 of 3

Figure N-3 Parent survey, FDOT Safe Routes to School, page 2 (Source: National Center for Safe Routes to School)



(Questions 13 and 14) Please answer these two questions based on your feelings (or what your child has told you) about your child walking or biking to/from school *whether or not your child actually walks or bikes to/from school.*

13. How much **FUN** is walking or biking to/from school for your child? *(check one box)*

| Very Fun | Fun | Neutral | Boring | Very Boring |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

14. How **HEALTHY** is walking or biking to/from school for your child? *(check one box)*

| Very Healthy | Healthy | Neutral | Unhealthy | Very Unhealthy |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

15. (a) How many full years of regular school have you completed? ________ years
*(grade school through graduate school)*
(b) Your spouse's/partner's education? *(if applicable)* ________ years

16. Please provide any additional comments below (use the back of this page, if needed):

______________________________________________

**Thank you for participating in this survey!**

**Interested in Learning More?**
If you are interested in discussing the conditions related to walking or biking to your child's school, please provide your contact information below *(Your name will not be associated with the results of this survey).*

Name: ______________________________

Email: ______________________________

Address: ______________________________

______________________________

Phone: __________________________

Page 3 of 3

Figure N-4 Parent survey, FDOT Safe Routes to School, page 3 (Source: National Center for Safe Routes to School)

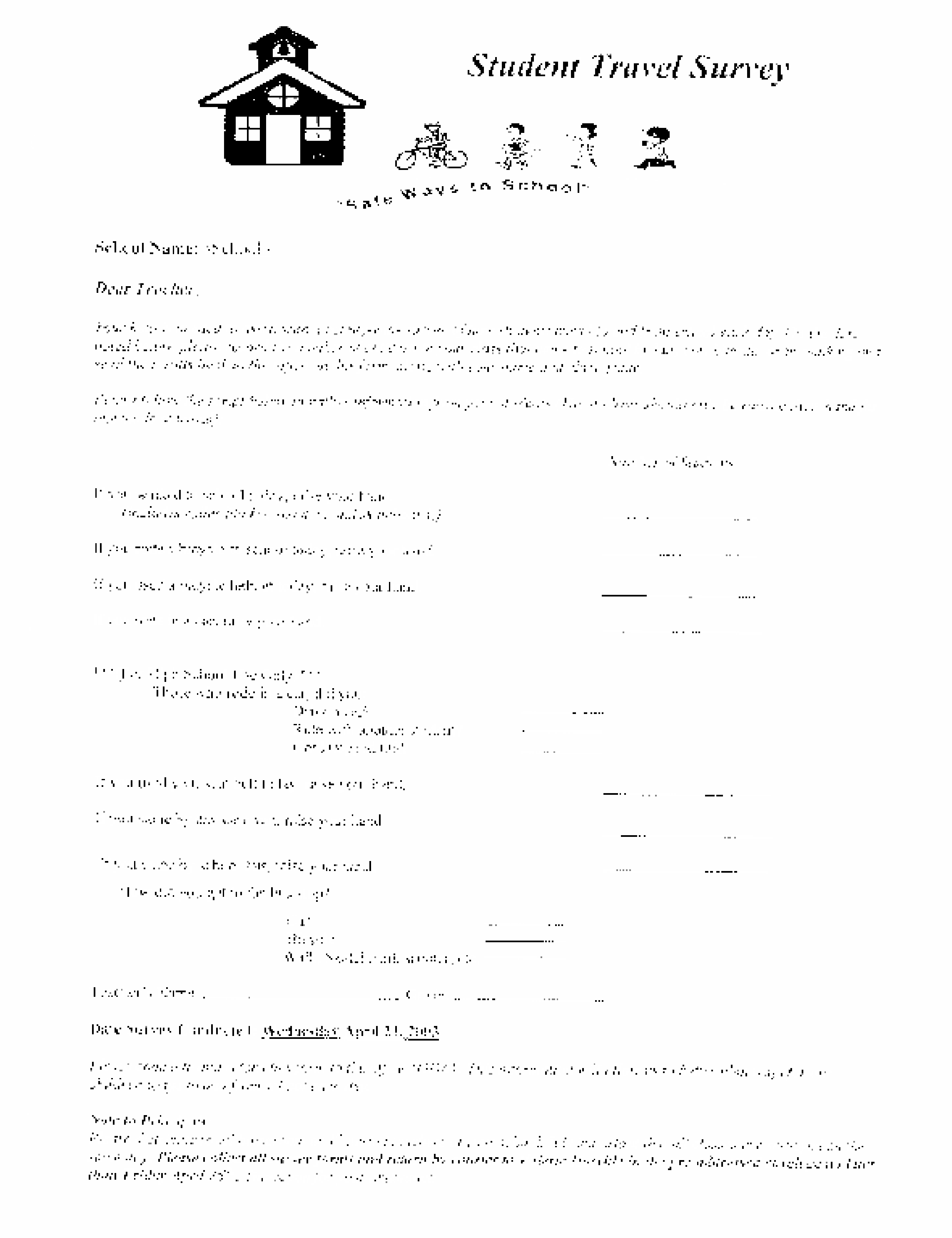



Figure N-5 Student travel survey, Brevard County Schools, 2003

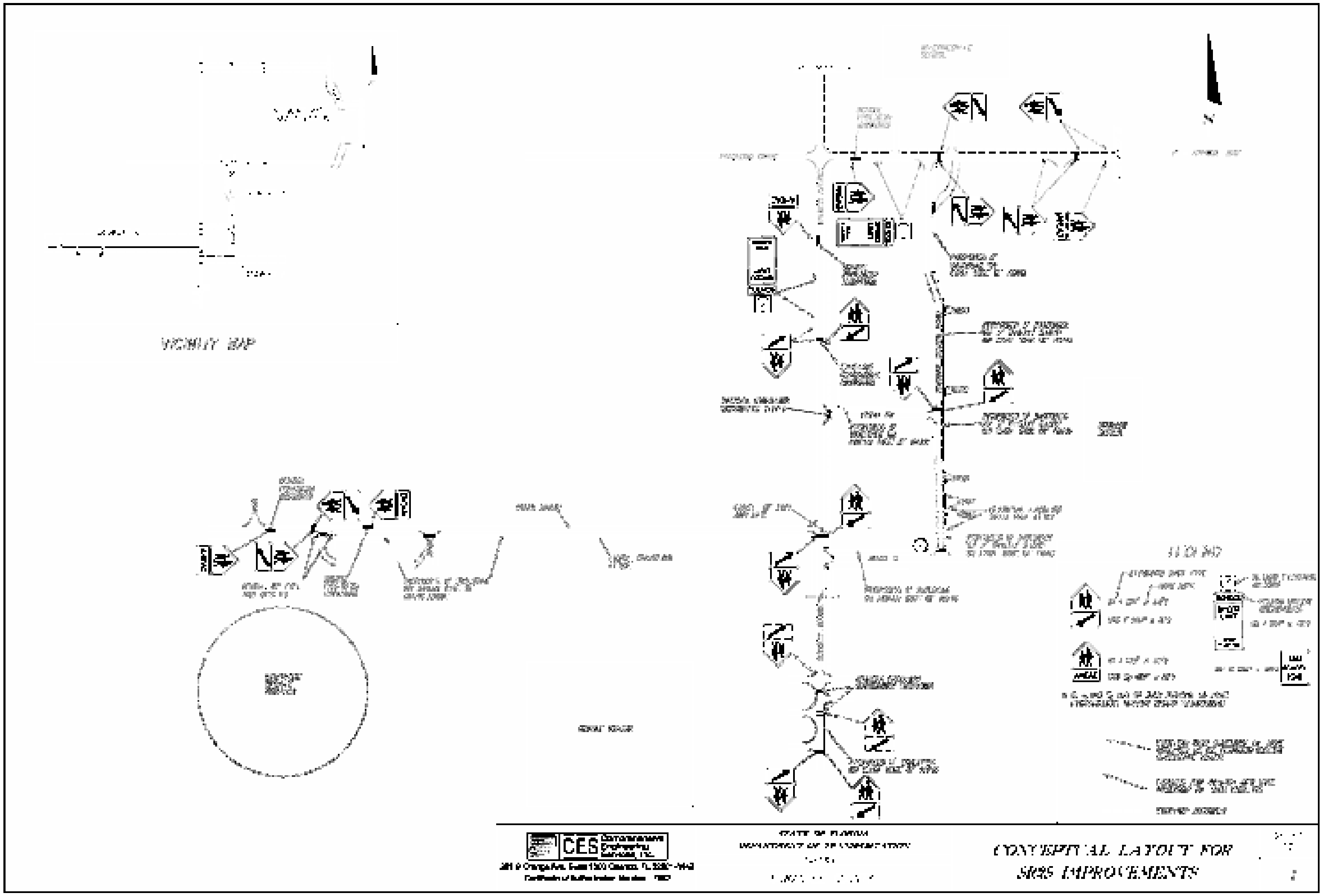



Figure N-6 Conceptual layout for Safe Routes to School improvements, Suwannee County, Florida (Sheet #1)

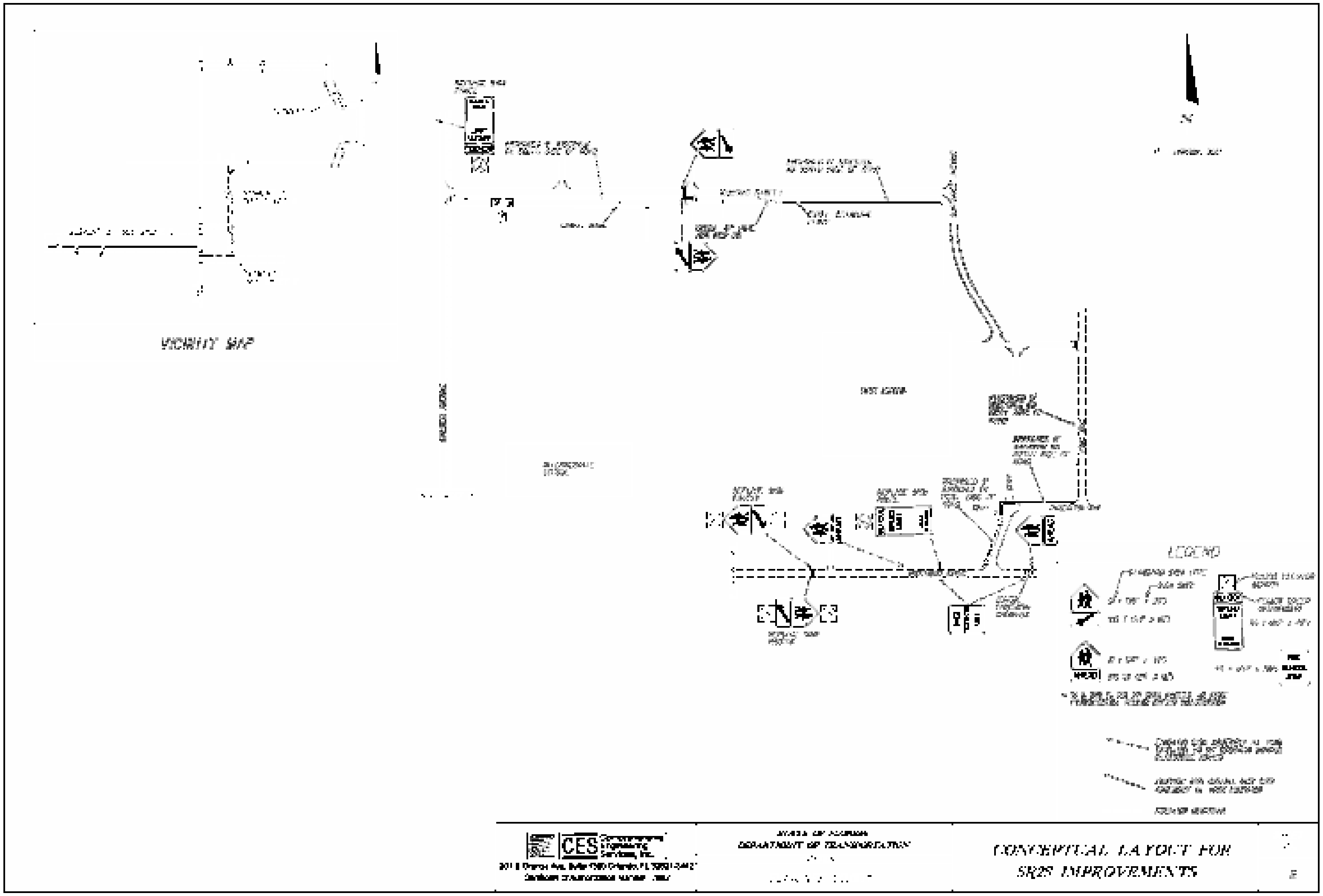



Figure N-7 Conceptual layout for Safe Routes to School improvements, Suwannee County, Florida (Sheet #2)

## Schedule of Events for May

**TEN TOE WALKS**

**Creeks, Bridges and Rail Walk** — **May 5, 6pm**

Well stroll along Westmoreland Park, get up close to Crystal Springs and Johnson Creeks, ending up at the new Three Bridges and returning through Garthwick and historic rail areas in Sellwood.

**Oaks Bottom Walk** — **May 12, 9am**

*Meet at SE 13th & Bidwell, sidewalk in front of Sellwood Library*

Enjoy a chance to see nesting osprey, herons and other wildlife along the Oaks Bottom wetland on the Springwater Trail. Our scenic loop will start and finish in Sellwood.

**Woodstock to Reed** — **May 17, 6pm**

*Meet at SE 44th & Woodstock*

This leisurely walk will wind through the Reed campus and the east side of the Reed Canyon with its wildlife viewing trails and wetland walkways before returning to the Woodstock neighborhood and business district.

**WOMEN ON BIKES CLINICS & RIDES**

**Let's Get Rollin' Clinic** — **May 12, 10am**

*Woodstock Community Center, 5905 SE 43rd*

A 3-hour clinic with conversations on how to choose the right bike and gear for you and your bike, recreational riding and commuting, riding techniques, use of the TriMet rack, and route planning.

**Wander West on the Springwater** — **May 14, 6pm**

*Meet at SE 22nd & Ave - Westmoreland Park*

Explore the trail to downtown Portland

**Wander West on the Springwater** — **May 21, 6pm**

*Meet in parking lot, SE 43rd & Rhone - Creston Park*

Explore the trail to downtown Portland

**SENIOR STROLLS**

*Senior Strolls are held Wednesdays at 10:00 a.m.*

**Crystal Springs Rhododendron Gardens** — **May 16**

*Meet at Crystal Springs Rhododendron Garden entrance, SE 28th Ave, one block north of Woodstock*

Stroll through one of Southeast Portland's most beautiful gardens, home to more than 2,500 rhododendrons, azaleas, and other plants. Winding paths gently guide visitors through lush foliage, along serene lakes, and by friendly ducks and geese.

**Total Distance:** Slightly over 1 mile

**Bus Line:** #19 Woodstock via SE 32nd & Rex (this bus takes alternating routes as it goes through Eastmoreland; ask the driver for the stop nearest the Garden).

**Transportation Resources**

Flexcar
a car sharing service
www.flexcar.com
503-328-FLEX (3539)

TriMet
transit planner and transit tracker services
www.trimet.org
503-238-RIDE (7433)

Ride Connection
transportation services for elderly and disabled
www.rideconnection.org

Portland Transportation Options
www.gettingaroundportland.org

City of Portland Bike Hotline

## Get Ready to Travel Smart

Celebrate your Portland Neighborhood. Experience firsthand why Portland is one of the best bicycling and walking cities in North America. Participate in all of the fun programs, activities and events the City of Portland Office of Transportation (PDOT) Transportation Options Division has planned for the next year. We'll have something for everyone.

Watch your mailbox for the **Transportation Options Order Form** in the coming weeks. The order form offers a wide range of travel resources to help you discover the ease of getting around Portland. We have a variety of road tested and successful programs and materials to offer including our **Southeast Walking Map** complete with bus and light rail routes and stops, bikeways, key business districts and landmarks, fountains, parks, schools and much more.

We are partnering with Kaiser Permanente for the fourth year to offer the **Ten Toe Express**, a walking campaign. Participants in the Ten Toe Express receive a walking kit complete with a pedometer, trip logs to help track your progress, and a short-tripper coupon book with discounts for local pedestrian friendly businesses. We also offer a series of guided walks, including **Senior Strolls** for older walkers, to help you stay motivated.

**Portland By Cycle** and the new **Women on Bikes** program return this year too. Portland By Cycle participants receive a bicycling kit with bike maps, a short-tripper coupon book for bicycle friendly businesses and other essential resources for the new or seasoned cyclist. We again offer a full schedule of guided **Portland By Cycle** bike rides as well.

Watch for future newsletters keeping you informed of all the events, rides and classes coming your way. And be sure to visit the Options Mobile at local neighborhood and street fairs throughout the spring and summer.

GETTING AROUND PORTLAND

# SMART TRIPS SOUTHEAST

TRANSPORTATION OPTIONS WWW.GETTINGAROUNDPORTLAND.ORG APRIL 2007

**FREE TRAVEL RESOURCES**

Watch your mailbox for the Transportation Options Order Form in the coming weeks. This order form offers a variety of valuable resources to help you travel smart.

We will also send you a free gift like this handy umbrella just for responding. So keep an eye out, order up and you'll be traveling around the southeast in comfort and style.

## You Have Options

What moves around the City offering fun programs and activities celebrating Portland as one of the most livable cities in the US? Its called SmartTrips and it's coming to your neighborhood. The SmartTrips Southeast area includes Ardenwald, Creston-Kenilworth, Eastmoreland, Reed, Sellwood-Moreland, and Woodstock neighborhoods. SmartTrips offers something for everyone.

Be sure to watch your mailbox for the Order Form in the coming weeks. The order form offers many resources to help you discover the ease of getting around Portland by foot and by bike, transit or carpool. We have a variety of programs and tools to offer so definitely check it out!

For the fourth year in a row, Transportation Options is partnering with Kaiser Permanente to offer the Ten Toe Express walking campaign. SmartTrips Southeast residents can order a free walking kit complete with a pedometer, a short-tripper coupon book for discounts at local businesses and a schedule of guided walks highlighting areas of interest in the community. Options also offers weekday Senior Strolls, shorter walks for seniors who want to stay active and experience great Portland neighborhoods.

Portland By Cycle and the Women on Bikes programs also return this year. A free bike kit includes the short-tripper coupon book and other essential resources for the new or seasoned cyclist. We offer a full schedule of guided bike rides and classes as well.

Watch for newsletters keeping you informed of all the events, rides and classes coming your way. And be sure to visit the OptionsMobile, a colorfully wrapped hybrid car, at local neighborhood and street fairs throughout the spring and summer. We hope to see you out there!

To find out more about Transportation Options Getting Around Portland programs, contact Linda Ginenthal at 503-823-5266 or linda.ginenthal@pdxtrans.org

SMART TRIPS MILWAUKIE • SENIOR STROLLS • THREE BRIDGES • SCHEDULE OF EVENTS • MORE

Figure N-8 Portland, Oregon - SmartTrips Southeast newsletter, front (Source: Transportation Options)

**PDOT HOSTS BICYCLE MASTER PLAN RIDES**

First Tuesdays hold new significance for Portland bicyclists. New Monthly Bicycle Master Plan Rides began with an inaugural ride in February. These rides aren't your average Sunday afternoon jaunt, however. The purpose of the rides are multi-tiered and aims to bring bicyclists together to educate, provide a discussion forum and to create a vision of a world class bicycling city.

The rides are not necessarily a fast ride rather riders are encouraged to follow a predetermined route in smaller groups of perhaps 3 to 4 people. Several stops are noted for each ride focusing on various types of treatments and devices used in the City's bikeway network. Participants then convene after the ride to discuss what they saw, how they felt about it and to offer fresh perspectives.

For more information on the Bicycle Master Plan Rides contact Roger Geller at 503-823-7671 or roger.geller@pdxtrans.org.

## Springwater Corridor Three Bridges Open

In the not so distant past those traveling west on the Springwater Corridor Trail enjoyed "car-free" jaunt until abruptly reaching the first obstacle at Johnson Creek. With the opening of the Springwater Corridor's Three Bridges obstacles are a thing of the past. Three new bridges span SE McLoughlin Boulevard, Union Pacific Railroad and Johnson Creek. The project is only 2,400 feet long but short the distance closes a significant gap providing safe crossing for commuters or families bicycling and walking on the trail.

The trail, with the exception of a one-mile gap in Sellwood requiring travel on neighborhood streets, is now complete from downtown Portland to Boring, Oregon for a distance of nearly 18 miles. Partial funding has been secured from Metro to complete the gap in Sellwood. Additional funding will come from federal transportation funds earmarked for specific regional trails through the efforts of Congressman Earl Blumenauer.

The trail allows you to increase your physical activity level while enjoying many different types of wildlife including woodpeckers, herons, bats and perhaps black tailed deer. Strollers and cyclists also pass through distinct zones such as marshes and forested areas. These zones display a variety of vegetation such as dogwood, blackberry, plum, willow and elderberry.

So take a walk or ride and enjoy the many aspects of the trail… visit OMSI, observe the wildlife at Oaks Bottom Refuge, picnic at Sellwood Riverfront Park, explore Powell Butte Nature Park or even have lunch in Boring.

## Options Ambassadors Wanted

Do you feel passionate about biking, walking, and getting around Portland without driving alone? Portland is one of the best bicycling and walking cities in North America and you can help strengthen that by becoming an Options Ambassador. The Options Ambassador Program is an opportunity for volunteers to get first-hand experience with Transportation Options' staff and reach out to Portland residents.

Ambassadors represent the Office of Transportation and encourage motorists, pedestrians, cyclists, and transit riders to travel safely together and share the road. Activities include bike rides, walks, neighborhood and community fairs, and business transportation fairs. Ambassador's commit to a minimum of two events during the 2007 event season.

Selected Ambassador applicants receive a 3-hour training on the information and skills necessary to talk with the public about all Portland transportation options. Additionally, Ambassadors get an official Transportation Options T-shirt, a variety of walking, biking and transit incentives throughout the summer, and an opportunity to expand their knowledge and skills.

To apply for the Transportation Options Ambassador Program, or for more information, contact Janis McDonald at 503-823-5358 or janis.mcdonald@pdxtrans.org.

SOUTHEAST SMART TRiPS

## SmartTrips Expands to Milwaukie

Transportation Options SmartTrips Southeast has been expanded to include 3,400 households in Portland's southerly neighbor of Milwaukie for 2007. This first of its kind partnership was made possible through the generous support of Metro's Regional Travel Options program awarding the two cities a grant to expand the project into Milwaukie.

Every second year, Metro's Regional Travel Options program administers a grant program seeking projects that promote transportation options. The grant program aims to fund projects and programs that reduce emissions tied to transportation in order to meet and maintain national air quality standards.

The partnership allows Options to expand our already popular guided walks, and bicycle rides, to include several destinations in Milwaukie such as Waterfront Park and historic Downtown Milwaukie. Milwaukie residents can look forward to new materials created for the project, including a new Milwaukie bicycle map.

CITY OF MILWAUKIE

The SmartTrips project comes at an exciting time for Milwaukie residents. In addition to updating their Transportation System Plan setting policies and priorities for all transportation modes, the City of Milwaukie is planning for improvements along Riverfront Park and for the Milwaukie-Metro Town Center. For more information on these projects, visit the City of Milwaukie website at www.cityofmilwaukie.org or contact Grady Wheeler with the City of Milwaukie at 503-786-7503.

## GET READY, GET SET, STROLL!

Get ready to get healthy, meet other seniors, and learn about some of Portland's great Southeast neighborhoods! Transportation Options invites you to join them for another great summer of Senior Strolls. These escorted strolls are easy, fun, and free!

Lack of physical activity is an important contributor to many chronic diseases in older adults, including heart disease, diabetes, colon cancer, and high blood pressure. According to the U.S. Department of Health and Human Services (U.S. HHS), only 31 percent of individuals aged 65 to 74 report participating in 20 minutes of moderate physical activity three or more days per week; 16 percent report 30 minutes of moderate activity five or more days per week.

The good news is, when it comes to physical activity and aging, it is never too late to become physically active. And even a small amount of activity can result in better health. Spending at least 30 minutes in moderate activity on all or most days of the week has remarkable health benefits for older adults (U.S. HHS).

That is precisely where Senior Strolls come in. Strolls will be held weekly from May 16 through October 10 every Wednesday at 10 am. Strolls range in length from under 1 mile to 2 miles by the end of the strolling season. The strolls are varied, and will take place in a variety of parks, beautiful gardens, colorful neighborhoods, and commercial areas. All of the starting and ending points are conveniently located along TriMet bus routes. To learn more about the strolls, please contact Donna Green at 503-823-6114 or donna.green@pdxtrans.org.

**INNER POWELL BLVD STREETSCAPE PLAN UPDATE**

Residents had the opportunity to comment on the proposed improvements for the Inner Powell Blvd Streetscape Plan at a Public Open House March 17.

The Open House at Cleveland HS offered a "self-guided" tour of different stations. Residents were encouraged to converse with transportation staff, offer comments and to vote on their favorite alternatives with colored dots.

The plan covers Powell Blvd from the Ross Island Bridge to 42nd Ave and identifies improvement alternatives within the existing right-of-way to improve the safety, accessibility and environment for pedestrians, bicyclists and transit riders while continuing to serve the vehicle traffic traveling Powell Boulevard. The recommended alternative will be presented at an Open House in May 2007 with a final streetscape plan completed in July 2007.

For more information about the Inner Powell Blvd Streetscape Plan please contact April Bertelsen at 503-823-6177 or april.bertelsen@pdxtrans.org.

**SENIOR STROLLS, CONTINUED**

**Reed College Tour** **May 23**
*Meet at NE corner of SE Woodstock & Reed College Parkway*
Founded in 1908, Reed College is close to celebrating its first 100 years of providing a balanced, comprehensive education in liberal arts and sciences. Enjoy this guided tour in and out of buildings noted for their architectural and historic significance.
**Total Distance:** Approximately 1.5 miles
**Bus Line:** #19

**Sellwood North** **May 30**
*Meet at SW corner of SE Milwaukie & Bybee*
This easy stroll will meander by lovely homes in this quiet neighborhood and includes a visit to Llewellyn Elementary School.
**Total Distance:** Just under 1 mile
**Bus Line:** #19

www.gettingaroundportland.org

Figure N-9 Portland, Oregon - SmartTrips Southeast newsletter, back (Transportation Options)

PORTLAND OFFICE OF TRANSPORTATION

POST-SURVEY OF NE HUB
PRE-SURVEY OF SE HUB

DATE

PHONE NUMBER

RESPONDENT'S NAME

INTERVIEWER'S INITIALS

CALL RECORD MATRIX

No answer / busy / disconnect (# attempts)

Under age of 18

Gender quota 50/50 male/female

Day of week

Not a resident of Target Area / Control Area

INTRODUCTION

(TO RANDOM HOUSEHOLD RESPONDENT) Hello, I'm (FIRST AND LAST NAME) from Campbell DeLong Resources calling on behalf of the City of Portland's Office of Transportation. We're doing a survey on transportation and travel habits of Portland residents like yourself. We're not selling anything, and all of your comments will be kept strictly confidential and anonymous. May I please speak with a (male/female) household member who is 18 years of age or older? IF NOT AVAILABLE, MAKE CALLBACK APPOINTMENT FOR FIRST POSSIBLE TIME.

(TO NEW HOUSEHOLD RESPONDENT) Hello, I'm (FIRST AND LAST NAME) from Campbell DeLong Resources calling on behalf of the City of Portland's Office of Transportation. We're doing a survey on transportation and travel habits of Portland residents like yourself. We're not selling anything, and all of your comments will be kept strictly confidential and anonymous.

ALL: The survey typically takes no more than 5 to 7 minutes to complete. Is now a convenient time for you? MAKE CALLBACK APPOINTMENT FOR FIRST POSSIBLE TIME.

Figure N-10 Portland, Oregon - SmartTrips Southeast survey script, page 1 (Source: Transportation Options)

IF NECESSARY: If you have any concerns, or want to confirm that the City is conducting this survey, please call [illegible] at the City of Portland's Office of Transportation at [illegible].

SCREENING

1. Do you, or does anyone in your household, work for the City of Portland, or work for a market research organization? REPEAT.

| | | |
|---|---|---|
| Yes | 1 | POLITELY DISCONTINUE |
| No | 2 | CONTINUE |

2. GENDER. RECORD. DO NOT ASK. CHECK QUOTAS.

| | |
|---|---|
| Male | 1 |
| Female | 2 |
| Unknown | 3 |

QUOTA: [illegible] MALE/FEMALE FOR BOTH NE AND SE SAMPLE

3a. What is your ZIP Code?

| | | |
|---|---|---|
| [illegible] | 1 | ASK 3D |
| [illegible] | 2 | ASK 3D |
| [illegible] | 3 | ASK 3B |
| [illegible] | 4 | ASK 3C |
| [illegible] | 5 | ASK 3B |
| All others/don't know | 99 | POLITELY DISCONTINUE |

3b. Are you east or west of [illegible] Avenue?

| | | |
|---|---|---|
| East | 1 | CONTINUE TO 3C |
| West | 2 | POLITELY DISCONTINUE |
| Don't know | 99 | POLITELY DISCONTINUE |

3c. Are you north or south of [illegible]?

| | | |
|---|---|---|
| North | 1 | SKIP TO 4 |
| South | 2 | POLITELY DISCONTINUE |
| Don't know | 99 | POLITELY DISCONTINUE |

3d. Are you east or west of Grand Avenue?

| | | |
|---|---|---|
| East | 1 | SKIP TO 4 |
| West | 2 | POLITELY DISCONTINUE |
| Don't know | 99 | POLITELY DISCONTINUE |

[illegible] 2 [illegible]

Figure N-11 Portland, Oregon – SmartTrips Southeast survey script, page 2 (Source: Transportation Options)

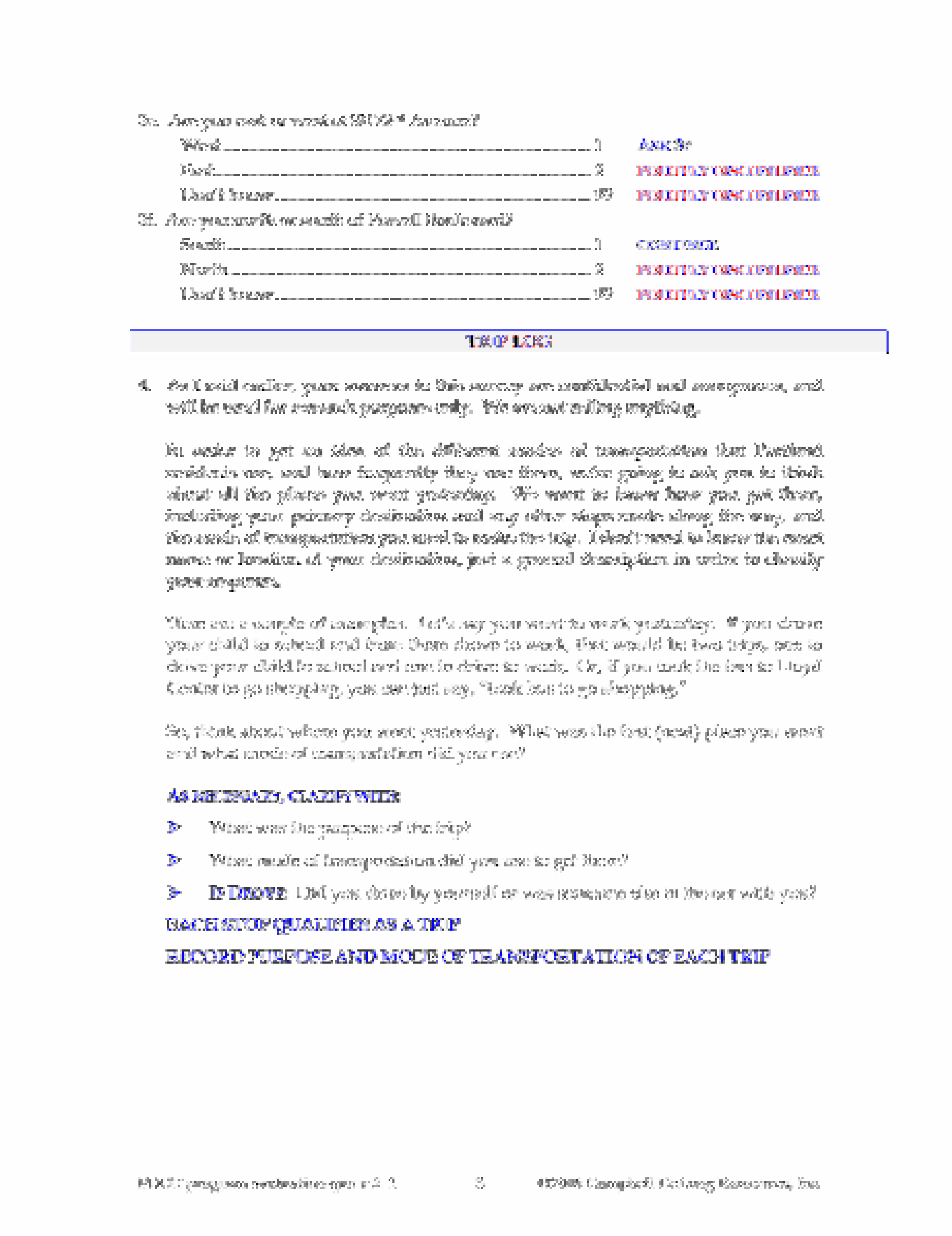
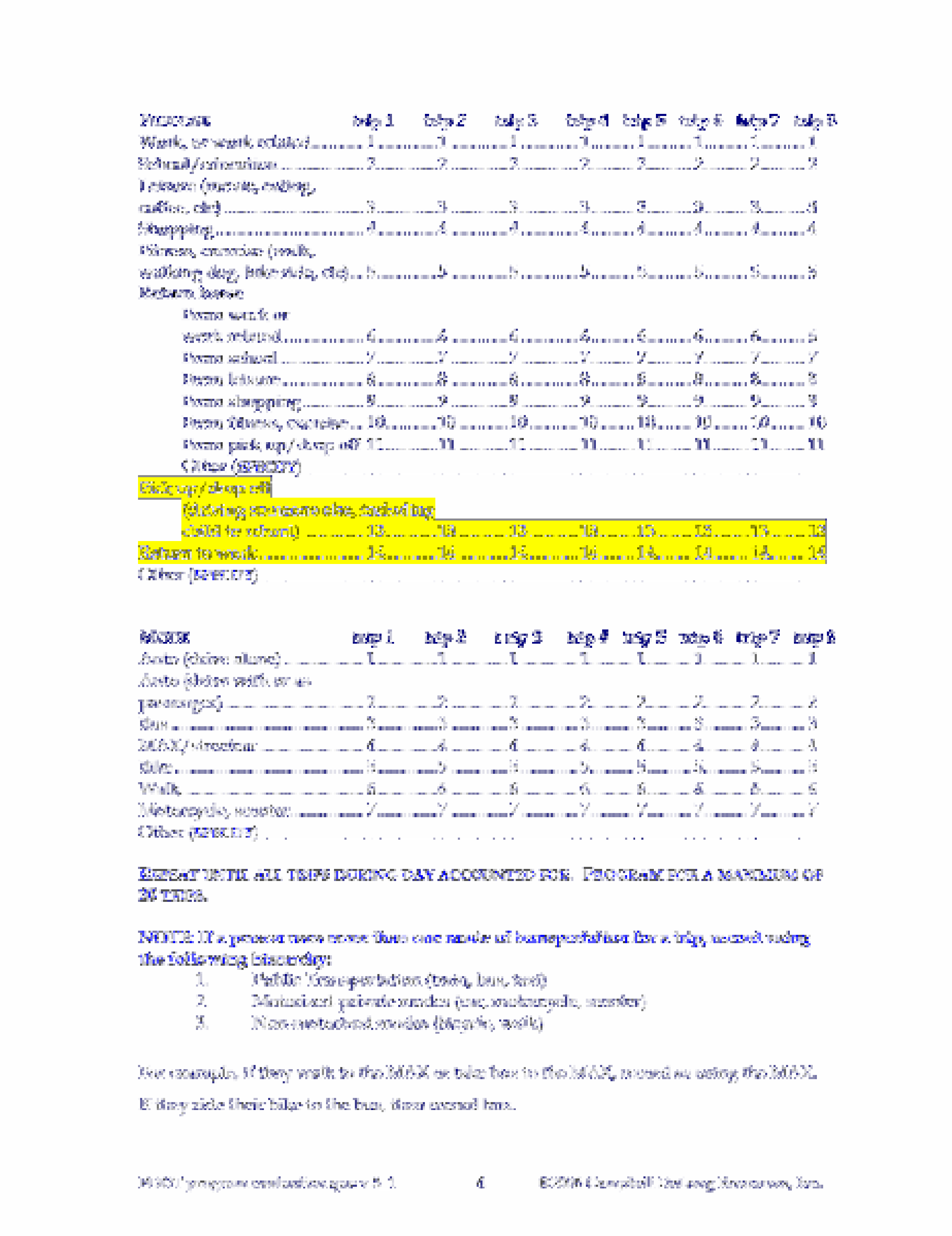



Figure N-12 Portland, Oregon - SmartTrips Southeast survey script, page 3 (Source: Transportation Options)



| PURPOSE | trip 1 | trip 2 | trip 3 | trip 4 | trip 5 | trip 6 | trip 7 | trip 8 |
|---|---|---|---|---|---|---|---|---|
| Work, or work related | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| School/education | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Leisure (movies, eating, coffee, etc) | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Shopping | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Fitness, exercise (walk, walking dog, bike ride, etc) | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Return home: | | | | | | | | |
| From work or work related | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| From school | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| From leisure | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| From shopping | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| From fitness, exercise | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| From pick up/drop off | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| Other (SPECIFY) | | | | | | | | |
| Pick up/drop off (driving someone else, such as taking child to school) | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| Return to work | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 |
| Other (SPECIFY) | | | | | | | | |

| MODE | trip 1 | trip 2 | trip 3 | trip 4 | trip 5 | trip 6 | trip 7 | trip 8 |
|---|---|---|---|---|---|---|---|---|
| Auto (drive alone) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Auto (drive with or as passenger) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Bus | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| MAX/streetcar | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Bike | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Walk | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Motorcycle, scooter | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| Other (SPECIFY) | | | | | | | | |

REPEAT UNTIL ALL TRIPS DURING DAY ACCOUNTED FOR. PROGRAM FOR A MAXIMUM OF 20 TRIPS.

NOTE: If a person uses more than one mode of transportation for a trip, record using the following hierarchy:

1. Public Transportation (train, bus, taxi)
2. Motorized private modes (car, motorcycle, scooter)
3. Non-motorized modes (bicycle, walk)

For example, if they walk to the MAX or take bus to the MAX, record as using the MAX.

If they ride their bike to the bus, then record bus.

Figure N-13 Portland, Oregon – SmartTrips Southeast survey script, page 4 (Source: Transportation Options)

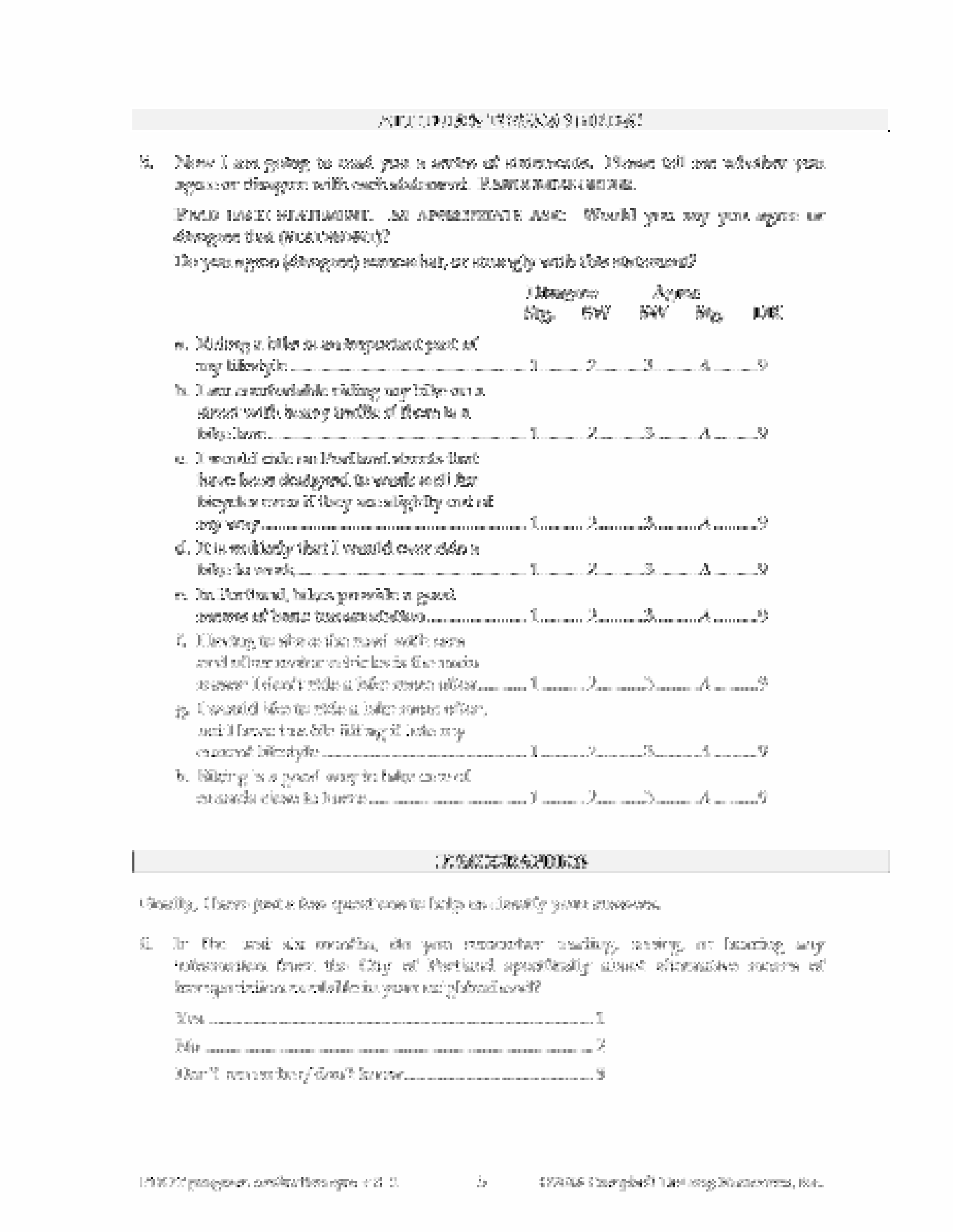


Figure N-14 Portland, Oregon – SmartTrips Southeast survey script, page 5 (Source: Transportation Options)

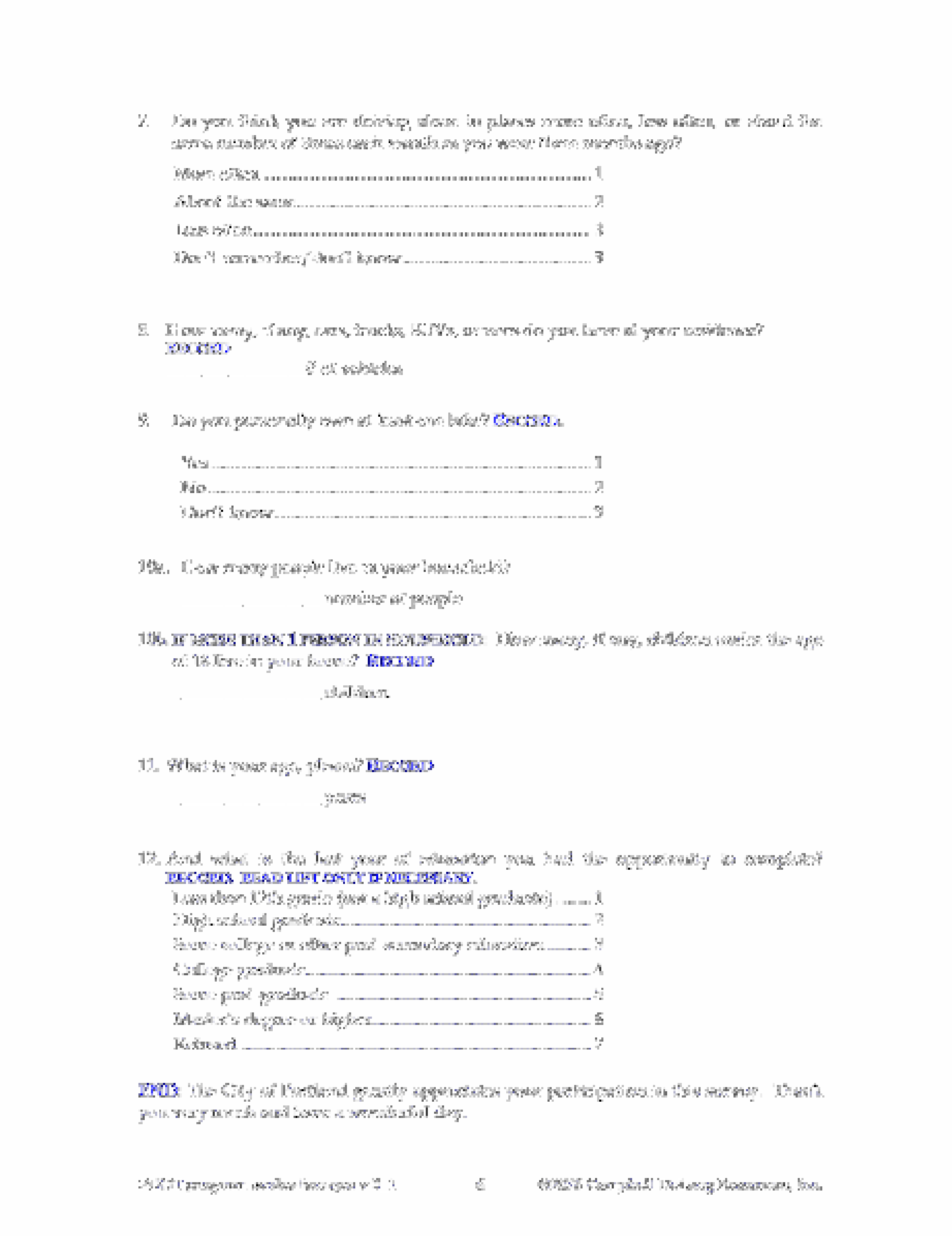


Figure N-15 Portland, Oregon – SmartTrips Southeast survey script, page 6 (Source: Transportation Options)


Figure N-16 Portland, Oregon – Bike Commute Challenge sponsors

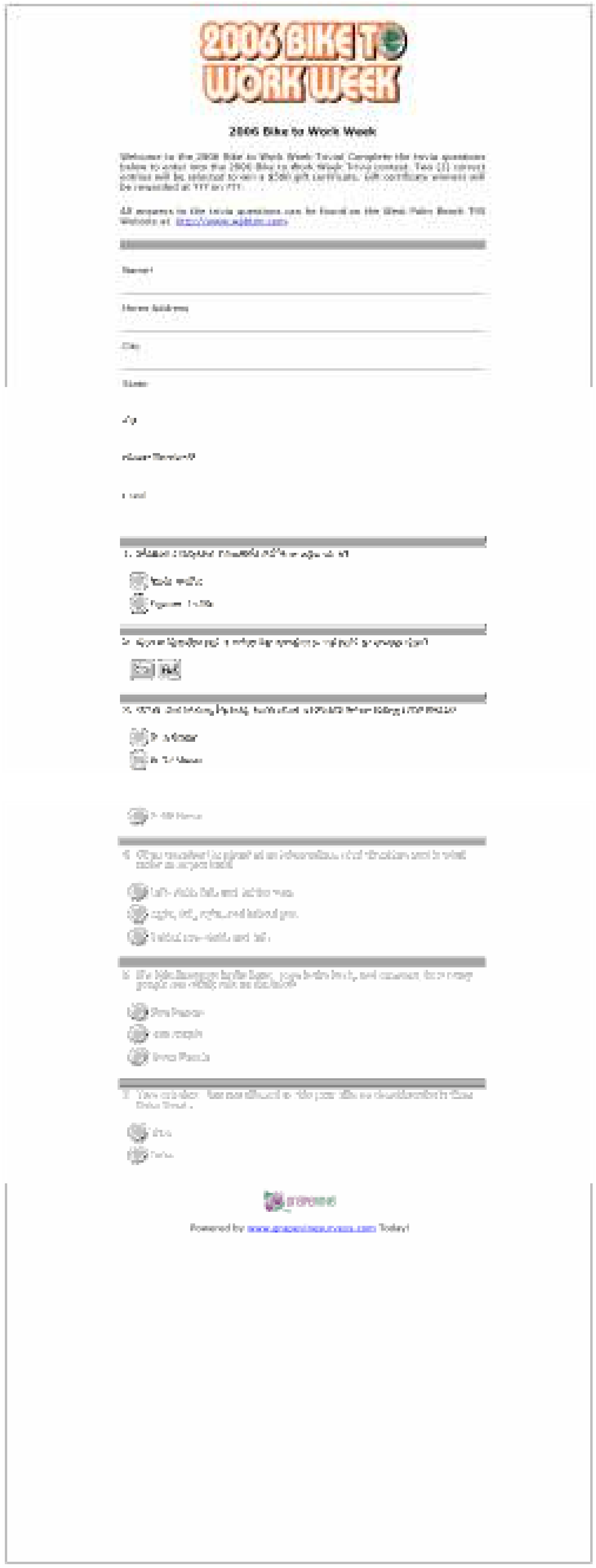
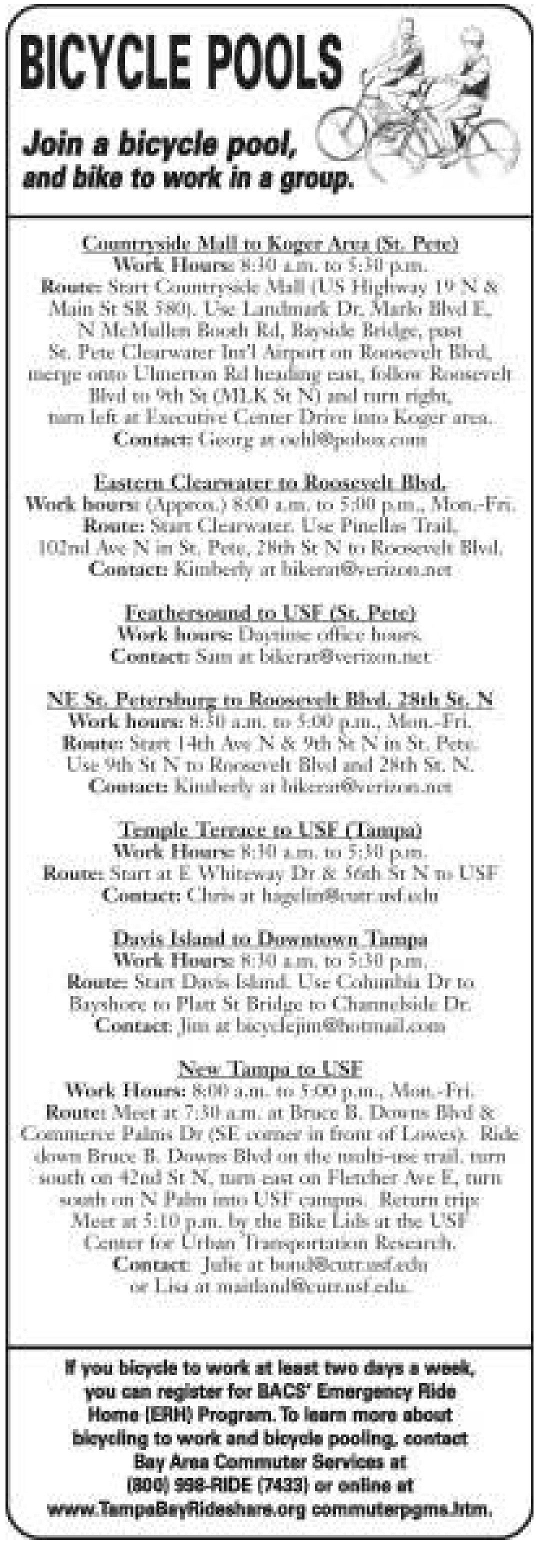



Figure N-17 Bike to Work Week trivia contest, West Palm Beach



# BICYCLE POOLS

***Join a bicycle pool, and bike to work in a group.***

<u>Countryside Mall to Koger Area (St. Pete)</u>
**Work Hours:** 8:30 a.m. to 5:30 p.m.
**Route:** Start Countryside Mall (US Highway 19 N & Main St SR 580). Use Landmark Dr, Marlo Blvd E, N McMullen Booth Rd, Bayside Bridge, past St. Pete Clearwater Int'l Airport on Roosevelt Blvd, merge onto Ulmerton Rd heading east, follow Roosevelt Blvd to 9th St (MLK St N) and turn right, turn left at Executive Center Drive into Koger area.
**Contact:** Georg at oehl@pobox.com

<u>Eastern Clearwater to Roosevelt Blvd.</u>
**Work hours:** (Approx.) 8:00 a.m. to 5:00 p.m., Mon.-Fri.
**Route:** Start Clearwater. Use Pinellas Trail, 102nd Ave N in St. Pete, 28th St N to Roosevelt Blvd.
**Contact:** Kimberly at bikerat@verizon.net

<u>Feathersound to USF (St. Pete)</u>
**Work hours:** Daytime office hours.
**Contact:** Sam at bikerat@verizon.net

<u>NE St. Petersburg to Roosevelt Blvd. 28th St. N</u>
**Work hours:** 8:30 a.m. to 5:00 p.m., Mon.-Fri.
**Route:** Start 14th Ave N & 9th St N in St. Pete. Use 9th St N to Roosevelt Blvd and 28th St. N.
**Contact:** Kimberly at bikerat@verizon.net

<u>Temple Terrace to USF (Tampa)</u>
**Work Hours:** 8:30 a.m. to 5:30 p.m.
**Route:** Start at E Whiteway Dr & 56th St N to USF
**Contact:** Chris at hagelin@cutr.usf.edu

<u>Davis Island to Downtown Tampa</u>
**Work Hours:** 8:30 a.m. to 5:30 p.m.
**Route:** Start Davis Island. Use Columbia Dr to Bayshore to Platt St Bridge to Channelside Dr.
**Contact:** Jim at bicyclejim@hotmail.com

<u>New Tampa to USF</u>
**Work Hours:** 8:00 a.m. to 5:00 p.m., Mon.-Fri.
**Route:** Meet at 7:30 a.m. at Bruce B. Downs Blvd & Commerce Palms Dr (SE corner in front of Lowes). Ride down Bruce B. Downs Blvd on the multi-use trail, turn south on 42nd St N, turn east on Fletcher Ave E, turn south on N Palm into USF campus. Return trip: Meet at 5:10 p.m. by the Bike Lids at the USF Center for Urban Transportation Research.
**Contact:** Julie at bond@cutr.usf.edu or Lisa at maitland@cutr.usf.edu.

**If you bicycle to work at least two days a week, you can register for BACS' Emergency Ride Home (ERH) Program. To learn more about bicycling to work and bicycle pooling, contact Bay Area Commuter Services at (800) 998-RIDE (7433) or online at www.TampaBayRideshare.org commuterpgms.htm.**

Figure N-18 Bicycle pool announcement, Bay Area Commuter Services, Tampa-St. Petersburg, Florida

## APPENDIX O Reserved

# APPENDIX P The Effect of Lane Width on Urban Street Capacity

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## Technical Memorandum

**Date:** March 22, 2007 Project #: 7969.

**To:** Sprinkle Consulting Engineers

**From:** John Zegeer

**Copy to:** Patrick McMahon and Paul Ryus

**Subject:** The Effect of Lane Width on Urban Street Capacity
FDOT Conserve by Bicycle Project

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One of the goals of the FDOT Conserve by Bicycle project is to determine how the provision of bicycling facilities can enhance opportunities for recreational travel. One potential treatment that is being considered for accommodating additional bicycle travel along urban streets is the narrowing of street lane widths in order to provide a striped bicycle lane on the paved roadway surface adjacent to these narrower lanes. In considering this treatment, a concern has been raised regarding the reduction in roadway capacity (for motorized vehicles) that could occur due to the lane width reduction.

The purpose of this memorandum is to provide a summary of relevant research that describes the relationship between lane width and urban street capacity. The next section of this memorandum summarizes the method by which urban street capacity is determined. Then, a summary of relevant research is provided. Finally, conclusions are drawn as to the impact of narrowing lanes on urban street capacity.

### How is Urban Street Capacity Determined?

Chapter 15 of HCM2000 provides the methodology for analyzing urban streets. (Highway Capacity Manual 2000. Fourth Edition. Transportation Research Board., Washington, D.C. 2000.) "Urban street level of service is based on average through-vehicle travel speed for the segment or for the entire street under consideration. The average travel speed is computed from the running times on the urban street (between signalized intersections) and the control delay experienced by through movements at signalized intersections." (page 15-2) "The capacity of an urban street is defined for a single direction of travel as the capacity of the through movement at its lowest point (usually at a signalized intersection). The capacity is determined by the number of lanes, the saturation flow rate per lane (influenced by geometric design and demand factors), and the green time per cycle for the through movement at the intersection." (page 15-9)

Chapter 16 of HCM2000 provides the methodology for analyzing signalized intersections. This methodology includes the determination of the saturation flow rate for each lane group. "The saturation flow rate is the flow in vehicles per hour that can be accommodated by the lane group assuming that the green phase were displayed 100 percent of the time (i.e., g/C = 1.0)." (page 16-9) The equation for this calculation is shown below:

$$s = s_o N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb} \quad \text{(Equation 16-4)}$$

where

$s$ = saturation flow rate for subject lane group, expressed as a total for all lanes in lane group (veh/h);

$s_o$ = base saturation flow rate per lane (pc/h/ln);

$N$ = number of lanes in lane group;

$f_w$ = adjustment factor for lane width;

$f_{HV}$ = adjustment factor for heavy vehicles in traffic stream;

$f_g$ = adjustment factor for approach grade;

$f_p$ = adjustment factor for existence of a parking lane and parking activity adjacent to lane group;

$f_{bb}$ = adjustment factor for blocking effect of local buses that stop within intersection area;

$f_a$ = adjustment factor for area type;

$f_{LU}$ = adjustment factor for lane utilization;

$f_{LT}$ = adjustment factor for left turns in lane group;

$f_{RT}$ = adjustment factor for right turns in lane group;

$f_{Lpb}$ = pedestrian adjustment factor for left-turn movements; and

$f_{Rpb}$ = pedestrian-bicycle adjustment factor for right-turn movements.

As shown in the above equation, the adjustment factor for lane width is the first of the eleven adjustment factors that is used in calculating the saturation flow rate for the subject lane group. "The lane width adjustment factor, $f_W$, accounts for the negative impact of narrow lanes on saturation flow rate and allows for an increased flow rate on wide lanes." (page 16-10)

**Summary of Relevant Research**

Four relevant research documents were found that provide guidance on the relationship between lane width and saturation flow rate:

1. Potts, I.B., et.al. *Relationship of Lane Width to Saturation Flow Rate on Urban and Suburban Signalized Intersection Approaches.* Presented at the 2007 Transportation Research Board Annual Meeting. Accepted for publication in a Transportation Research Record.

2. Zegeer, J.D. *Field Validation of Intersection Capacity Factors.* Transportation Research Record 1091, Transportation Research Board. 1986.
3. Agent, K.R. and J.D. Crabtree. *Analysis of Saturation Flow at Signalized Intersections.* Kentucky Transportation Research Program University of Kentucky. February, 1983.
4. Bonneson, J.A. *Modeling Queued Driver Behavior at Signalized Junctions.* Transportation Research Record 1365, Transportation Research Board. 1992.

The first paper cited above provides an overview of the other three research documents. So, the remainder of this section contains direct quotes from that paper.

Zegeer (2) evaluated the saturation flow rates on approaches with lane widths varying between 2.6 and 4.7 m (8.5 and 15.5 ft). Saturation flow data was collected from 2,733 vehicles on eleven approaches with lane widths varying between 2.6 and 2.9 m (8.5 and 9.5 ft). Four approaches with lane widths varying between 3.9 and 4.7 m (13.0 and 15.5 ft) were also surveyed, with a sample size of 1,568 saturation flow vehicles. All baseline conditions except for lane width were held constant at these locations. The survey results were then compared with those of the baseline condition surveys (with a sample size of 6,687 saturation flow vehicles). The narrower lane widths demonstrated saturation flow rates between 2 and 5 percent less than did those in the baseline surveys, while the wider lane widths demonstrated saturation flow rates 5 percent greater than did those in the baseline surveys. Zegeer proposed the following lane width adjustment factors:

| Lane width category (ft) | Saturation flow adjustment factor |
|---|---|
| 8 – 8.9 | 0.95 |
| 9 – 9.9 | 0.98 |
| 10 – 12.9 | 1.00 |
| 13 – 15.9 | 1.05 |

A 1983 study by Agent (3) of the effects of lane width on saturation flow indicated that lane width did not have an effect on saturation flow for lane widths of 3.0 m (10 ft) or more. For lane widths between 2.7 and 3.0 m (9 and 10 ft), a 5 percent reduction in saturation flow was found compared to lane widths of 3.0 m (10 ft) or more. No lane widths below 2.7 m (9 ft) were observed. There was a slight unexplained reduction in saturation flow for lane widths greater than 4.5 m (15 ft). A similar analysis was performed with the limited data available for commercial vehicles, and no effect was found even for lane widths below 3.0 m (10 ft). Table 1 illustrates the effect of lane width on saturation flow found by Agent.

**TABLE 1. Effect of lane width on saturation flow**

| Lane width(ft) | Total headway (sec) | Average headway (sec) | Saturation flow (vphg)[a] |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 9 – 9.9 | 858 | 2.29 | 1,572 |
| 10 – 10.9 | 2,839 | 2.16 | 1,667 |
| 11 – 12.9 | 11,089 | 2.18 | 1,651 |
| 13 – 14.9 | 2,454 | 2.18 | 1,651 |
| 15 or more | 680 | 2.21 | 1,629 |
| 10 – 14.9 | 16,382 | 2.18 | 1,654 |
| 10 or more | 17,062 | 2.18 | 1,653 |

[a] vphg—vehicles per hour of green time.

In a 1992 study by Bonneson (4), it was determined that discharge headway is a function of a vehicle's position in the queue and, therefore, measurements taken between the fourth and eighth vehicles will have longer headways than measurements taken between the eighth and eleventh vehicles. Using empirical data from two study sites, Bonneson developed a model to estimate the impact of queue position on saturation flow rate. Bonneson found that the minimum discharge headway using queue positions four through ten is about 0.02 s/veh shorter than that found when using queue positions four through eight. This difference translates into a base saturation flow rate ratio of 1.3 percent.

*The following text summarizes the research results from the study conducted by Potts, et.al. (1):*

Field studies were conducted at signalized intersections to determine the difference in saturation flow rates of exclusive through lanes with 2.7-, 3.0-, 3.3-, 3.6-, and 4.0-m (9-, 10-, 11-, 12-, and 13-ft) lane widths. Left- and right-turn vehicles were not surveyed. Data collection focused on through travel lanes under the most ideal conditions possible to minimize the influence of site-specific factors. At those intersection approaches where exclusive left- or right-turn lanes were present, vehicles turning from the exclusive turn lanes were observed for a minimum period of time to ensure that they did not influence surveyed vehicles in the adjacent through lanes. To eliminate any influence of turning vehicles at sites with shared through-right or through-left lanes, data were not collected for signal cycles during which any turning movement took place.

Saturation flow headways were measured beginning when the front axle of the fourth vehicle in queue crossed the stop bar. The cumulative elapsed time was then measured when the front axle of the last vehicle in queue (stopped at the onset of the green signal phase) crossed the stop bar. Any impedance (driveway movements, bus stop activity, pedestrian or bicycle activity) that could influence the saturation flow rate during a surveyed signal green phase was noted. The number of heavy vehicles per cycle was documented.

For analysis purposes, the study sites were grouped into lane width categories as follows:

- 2.9 m (9.5 ft) (9 study sites)
- 3.3 to 3.6 m (11 to 12 ft) (12 study sites)
- 4.0 m (13 ft) and greater (4 study sites)

From the average headway of each headway sample, an average saturation flow rate was calculated. Table 2 presents basic average saturation flow statistics (sample size, mean, median, minimum, maximum, standard deviation, and relative standard deviation) for each lane width category.

**TABLE 2. Average saturation flow statistics (pc/h/ln) for each lane width category**

| Lane width category (ft) | N | Mean | Median | Minimum | Maximum | Standard deviation | CV (%)[1] |
|---|---|---|---|---|---|---|---|
| 9.5 | 334 | 1,752 | 1,714 | 711 | 3,000 | 282 | 16.1 |
| 11 to 12 | 653 | 1,830 | 1,831 | 550 | 2,746 | 274 | 15.0 |
| 13+ | 209 | 1,913 | 1,901 | 962 | 3,000 | 293 | 15.3 |
| Total | 1,196 | | | | | | |

[1] Coefficient of variation = 100% x standard deviation/mean.

The results of this research indicate that using narrow lanes (i.e., 2.9 m [9.5 ft]) on signalized intersection approaches on urban and suburban arterials resulted in an average saturation flow rate that is approximately 78 to 79 pc/h/ln, or 4.3 percent, lower than if 3.3- to 3.6-m (11- to 12-ft) lanes are used. Similarly, using lane widths of 4.0 m (13 ft) or greater resulted in an average saturation flow rate that is approximately 82 to 84 pc/h/ln, or 4.3 to 4.4 percent, higher than if 3.3- to 3.6-m (11- to 12-ft) lanes are used. Both relationships were negligibly affected by whether average saturation flow was adjusted for the position of the vehicle in the queue.

The HCM provides saturation flow rate adjustment factors for lane widths that are greater than or less than 3.6 m (12 ft). Table 3 compares the saturation flow rate estimates based on HCM procedures to those measured in the current research. The table shows that the measured saturation flow rate values are generally lower than those obtained from HCM procedures. Furthermore, the percent difference in saturation flow rate between sites with 2.9- to 3.6-m (9.5-to 12-ft) lanes was found to be about half the value used in the HCM. These findings should be considered as a basis for revisions to the HCM. In particular, there appears to be justification for revising the HCM lane width adjustment factors for lane widths less than 3.6 m (12 ft).

**TABLE 3. Comparison of saturation flow rate values from this research to HCM values**

| Lane width (ft) | HCM | | Current research | |
|---|---|---|---|---|
| | Adjusted saturation flow rate[a] (pc/h/ln) | Percent difference from value for 12-ft lanes | Adjusted saturation flow rate[b] (pc/h/ln) | Percent difference from values for 12-ft lanes |
| 9.5 | 1,742 | –8.3 | 1,736 | –4.4 |
| 11 | 1,837 | –3.3 | 1,815[c] | 0 |
| 11.5 | 1,868 | –1.7 | 1,815[c] | 0 |
| 12 | 1,900 | 0.0 | 1,815[c] | 0 |
| 13 | 1,963 | +3.3 | 1,898[d] | +4.5 |
| 14 | 2,026 | +6.7 | 1,898[d] | +4.5 |

[a] The HCM saturation flow rates have been adjusted for lane width.

[b] The saturation flow rates from the current research have been adjusted for queue position.
[c] This value was derived for sites with a range of lane widths from 11 to 12 ft.
[d] This value was derived for sites with a range of lane widths of 13 ft or more.

**Conclusions Drawn from the Research**

All of the relevant research is in general agreement as to the impact of narrowing lane width on saturation flow for through lanes on signalized intersection approaches. The measured saturation flow rates are similar for lane widths between 10 feet and 12 feet. For lane widths below 10 feet, there is a measurable decrease in saturation flow rate. Thus, so long as all other geometric and traffic signalization conditions remain constant, there is no measurable decrease in urban street capacity when through lane widths are narrowed from 12 feet to 10 feet.