5-30-2014

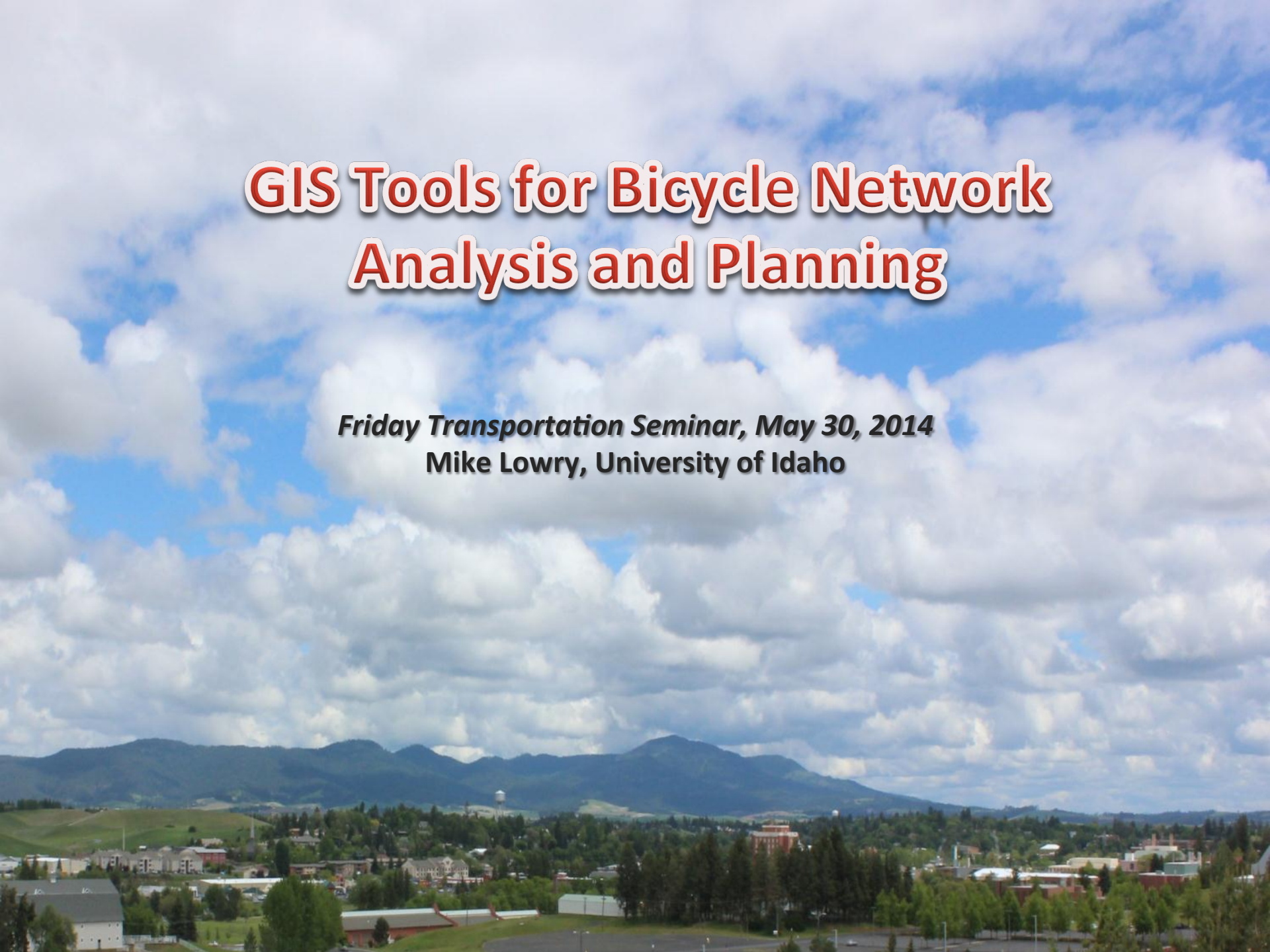
# GIS Tools for Bicycle Network Analysis and Planning

Mike Lowry
*University of Idaho*

# GIS Tools for Bicycle Network Analysis and Planning

*Friday Transportation Seminar, May 30, 2014*

**Mike Lowry, University of Idaho**

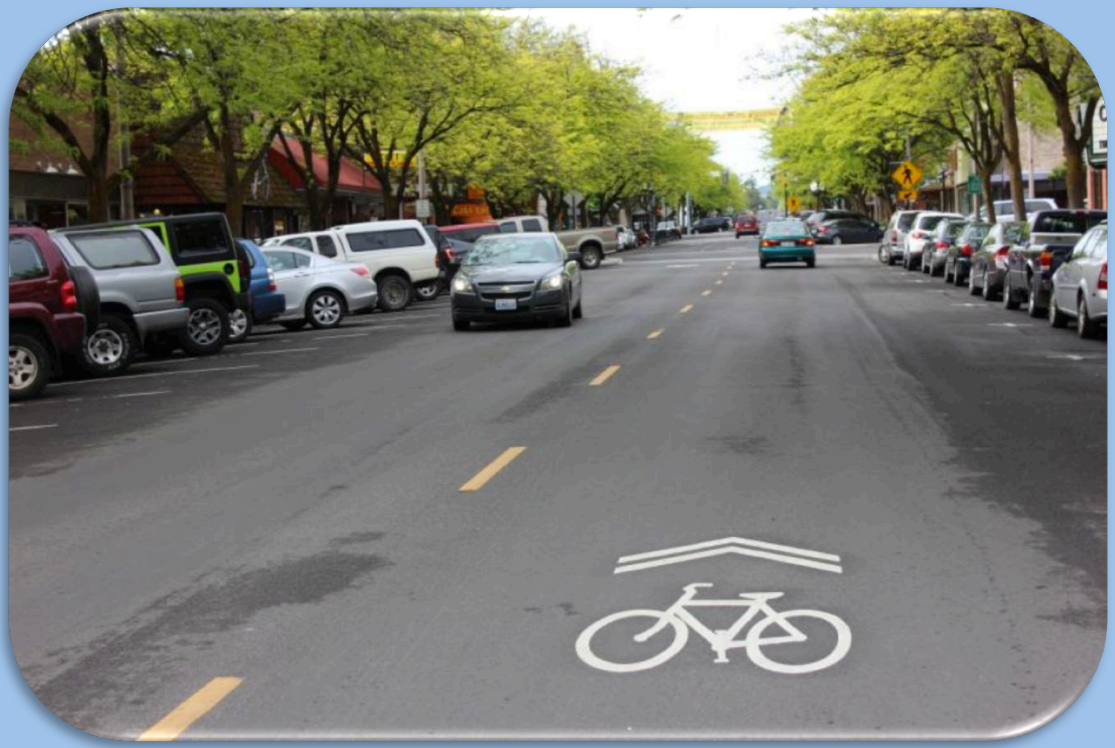


**Tool 1: Calculate Bicycle Level of Service**

**Tool 2: Calculate Community-wide Bikeability**

**Tool 3: Estimate Bicycle Volumes**

**Tool 4: Assess Dangerous Situation Exposure**



Tool 1

# CALCULATE BICYCLE LEVEL OF SERVICE

# Background

- **Bicycle Suitability**

  Perceived comfort and safety of a segment of street or pathway

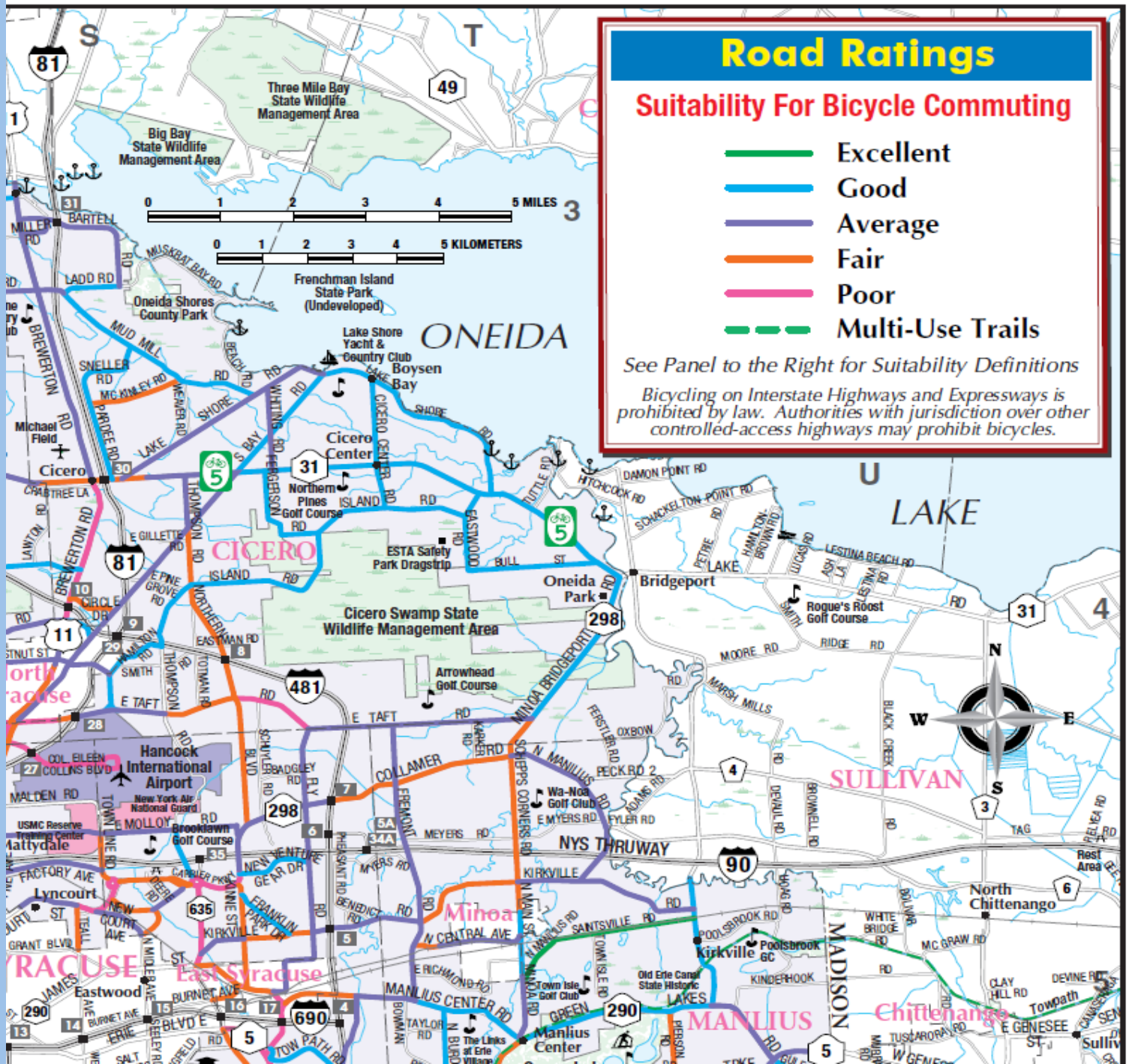
- **Bikeability**

  Perceived comfort and safety of network connectivity for accessing important destinations

- **Bicycle Friendliness**

  Perceived comfort and safety of all aspects of bicycle travel, including bikeability, laws and policies to promote bicycling, education efforts to encourage bicycling, and general acceptance of bicycling throughout the community

| Name of Method | Acronym | Author | Date |
|---|---|---|---|
| **Bicycle Safety Index Rating** | BSIR | Davis | 1987 |
| **Bicycle Stress Level** | BSL | Sorton and Walsh | 1994 |
| **Road Condition Index** | RCI | Epperson | 1994 |
| **Interaction Hazard Score** | HIS | Landis | 1994 |
| **Bicycle Suitability Rating** | BSR | Davis | 1995 |
| **Bicycle Level of Service** | BLOS | Botma | 1995 |
| **Bicycle Level of Service** | BLOS | Dixon | 1996 |
| **Bicycle Suitability Score** | BSS | Turner et al | 1997 |
| **Bicycle Compatibility Index** | BCI | Harkey et al | 1998 |
| **Bicycle Suitability Assessment** | BSA | Emery and Crump | 2003 |
| **Rural Bicycle Compatibility Index** | RBCI | Jones | 2003 |
| **Compatibility of Roads for Cyclists** | CRC | Noel et al | 2003 |
| **Bicycle Level of Service** | BLOS | Zolnik | 2007 |
| **Bicycle Level of Service** | BLOS | Jensen | 2007 |
| **Bicycle Level of Service** | BLOS | Petritsch et al | 2007 |
| **Bicycle Environmental Quality Index** | BEQI | SFDPH | 2009 |
| **Bicycle Quality Index** | BQI | Birk et al | 2010 |
| **Bicycle Level of Service** | BLOS | HCM | 2011 |
| **Bicycle Levels of Traffic Stress** | LTS | Mekuria and Furth | 2012 |
| **Protected Lane Level of Service** | PL-LOS | Foster and Monsere | Today |


Road Ratings
Suitability For Bicycle Commuting
Excellent
Good
Average
Fair
Poor
Multi-Use Trails
See Panel to the Right for Suitability Definitions
Bicycling on Interstate Highways and Expressways is prohibited by law. Authorities with jurisdiction over other controlled-access highways may prohibit bicycles.
ONEIDA
LAKE
SULLIVAN
MADISON
MANLIUS
CICERO
SYRACUSE
East Syracuse
Minoa
Chittenango
North Chittenango
Three Mile Bay State Wildlife Management Area
Big Bay State Wildlife Management Area
Frenchman Island State Park (Undeveloped)
Oneida Shores County Park
Lake Shore Yacht & Country Club
Boysen Bay
Cicero Center
Northern Pines Golf Course
ESTA Safety Park Dragstrip
Cicero Swamp State Wildlife Management Area
Arrowhead Golf Course
Oneida Park
Bridgeport
Rogue's Roost Golf Course
Hancock International Airport
New York Air National Guard
USMC Reserve Training Center
Brooklawn Golf Course
Wa-Nee Golf Club
Kirkville
Poolsbrook GC
Town Isle Golf Club
Old Erie Canal State Historic
The Links at Erie Village
Manlius Center
Michael Field
Lyncourt
Eastwood
Mattydale
Cicero
Rest Area
NYS THRUWAY
0 1 2 3 4 5 MILES
0 1 2 3 4 5 KILOMETERS

| Attribute | Method | | | | |
|---|---|---|---|---|---|
| | BSL | BSS | BCI | BSA | BLOS |
| width of outside lane | x | x | x | x | x |
| width of bike lane | | | x | x | x |
| width of shoulder | | x | x | x | x |
| on-street parking | | | x | x | x |
| presence of curb | | | | x | x |
| vehicle traffic volume | x | x | x | x | x |
| number of lanes | | | | x | x |
| speed limit | x | x | x | x | x |
| percent heavy vehicles | | | x | | x |
| pavement condition | | x | | x | x |
| elevation grades | | | | x | |
| adjacent land use | | | x | x | |
| storm drain grate | | | | x | |
| physical median | | | | x | |
| turn lanes | | | x | x | |
| frequent curves | | | | x | |
| restricted sight distance | | | | x | |
| numerous driveways | | | | x | |
| presence of sidewalks | | | | x | |

## Equation

$$\textit{Bicycle Level of Service} = 0.76 + [-0.005((w_{ol} + w_{bl} + w_{os})(2 - 0.005v) + (w_{bl} + w_{os} - 20p_{pk}) - 1.5c)^2] + 0.507 \ln\left(\frac{v}{4N_{th}}\right) + 0.199[1.119 \ln(S - 20) + 0.8103](1 + 0.1038P_{HV})^2 + 7.066\left(\frac{1}{P_c^2}\right)$$

## Input

| Attribute | Description |
|---|---|
| wol | width of outside lane (ft) |
| wbl | width of bike lane (ft) |
| wos | width of outside shoulder including parking and gutter (ft) |
| ppk | estimated proportion of on-street parking that would be occupied during analysis period (decimal) |
| c | curb present (yes = 1, no =0) |
| v | directional analysis period vehicle volume (vph) |
| Nth | number of through lanes (#) |
| S | average vehicle speed (mph) |
| PHV | percent heavy vehicles (decimal) |
| Pc | pavement condition (poor-excellent) (0-5) |


## Output

| BLOS | Letter Grade |
|---|---|
| ≤ 2.00 | A |
| 2.00-2.75 | B |
| 2.75-3.50 | C |
| 3.50-4.25 | D |
| 4.25-5.00 | E |
| >5.00 | F |

## Equation

$$\text{Bicycle Suitability Score} = \text{Traffic Volume Factor Score} + \text{Shoulder Width Factor Score} + \text{Speed Limit Factor Score} + \text{Pavement Factor Score}$$

## Input

| Traffic Volume (ADT per lane) | Shoulder Width [If no shoulder, Curb Lane Width] (ft) | Speed Limit (mph) | Pavement Condition (HPMS rating) | Factor Score |
|---|---|---|---|---|
| ≤ 1,000 | ≥ 6 [≥ 15] | ≤ 40 | 4-5 | 2 |
| 1,000-1,999 | 4-6 [14-15] | 49-50 | 3-4 | 1 |
| 2,000-4,999 | 2-4 [12-14] | 50-59 | 3 | 0 |
| 5,000-9,999 | 0-2 [12] | 60-69 | 2-3 | -1 |
| ≥ 10,000 | 0 [≤ 12] | ≥ 70 | 1-2 | -2 |

## Output

| Score Range | Interpretation |
|---|---|
| 6 to 8 | All four suitability factors have greater than minimum desirable values. The physical characteristics of the roadway are most likely desirable by intermediate to experienced bicyclists. |
| -1 to 5 | At least three of the four suitability factors have minimum desirable or greater than minimum desirable values. One suitability factor may have less than desirable values. The physical characteristics of the roadway could be desirable by intermediate to experienced bicyclists. |
| -2 to -5 | At least two of the four suitability factors have less than minimum desirable values. One or two of the suitability factors may have minium desirable values. The physical characteristics of the roadway may not be desirable by intermediate to experienced bicyclists. |
| -6 to -8 | All four of the suitability factors have less than the minimum desirable values. The physical characteristics of the roadway are most likely undesirable by intermediate to experienced bicyclists. |

*Intended for state highways and intermediate or experienced bicyclists.*

| | |
|---|---|
| Date: April 4, 2002 | Comments/Suggested Improvements: |
| Data Collector Name: Jim | **BICYCLE SUITABILITY ASSESSMENT** |
| Segment ID Number/Name: 101 - Sample | |
| Boundary streets: Walnut / Tulip | |

| A) General Road Factors | Measures |
|---|---|
| 1) Annual Avg. Daily Traffic (AADT) | 16,500 |
| 2) Total number of through lanes | 2 |
| 3) Speed (mph) | 35 |
| 4) Outside lane width (e.g., 11.5') | 12.5 |
| 5) Bike lane or paved shoulder width (e.g., 4.5') (Note - a **marked** bike lane.) | Ø |

*Record these measures in the formula below*

| B) Pavement Factors | Score |
|---|---|
| 1) (*circle one pavement description*) | (*record score*) |
| Very Good = 0.25 | |
| Good = 0.75 | 0.75 |
| Fair = 1.50 | |
| Poor = 2.25 | |
| Very Poor = 3.75 | |
| 2) Presence of a Curb (Y) N | Yes = 0.25 |
| 3) Rough RR Crossing Y (N) | Yes = 0.50 |
| 4) Storm Drain Grate (Y) N | Yes = 0.75 |
| **TOTAL Scores** *Record score in formula below* | 1.75 |

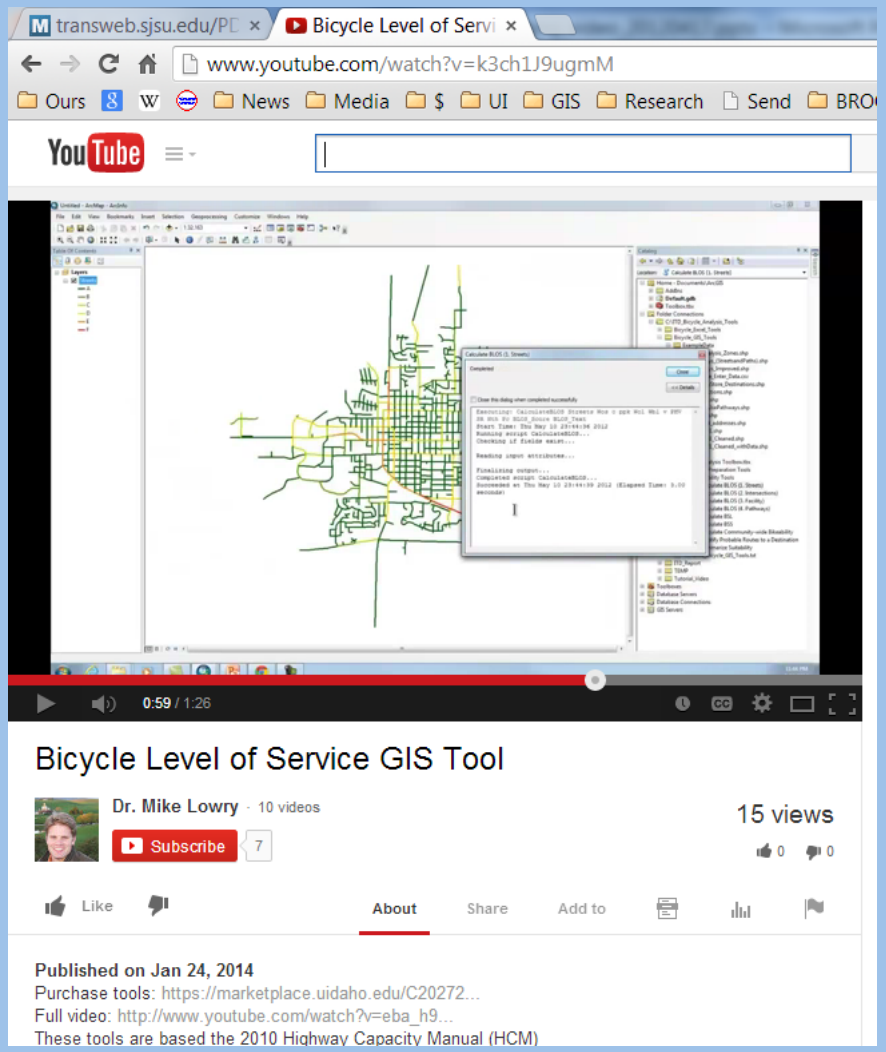
| C) Location Factors | Yes/No (*circle*) | Score for "Yes" |
|---|---|---|
| 1) Angle Parking | Y (N) | 0.75 |
| 2) Parallel Parking | (Y) N | 0.50 |
| 3) Right-Only Turn Lanes | (Y) N | 0.25 |
| 4) Center (Both)Turn Lane | Y (N) | -0.25 |
| 5) Physical Median | Y (N) | -0.50 |
| 6) Paved Shoulder | Y (N) | -0.75 |
| 7) Marked Bike Lane | Y (N) | -1.00 |
| 8) Severe Grades | Y (N) | 0.50 |
| 9) Moderate Grades | (Y) N | 0.25 |
| 10) Frequent Curves | (Y) N | 0.25 |
| 11) Restricted Sight Distance | (Y) N | 0.50 |
| 12) Numerous Driveways | (Y) N | 0.50 |
| 13) Numerous Intersections | Y (N) | 0.75 |
| 14) Difficult Intersections | Y (N) | 1.00 |
| 15) Industrial Land Use | Y (N) | 0.50 |
| 16) Commercial Land Use | (Y) N | 0.25 |
| 17) Sidewalk Only One Side | (Y) N | 0.25 |
| 18) Sidewalks do not exist | Y (N) | 0.50 |
| **TOTAL all "YES" points** *Record score in formula below* | | 2.75 |

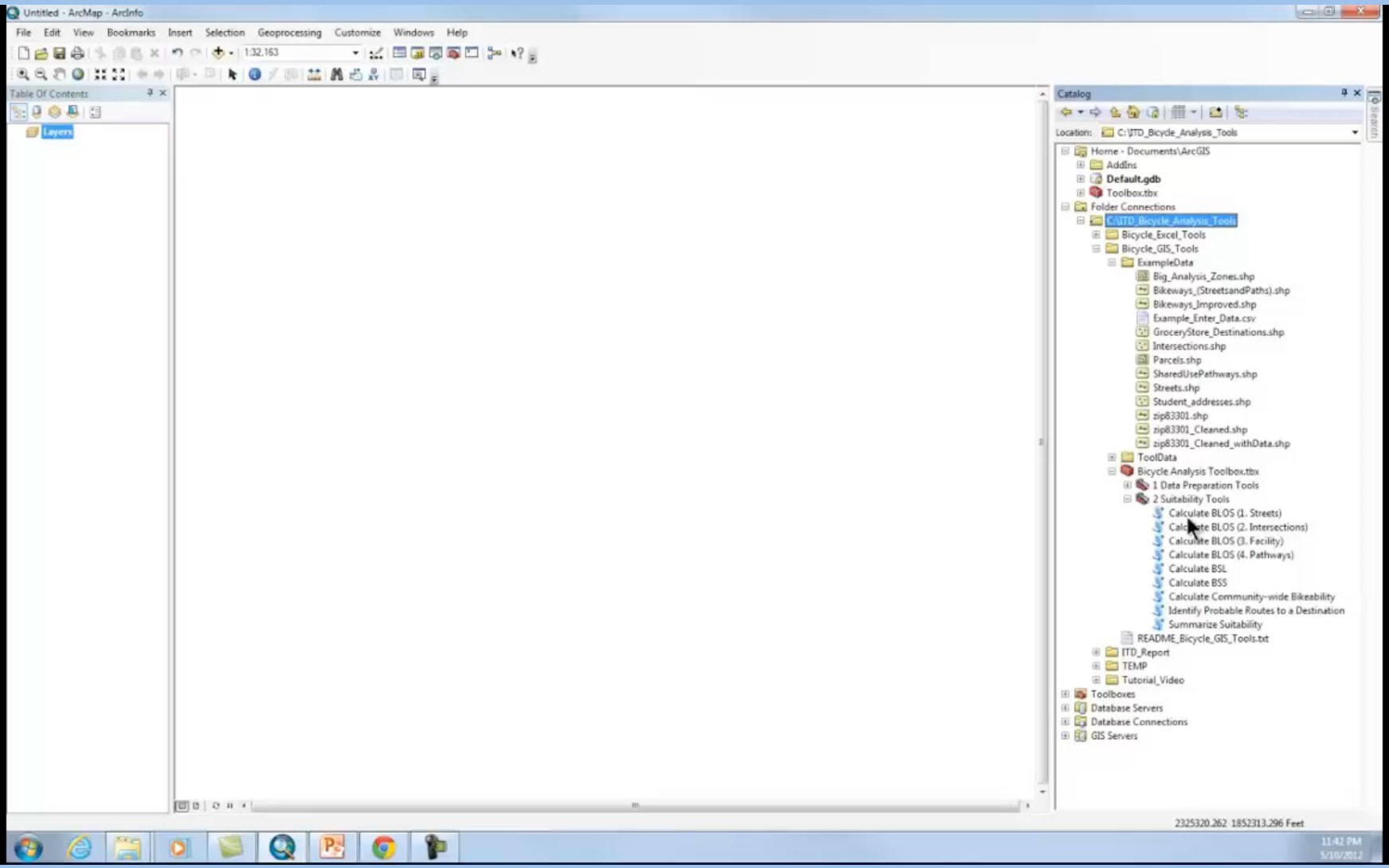
$$\frac{\text{AADT}}{\text{\# of thru Lanes} \times 2500} + \frac{\text{Speed (mph)}}{35} + \frac{14 - \text{Outside Lane Width} - \text{Bike Lane or Paved Shoulder Width}}{2} + \text{Pavement Factors} + \text{Location Factors} = \text{Bicycle Suitability Score}$$

$$\frac{16,500}{2 \times 2500} + \frac{35}{35} + \frac{14 - 12.5 - \text{Ø}}{2} + 1.75 + 2.75 = 9.6$$

# [BLOS Demonstration video]

http://www.youtube.com/watch?v=k3ch1J9ugmM

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Layers
Catalog
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Home - Documents\ArcGIS
AddIns
Default.gdb
Toolbox.tbx
Folder Connections
C:\ITD_Bicycle_Analysis_Tools
Bicycle_Excel_Tools
Bicycle_GIS_Tools
ExampleData
Big_Analysis_Zones.shp
Bikeways_(StreetsandPaths).shp
Bikeways_Improved.shp
Example_Enter_Data.csv
GroceryStore_Destinations.shp
Intersections.shp
Parcels.shp
SharedUsePathways.shp
Streets.shp
Student_addresses.shp
zip83301.shp
zip83301_Cleaned.shp
zip83301_Cleaned_withData.shp
ToolData
Bicycle Analysis Toolbox.tbx
1 Data Preparation Tools
2 Suitability Tools
Calculate BLOS (1. Streets)
Calculate BLOS (2. Intersections)
Calculate BLOS (3. Facility)
Calculate BLOS (4. Pathways)
Calculate BSL
Calculate BSS
Calculate Community-wide Bikeability
Identify Probable Routes to a Destination
Summarize Suitability
README_Bicycle_GIS_Tools.txt
ITD_Report
TEMP
Tutorial_Video
Toolboxes
Database Servers
Database Connections
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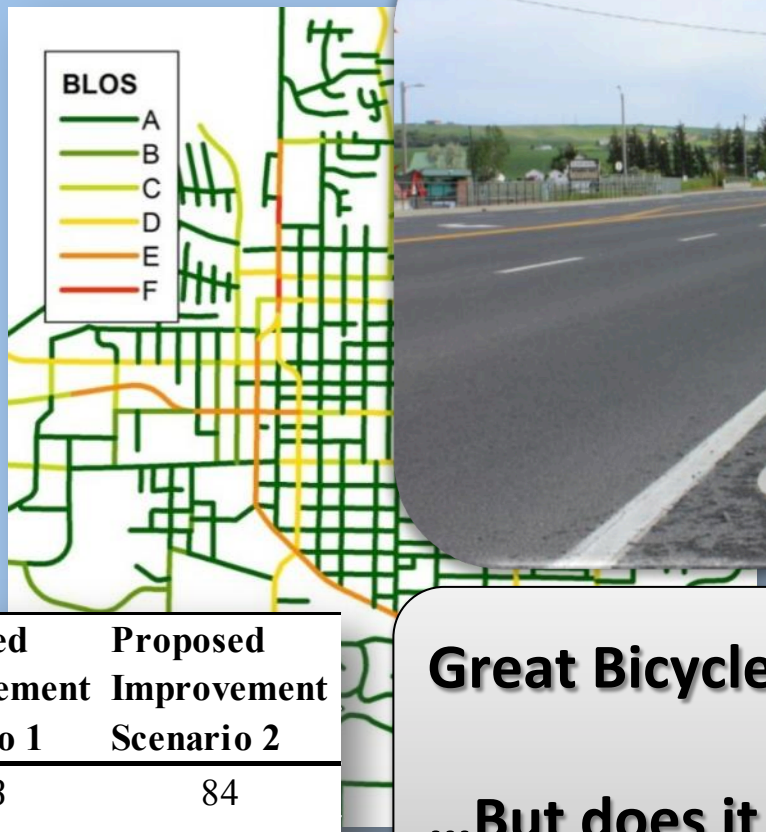



| BLOS | Current Conditions | Proposed Improvement Scenario 1 | Proposed Improvement Scenario 2 |
|---|---|---|---|
| A | 70 | 78 | 84 |
| B | 7 | 8 | 5 |
| C | 10 | 8 | 5 |
| D | 7 | 3 | 3 |
| E | 3 | 1 | 1 |
| F | 3 | 2 | 2 |

**Great Bicycle Suitability…**

**…But does it go anywhere?**


Tool 2

# CALCULATE COMMUNITY-WIDE BIKEABILITY

- **Bicycle Suitability**

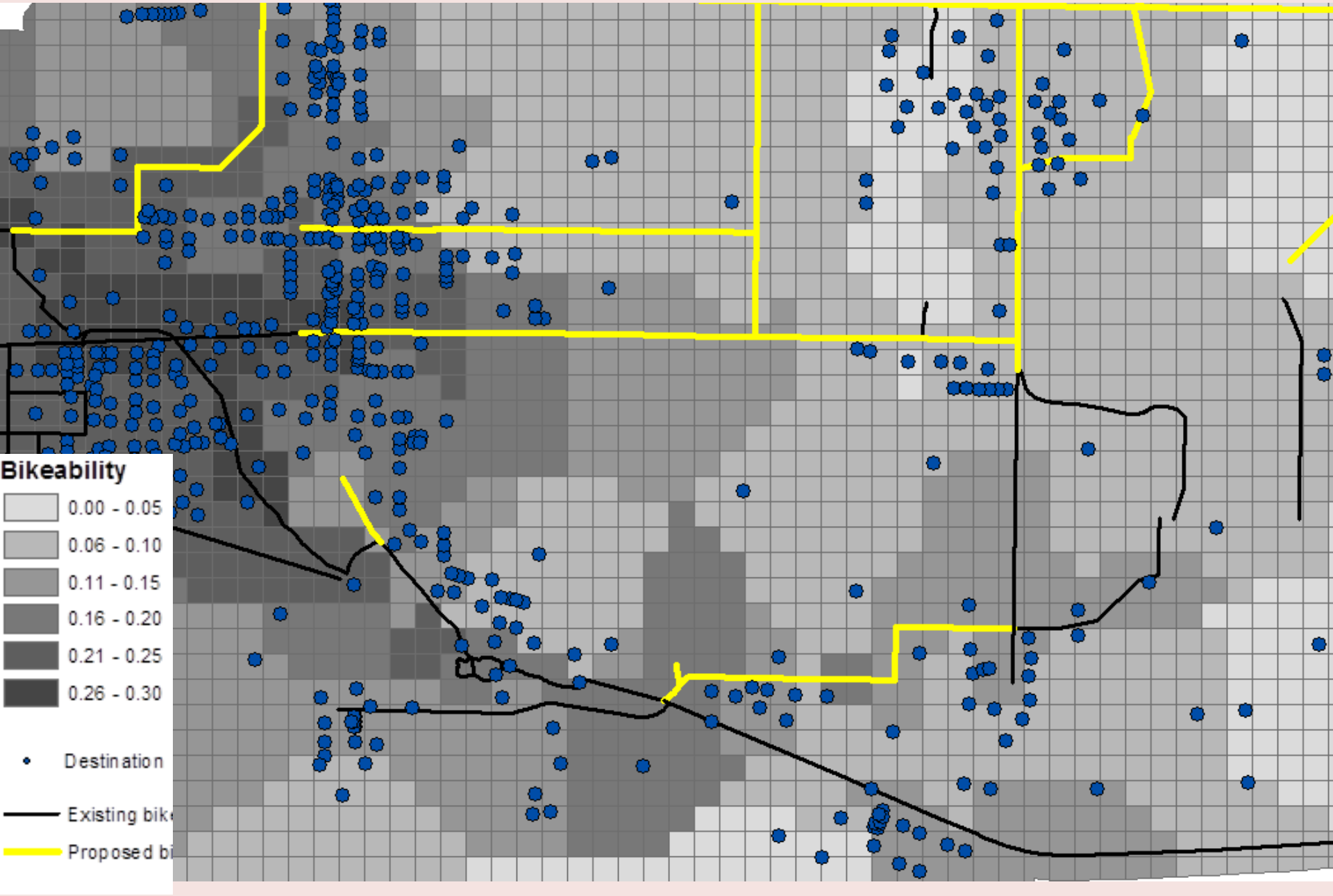
  Perceived comfort and safety of a segment of street or pathway

- **Bikeability**

  Perceived comfort and safety of network connectivity for accessing important destinations

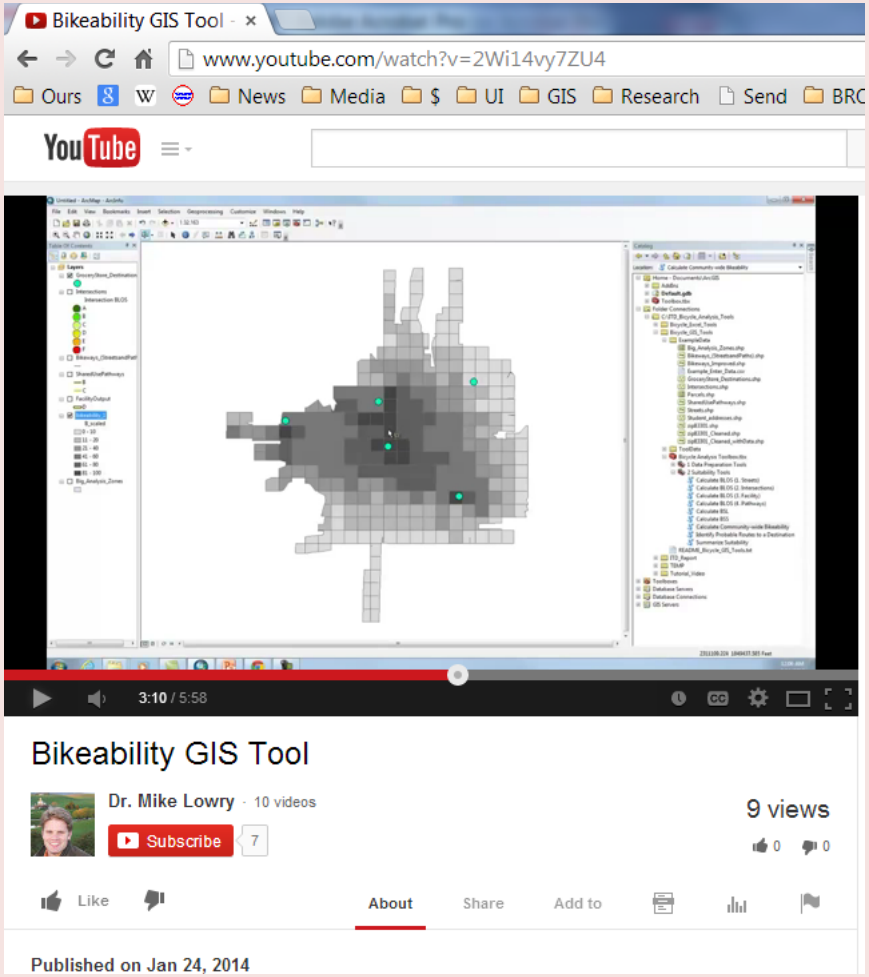
- **Bicycle Friendliness**

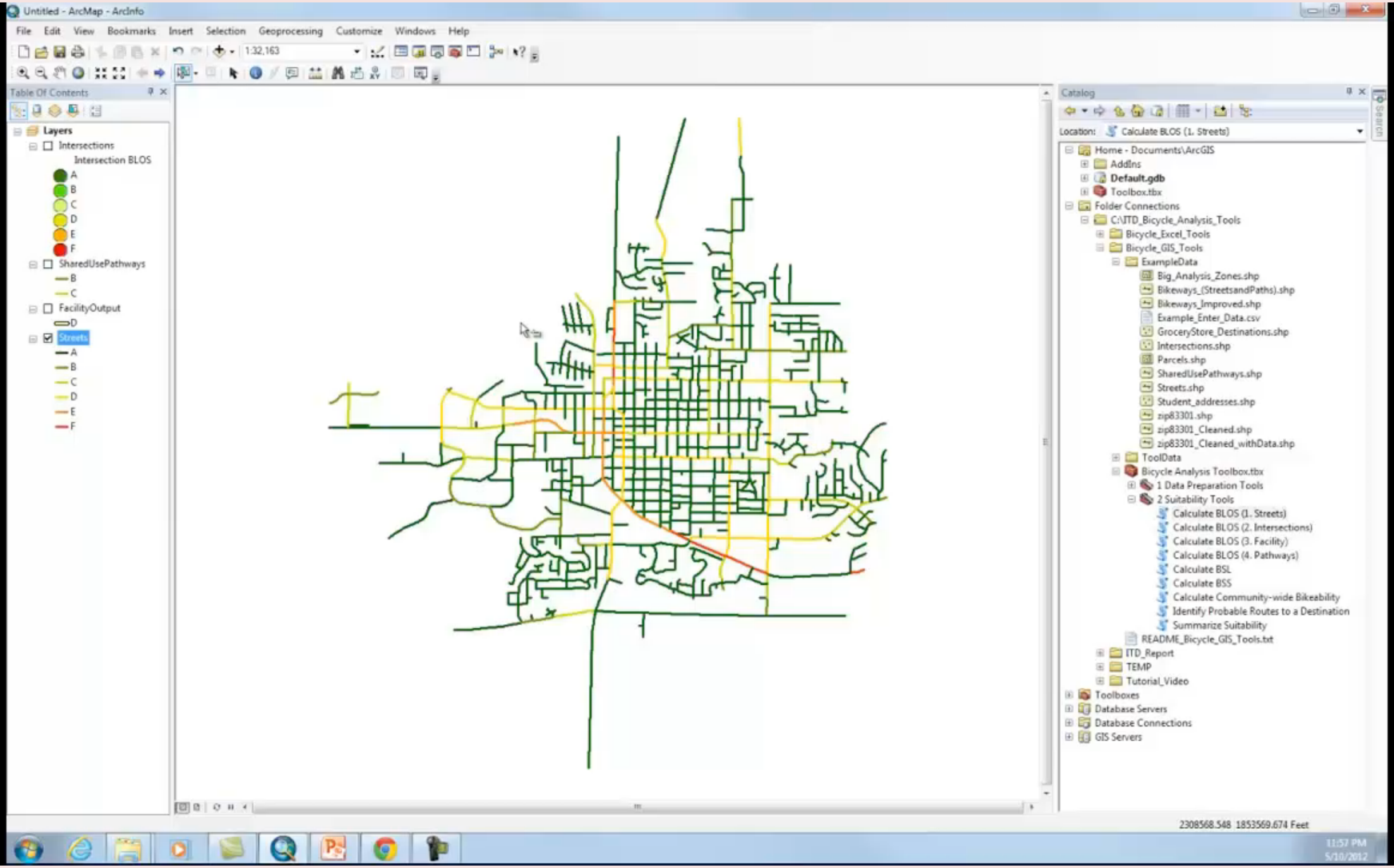
  Perceived comfort and safety of all aspects of bicycle travel, including bikeability, laws and policies to promote bicycling, education efforts to encourage bicycling, and general acceptance of bicycling throughout the community


Bikeability
0.00 - 0.05
0.06 - 0.10
0.11 - 0.15
0.16 - 0.20
0.21 - 0.25
0.26 - 0.30
Destination
Existing bik
Proposed bi

# [Bikeability Demonstration video]

http://www.youtube.com/watch?v=2Wi14vy7ZU4

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File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:32,163
Table Of Contents
Layers
Intersections
Intersection BLOS
A
B
C
D
E
F
SharedUsePathways
B
C
FacilityOutput
D
Streets
A
B
C
D
E
F
Catalog
Location: Calculate BLOS (1. Streets)
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Parcels.shp
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Streets.shp
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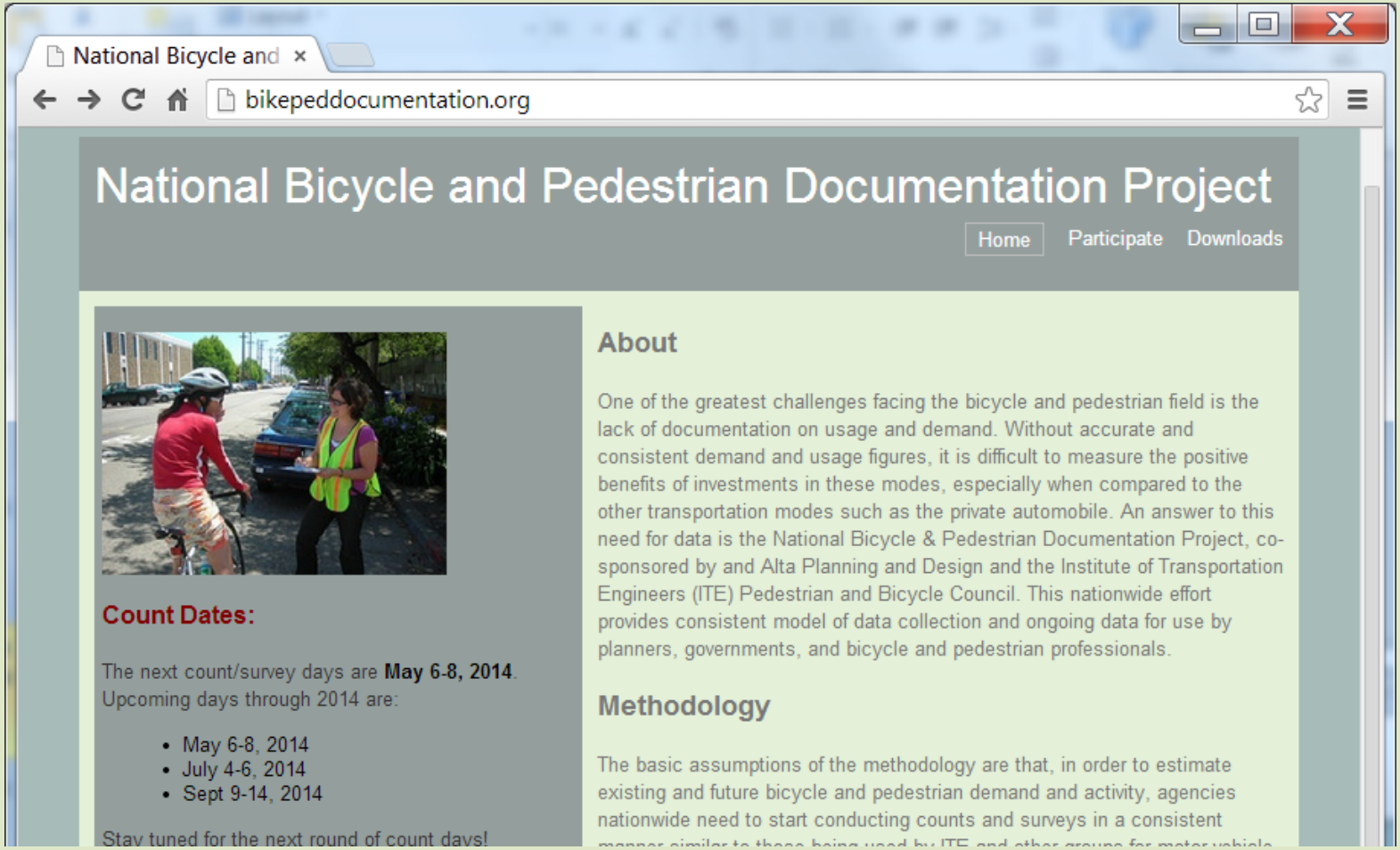
Database Connections
GIS Servers
2308568.548 1853569.674 Feet

Tool 3

# ESTIMATE BICYCLE VOLUMES

# Background

## Citizen-volunteer count programs



# Instructions

The other dates were selected to provide a representative sampling of activity during a typical spring (May) and winter (January) period. The 4th of July period was selected because it will afford both a typical summer weekday and what is typically the busiest holiday period and activity period for recreational facilities and activities.

Having an official count week is also important for generating enthusiasm around the date. Much like nationwide Bike to Work Weeks, we hope that the National Documentation Project Week in September will become a much-anticipated annual event in localities around the nation.

### Times

Based on our research, we are recomme
below). However, if you have been doin
using these same time periods for all fut

***RECOMMEN***
Weekday, 5-
Saturday, 12

***SECONDARY***
Weekday, 7
Saturday, 7 A

### Rationale for Time Periods

Time periods are more important for co
periods were chosen since the afternoo
travelers, with commuters, school childr
conducted during these periods will pro
bicycling during the peak periods of the
peak period. Actual local peak periods n
that the national count time periods be
periods if it is determined that this perio

### Automatic Machines

While the NBPD is based on manual cou
conducting counts to consider conductin
community. These machines will give in
usage, benefits and other information.

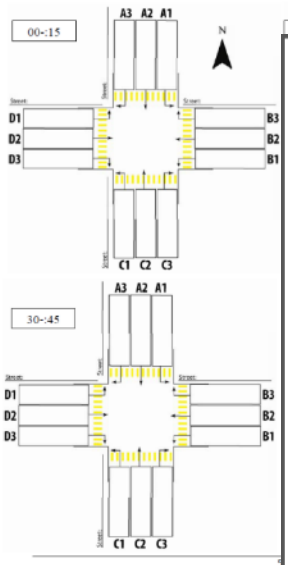
### Weather

Weather may be a determinant in select
conduct counts and surveys, but a partic
poor or unusual during the count period

# Forms

Please fill in your name, count location, date, time period, and weather conditions (fair, rainy, very cold).
Count all bicyclists crossing through the intersection under the appropriate categories.

- Count for two hours in 15-minute increments.
- Count bicyclists who ride on the sidewalk.
- Count the number of people on the bicycle, not the number of bicycles.
- Use one intersection graphic per 15-minute interval.




# Training Presentation

## How do you count this?

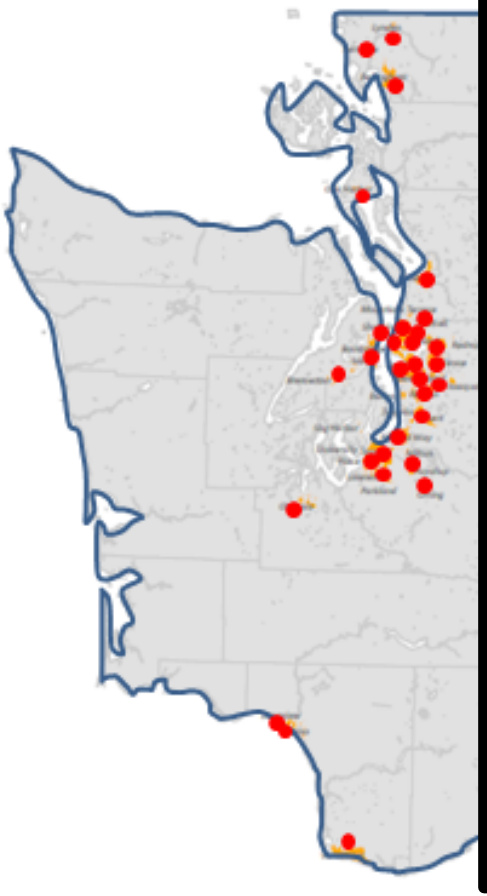
alta PLANNING + DESIGN



estrian Documentation Project
Home Participate Downloads
rials

# Citizen Volunteer Counts

## 2012 Washington State Bicycle and Pedestrian Documentation Project



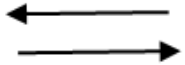
### Table 2: Count cities and locations by year

| City | 2008 AM | 2008 PM | 2009 AM | 2009 PM | 2010 AM | 2010 PM | 2011 AM | 2011 PM | 2012 AM | 2012 PM |
|---|---|---|---|---|---|---|---|---|---|---|
| Bainbridge Island | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 1 | 5 | 4 |
| Bellevue | 4 | 3 | 13 | 13 | 13 | 13 | 5 | 7 | 7 | 8 |
| Bellingham | 6 | 6 | 12 | 12 | 17 | 17 | 18 | 18 | 18 | 18 |
| Bothell | 5 | 6 | 6 | 4 | 6 | 3 | 6 | 5 | 6 | 5 |
| Bremerton | 6 | 6 | 6 | 4 | 6 | 5 | 1 | 3 | 6 | 5 |
| Burien | 0 | 0 | 4 | 9 | 9 | 9 | 9 | 9 | 10 | 10 |
| Ellensburg | 6 | 4 | 5 | 4 | 2 | 3 | 3 | 5 | 4 | 4 |
| Everett | 6 | 6 | 9 | 9 | 8 | 5 | 10 | 9 | 11 | 11 |
| Federal Way | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 |
| Ferndale | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Gig Harbor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Issaquah | 0 | 0 | 6 | 4 | 7 | 3 | 6 | 3 | 6 | 6 |
| Kelso | 0 | 0 | 5 | 7 | 8 | 8 | 0 | 1 | 2 | 0 |

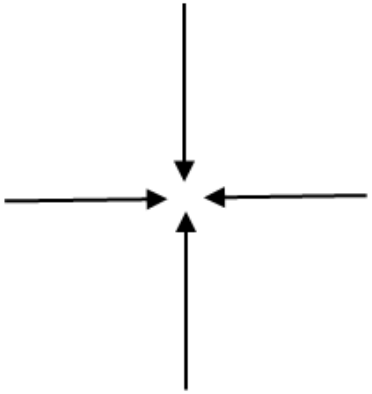
Table 2: Count cities and locations by year

| City | 2008 AM | 2008 PM | 2009 AM | 2009 PM | 2010 AM | 2010 PM | 2011 AM | 2011 PM | 2012 AM | 2012 PM |
|---|---|---|---|---|---|---|---|---|---|---|
| Bainbridge Island | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 1 | 5 | 4 |
| Bellevue | 4 | 3 | 13 | 13 | 13 | 13 | 5 | 7 | 7 | 8 |
| Bellingham | 6 | 6 | 12 | 12 | 17 | 17 | 18 | 18 | 18 | 18 |
| Yakima | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 3 | 1 | 1 |
| Total | 91 | 92 | 152 | 149 | 184 | 182 | 191 | 176 | 202 | 207 |
| | 183 | | 301 | | 366 | | 367 | | 409 | |

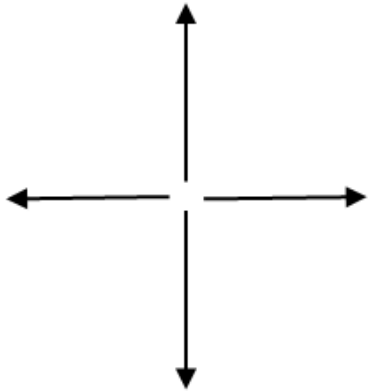
2 Movement
Screenline



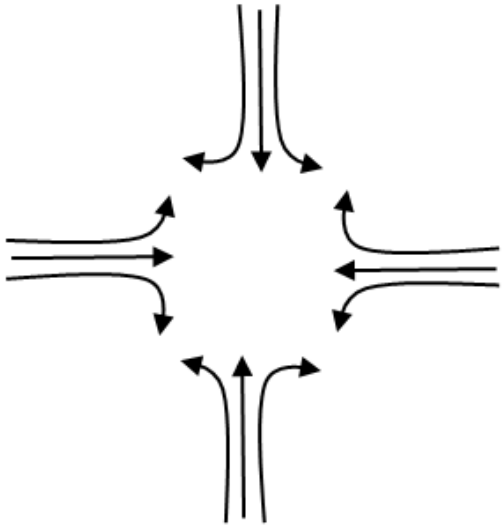
4 Movement
Toward Intersection



4 Movement
Leaving Intersection

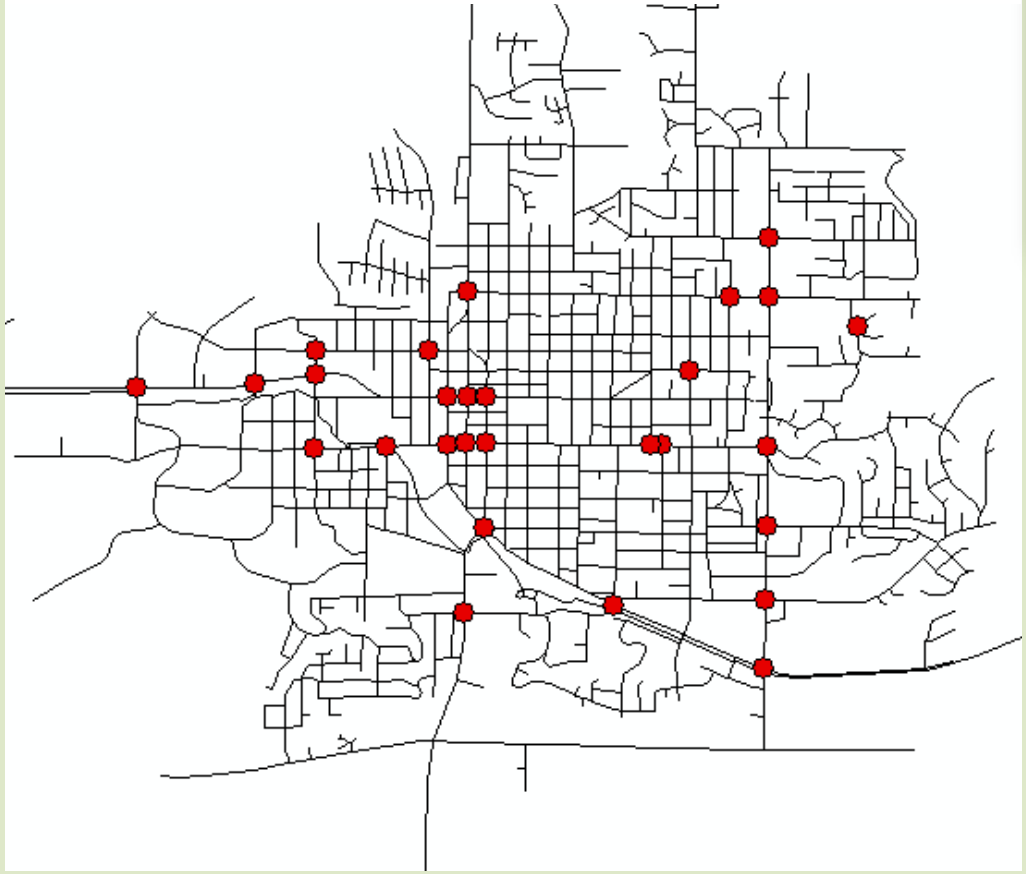


12 Movement



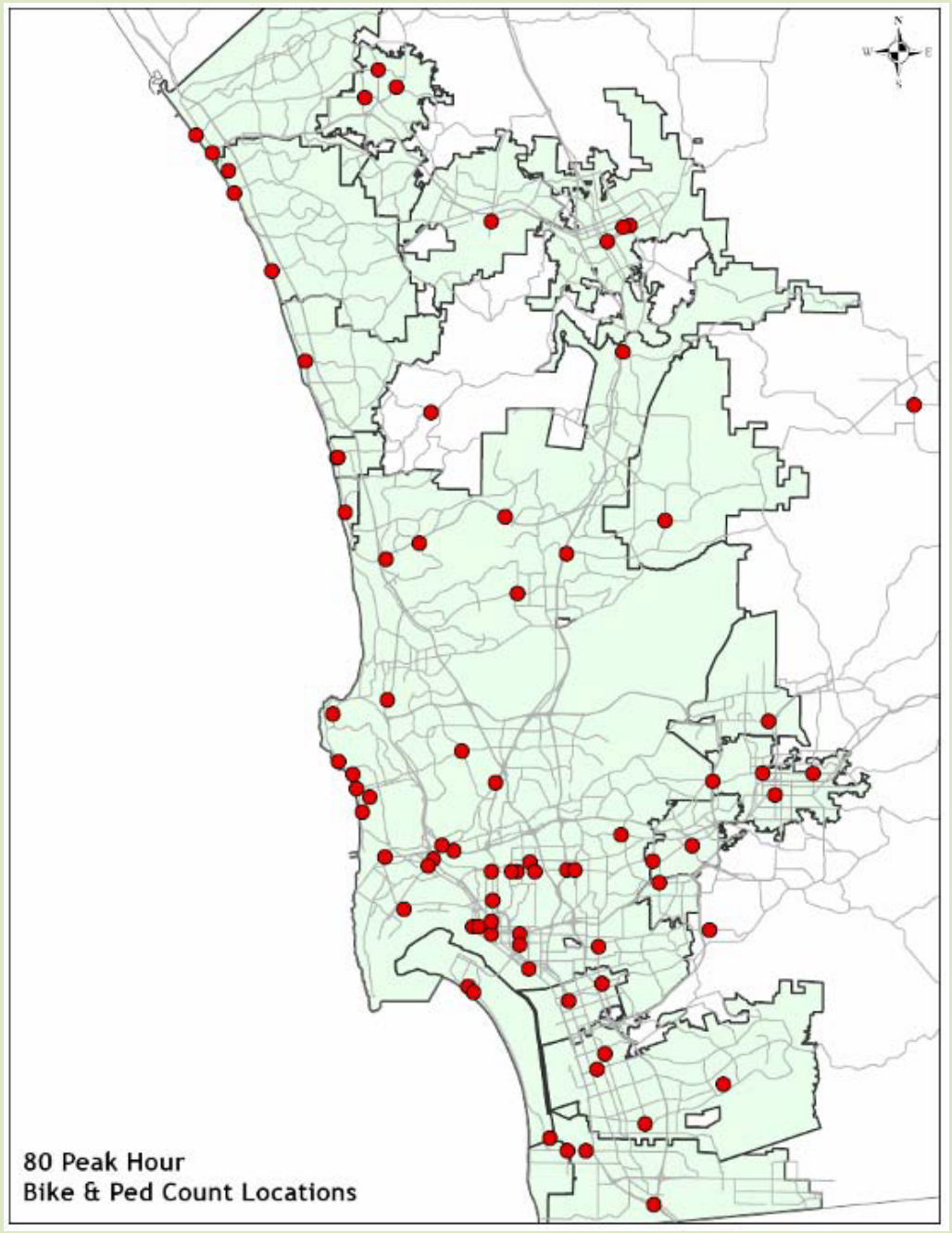
# How can citizen-volunteer count data be used?

## Snap shot of volumes



- 26 Locations
- 2011, 2012, 2013
- 7:00 – 9:00 AM
- 4:00 – 6:00 PM

**80 locations!**



# Background

**Estimating Bicycle Demand**

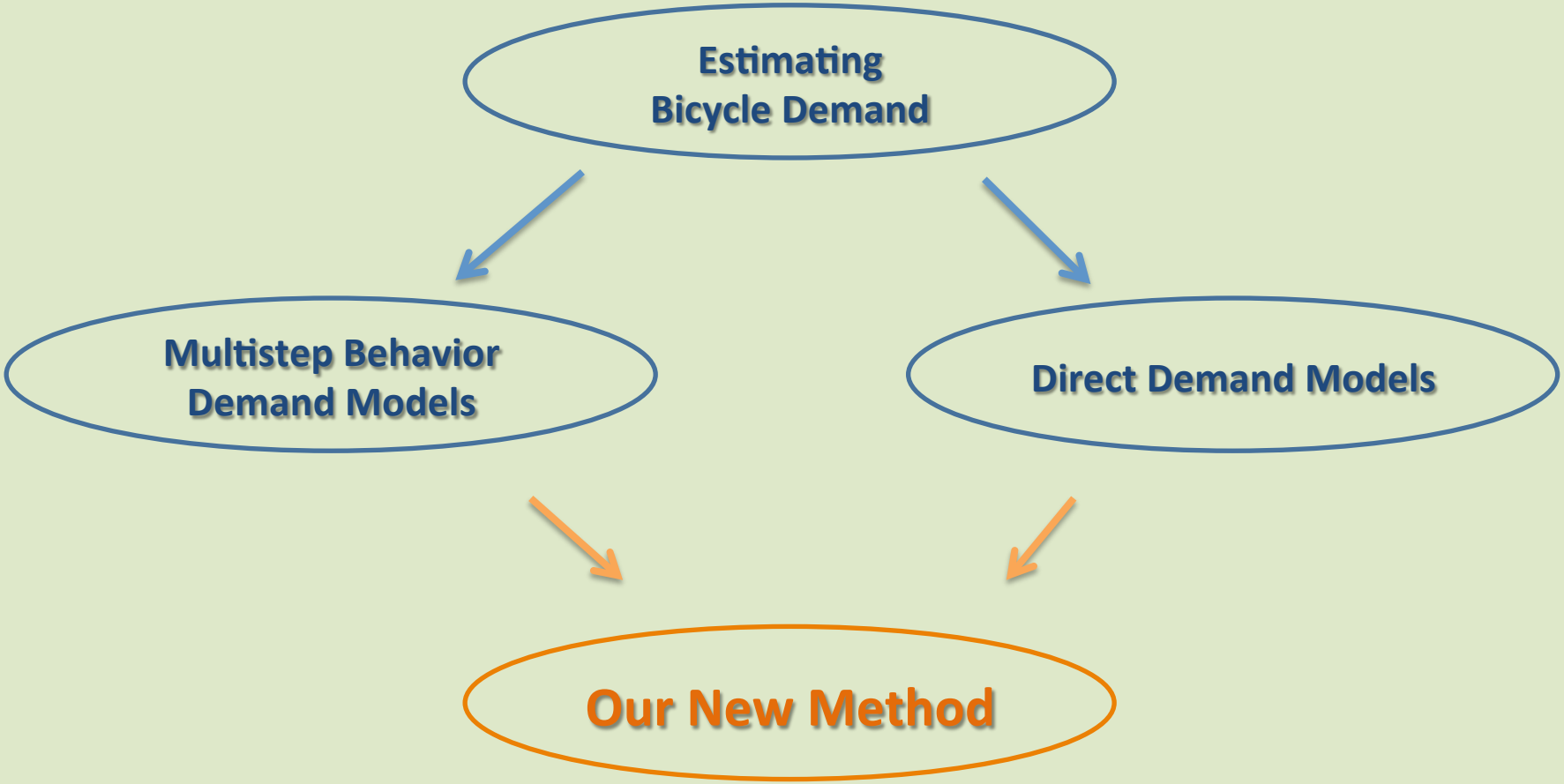
**Multistep Behavior Demand Models**

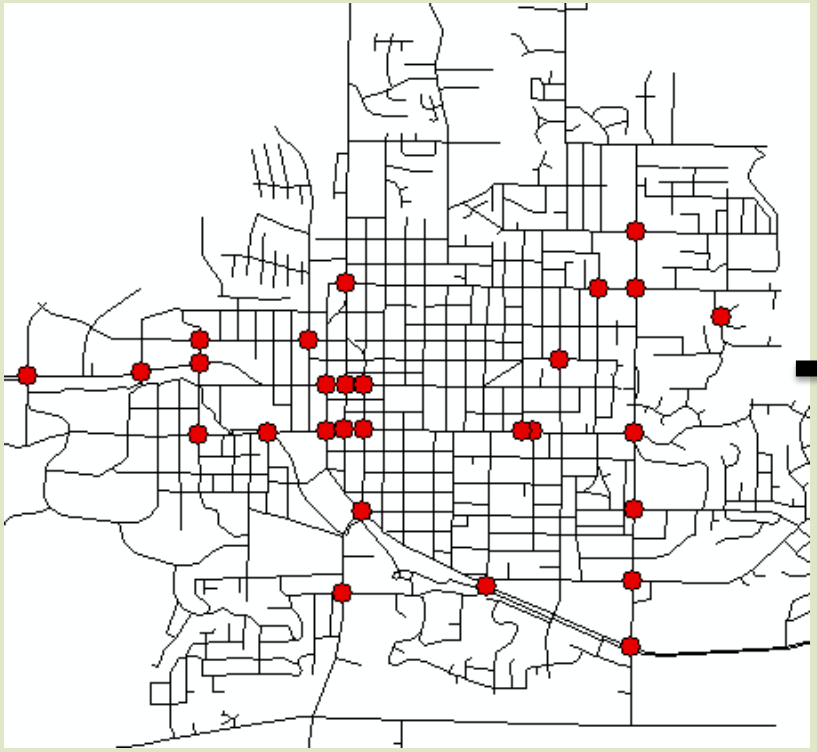
1. Trip generation
2. Trip distribution
3. Mode choice
4. Route assignment

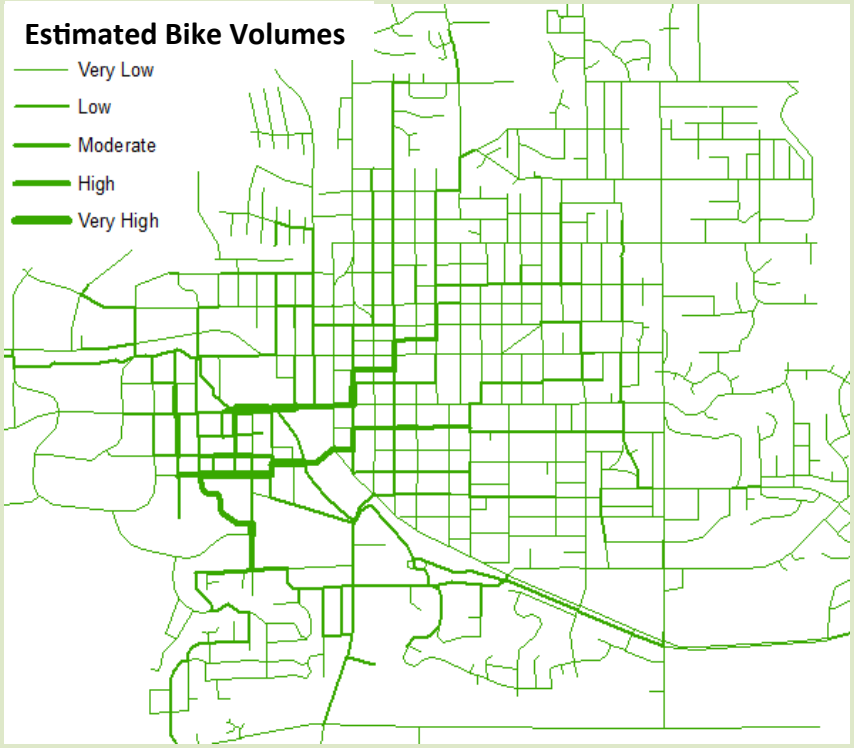
**Direct Demand Models**

Volume = $\beta_0$
+ $\beta_1$(Functional class)
+ $\beta_2$(Adjacent land use)
+ $\beta_3$(Distance to BART)

# Background


Estimating
Bicycle Demand
Multistep Behavior
Demand Models
Direct Demand Models
Our New Method

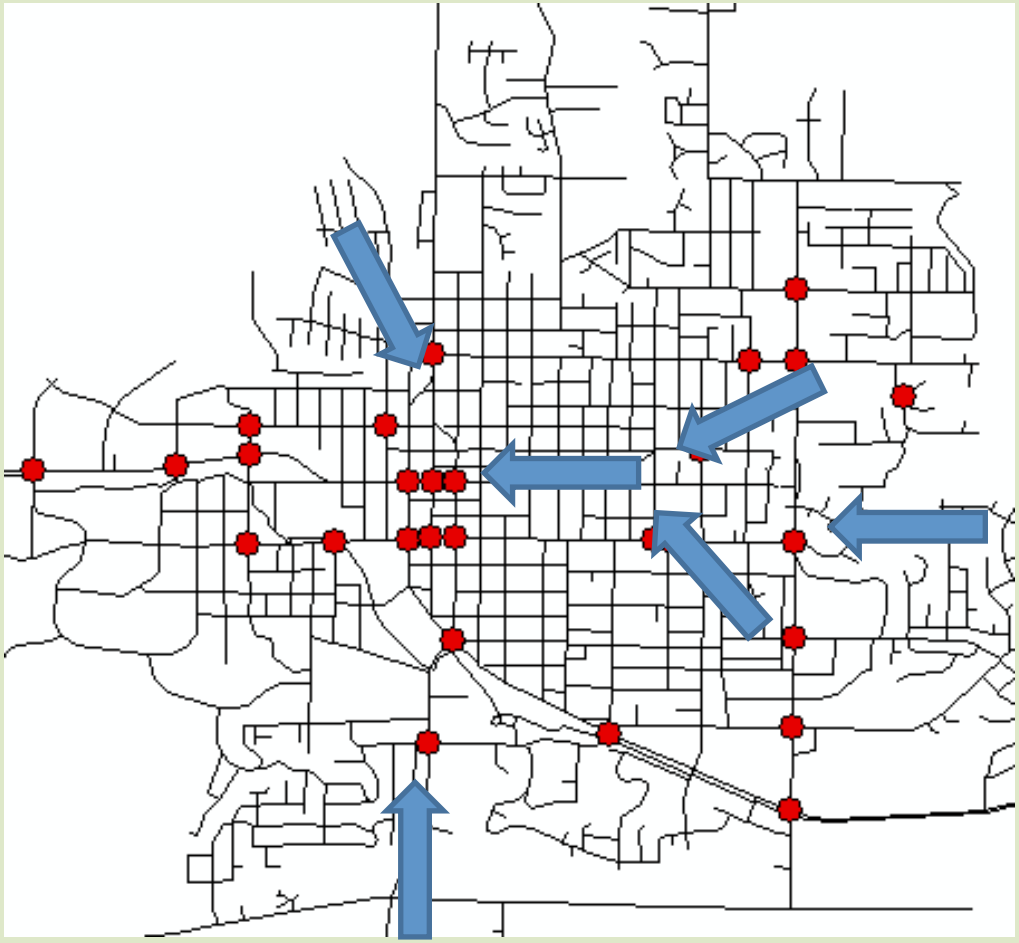





**Observed Count Points**

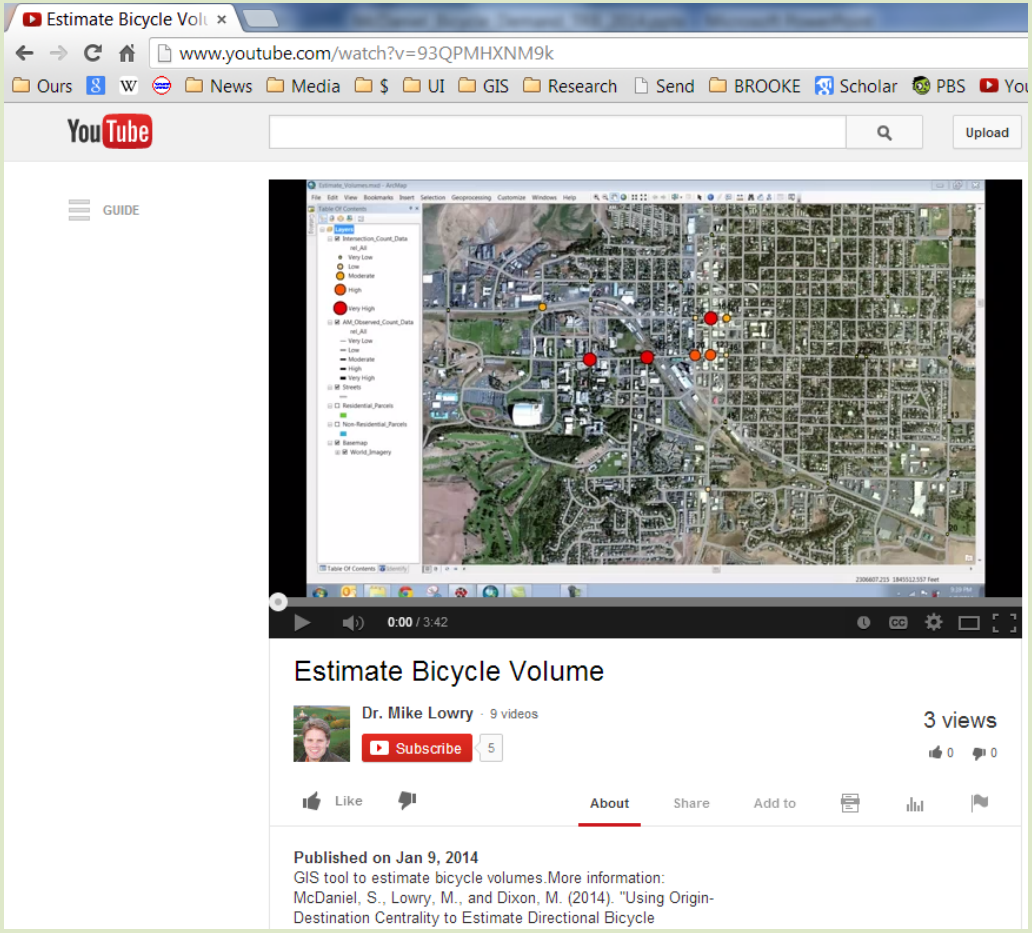
**Network-wide 2 Hour Volume**

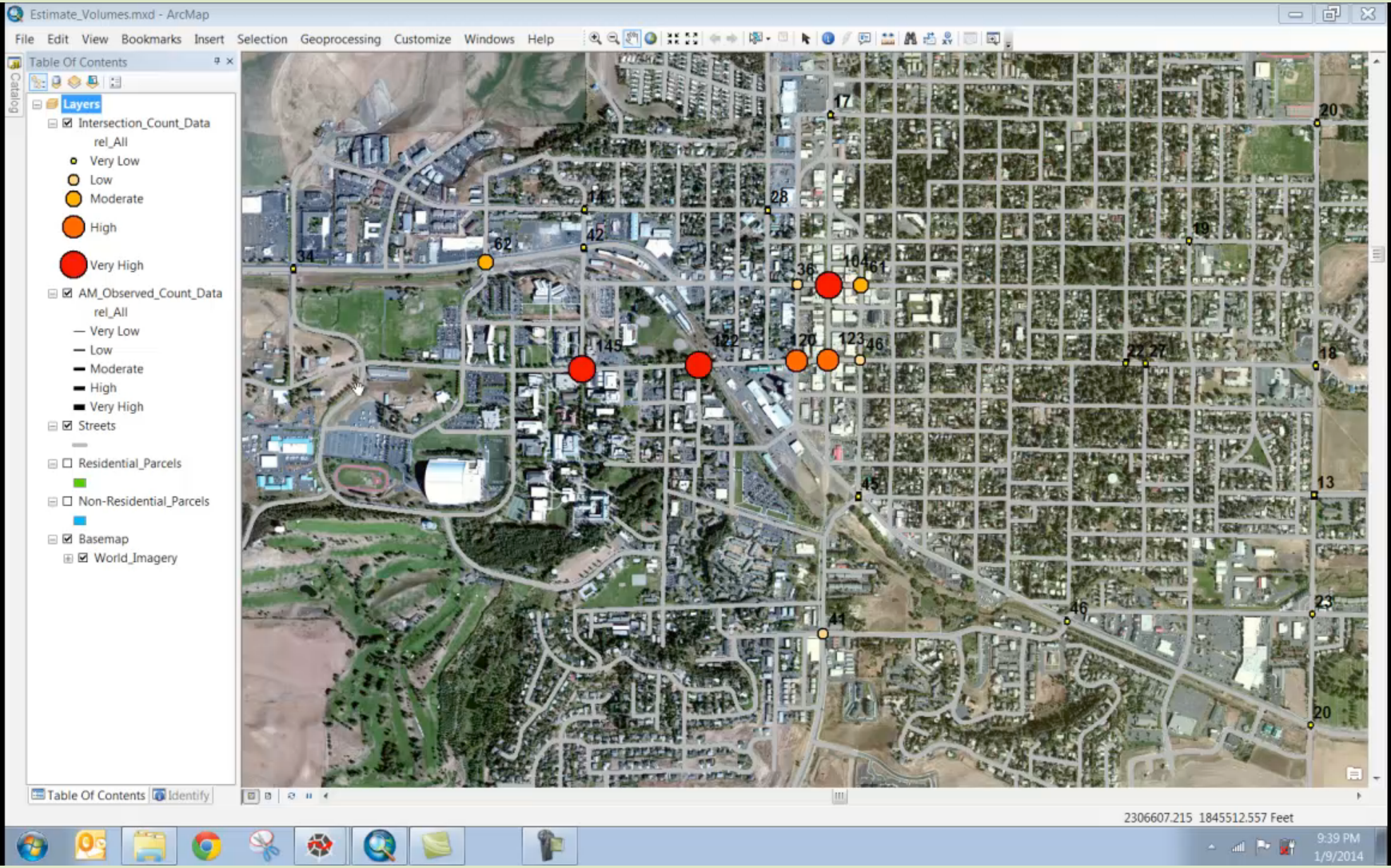
# Topological Flow



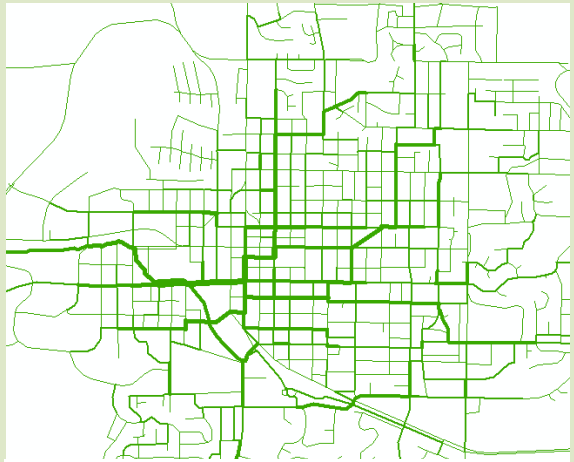
# [Volume Estimation Demonstration video]

http://www.youtube.com/watch?v=dMp2XIQaykw

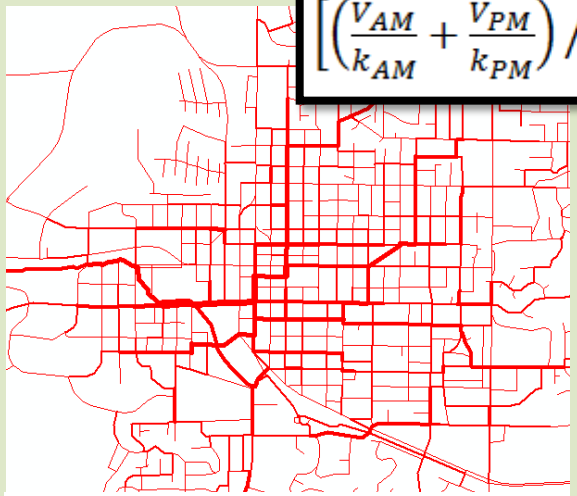



Estimate_Volumes.mxd - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
Intersection_Count_Data
rel_All
Very Low
Low
Moderate
High
Very High
AM_Observed_Count_Data
rel_All
Very Low
Low
Moderate
High
Very High
Streets
Residential_Parcels
Non-Residential_Parcels
Basemap
World_Imagery
Table Of Contents
Identify
2306607.215 1845512.557 Feet
9:39 PM
1/9/2014

# Step 1. Spatially Extrapolate



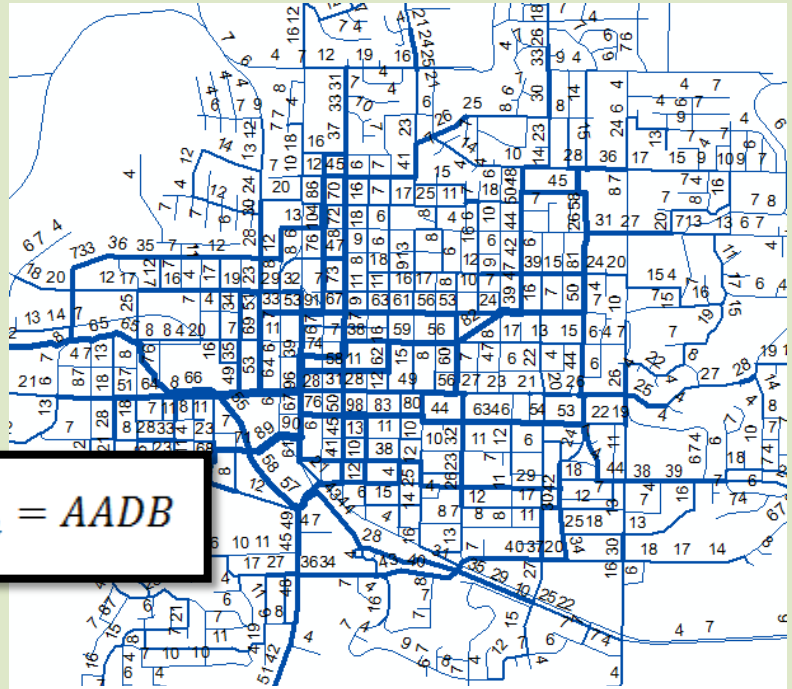
AM 2 Hour Volume



PM 2 Hour Volume

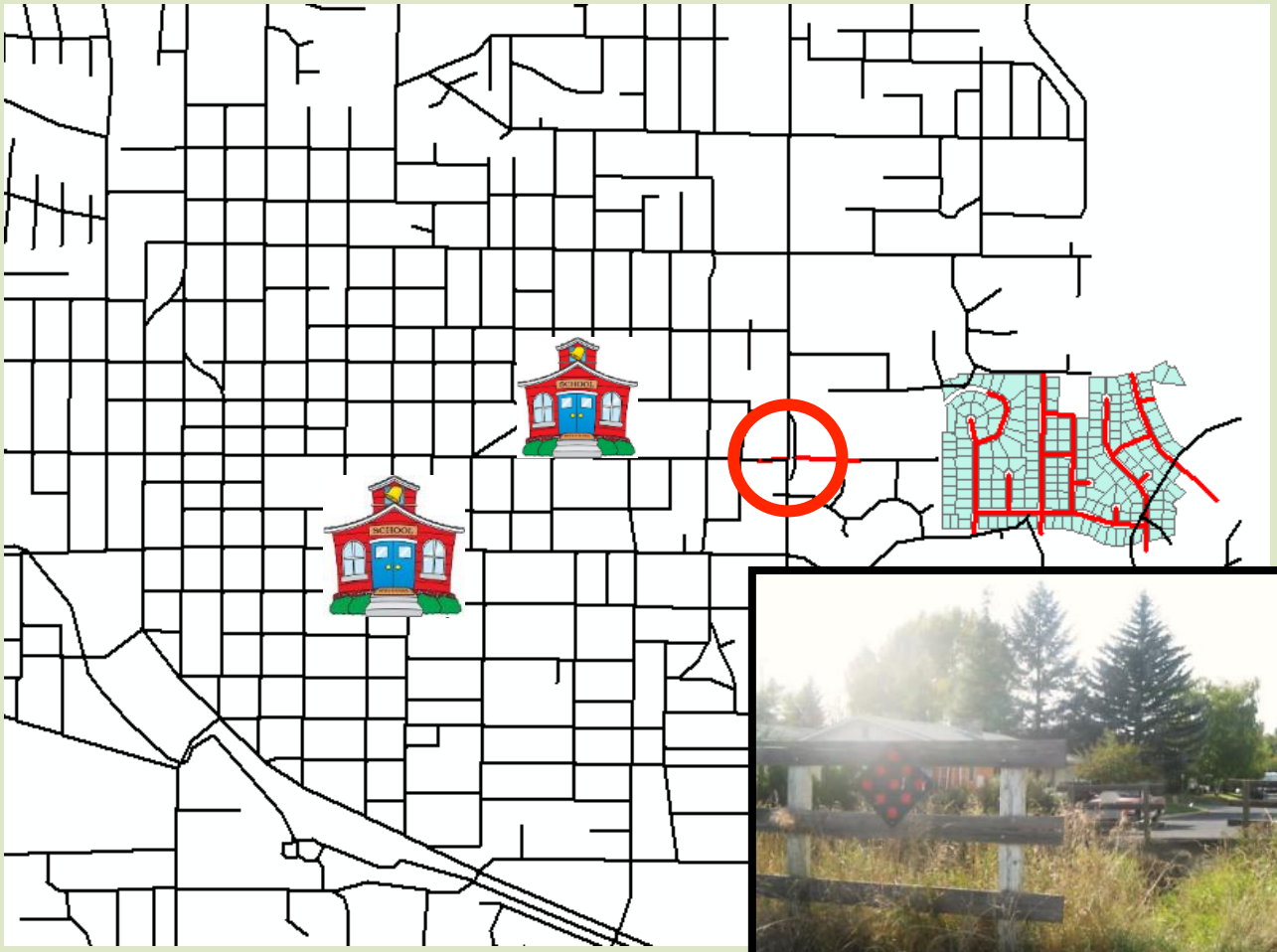
$$\left[\left(\frac{V_{AM}}{k_{AM}} + \frac{V_{PM}}{k_{PM}}\right)/2\right] * F_{day} * F_{month} = AADB$$

# Step 2. Temporally Extrapolate



AADB

# Scenario Planning



# Scenario Planning

**Third Street Bicycle Volumes Existing and Forecasted**

| Intersection Cross Street | Existing Conditions (AADB) | Proposed Scenario (AADB) |
|---|---|---|
| Van Buren Street | 24 | 226 |
| Harrison Street | 28 | 230 |
| Tyler Street | 32 | 230 |
| Polk Street | 44 | 253 |
| Taylor Street | 89 | 239 |
| Fillmore Street | 127 | 255 |
| Pierce Street | 146 | 255 |

**Increase of about 200 bicyclists per day.**

**Increase of about 150 bicyclists per day.**

Tool 4

# ASSESS DANGEROUS SITUATION EXPOSURE

# Background

## Challenge of Accident Analysis

1. Lack of Volume Data
2. Lack of Accident Data

# Dangerous Situations
## (Situational Antecedents to accidents)

| Dangerous Situation | Description | References |
|---|---|---|
| Mixed cycling in harsh traffic | Cycling in the vehicle travel lane on a road with high vehicle volume, speed, and/or percent heavy vehicle | Mapes, 2009; Teschke, 2012; Harkey and Stewart, 1997; Elvik et al., 2009; Moritz 1997; Tinsworth et al., 1994; Allen-Munley et al., 2004; Klop and Khattak, 1999; Vandenbulcke 2013; Schepers et al., 2013; CROW 2007; Kim et al., 2007; Stone and Broughton, 2003; Carter et al., 2007; McCarthy and Gilbert, 1996 |
| Dedicated ROW in harsh traffic | Cycling in a dedicated right-of-way adjacent to high vehicle volume, speed, and/or percent heavy vehicle | Reynolds et al., 2009; Pucher and Buehler, 2012. |
| Separated cycling | Physically separated on-street cycling, such as cycle tracks | Lusk et al., 2011; Lusk et al., 2013; Kin et al., 2007; Wachtel and Lewiston, 1994; Schepers et al., 2011 |
| Cramped Space | Roads without a bike lane or shoulder, narrow travel lanes | McCarthy and Gilbert, 1996; Vandenbulcke 2011; Allen-Munley et al., 2004; Klop and Khattak, 1999; Harkey and Stewart, 1997 |
| Excessive space | Roads with wide travel lanes, no bike lane, and at least moderate speed | Allen-Munley et al., 2004; Hunter et al., 1999 |
| Dooring and vehicle parking | Areas with on-street parking and high parking turnover | Vandenbulcke et al., 2013; Tilahun et al., 2007 |
| Frequent access points | High frequency of driveways | Allen-Munley et al., 2004; Emery and Crump, 2003 |

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# Dangerous Situations

| Dangerous Situation | Description | References |
|---|---|---|
| Crossing harsh traffic | Crossing a road with high vehicle volume, speed, and/or percentage heavy vehicle | Summala et al., 1996; CROW, 2007; Schepers et al., 2011 |
| Complicated intersections | Navigating; e.g. five point intersections or roundabouts | Daniels et al., 2009; Brüde and Larsson, 2000; Schoon and Van Minnen, 1994; Vandenbulcke et al., 2013 |
| Right hook | Right-turning cars conflicting with through cyclist | McCarthy and Gilbert, 1996; Räsänen and Summala, 1998; Schimek, 2014; Weigand, 2008; Schepers et al., 2013; Furth et al., 2014 |
| Left sneak | Cyclist sneaking across travel lanes to complete a left turn | Hunter et al., 1999 |
| Thru clip | Left turning vehicles conflict with through cyclist | Summala et al., 1996; Räsänen and Summala, 1998; Schimek, 2014; Shepers et al., 2014 |
| Gaps in bicycle network | Discontinuity of bicycle the network | Krizek and Roland, 2005; Mekuria et al., 2012 |
| Wrong-way riding | Cycling the wrong-way on a one-way street. | Wachtel and Lewiston, 1994; Räsänen and Summala, 1998; Schimek, 2014; Summala et al., 1996; Hunter et al., 1999; |
| Sidewalk riding | Cyclist utilizing sidewalks | Schimek, 2014; Wachtel and Lewiston 1994; |
| Infrequent cyclers | Low cyclist volume | Elvik et al., 2009; Jacobsen, 2003; Nordback et al., 2014; Brüde and Larsson, 1993; CROW 2007 |

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| Infrequent cyclers | Low cyclist volume | Elvik et al., 2009; Jacobsen, 2003; Nordback et al., 2014; Brüde and Larsson, 1993; CROW 2007 |

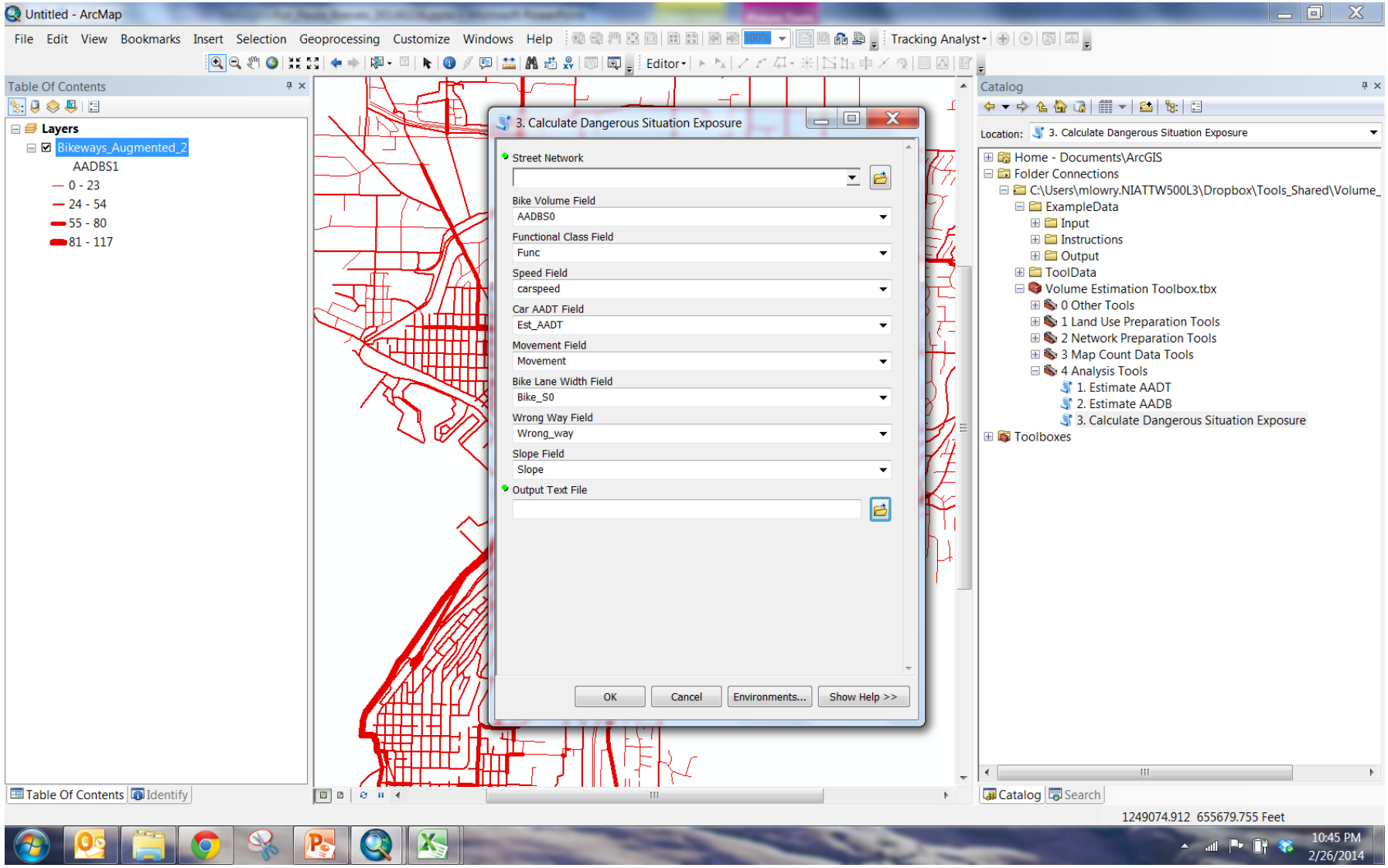
# Step 1. Define Exposure Metrics

| Dangerous Situation | Metric |
|---|---|
| Separated cycling in harsh traffic | Bike lane<br>Vehicle volume > 8,000 AADT |
| Mixed cycling in harsh traffic | No bike lane<br>Vehicle volume > 3,000 AADT |
| Cramped space | Vehicle lane width < 12 ft<br>Vehicle volume > 1,000 AADT<br>Vehicle speed limit > 20 mph |
| Parking maneuvers and dooring | Parking turnover > 4 maneuvers per hr |
| Frequent acces points | Access points > 30 per mile |
| Steep grade | Grade > 4% |
| Wrong-way riding | Wrong-way riding occurrence |
| Unexpected cyclers | Cyclist volume < 50 AADB |

**Community-specific metrics should be based on:**

- **Public involvement**
- **Local experience**
- **Latest research**

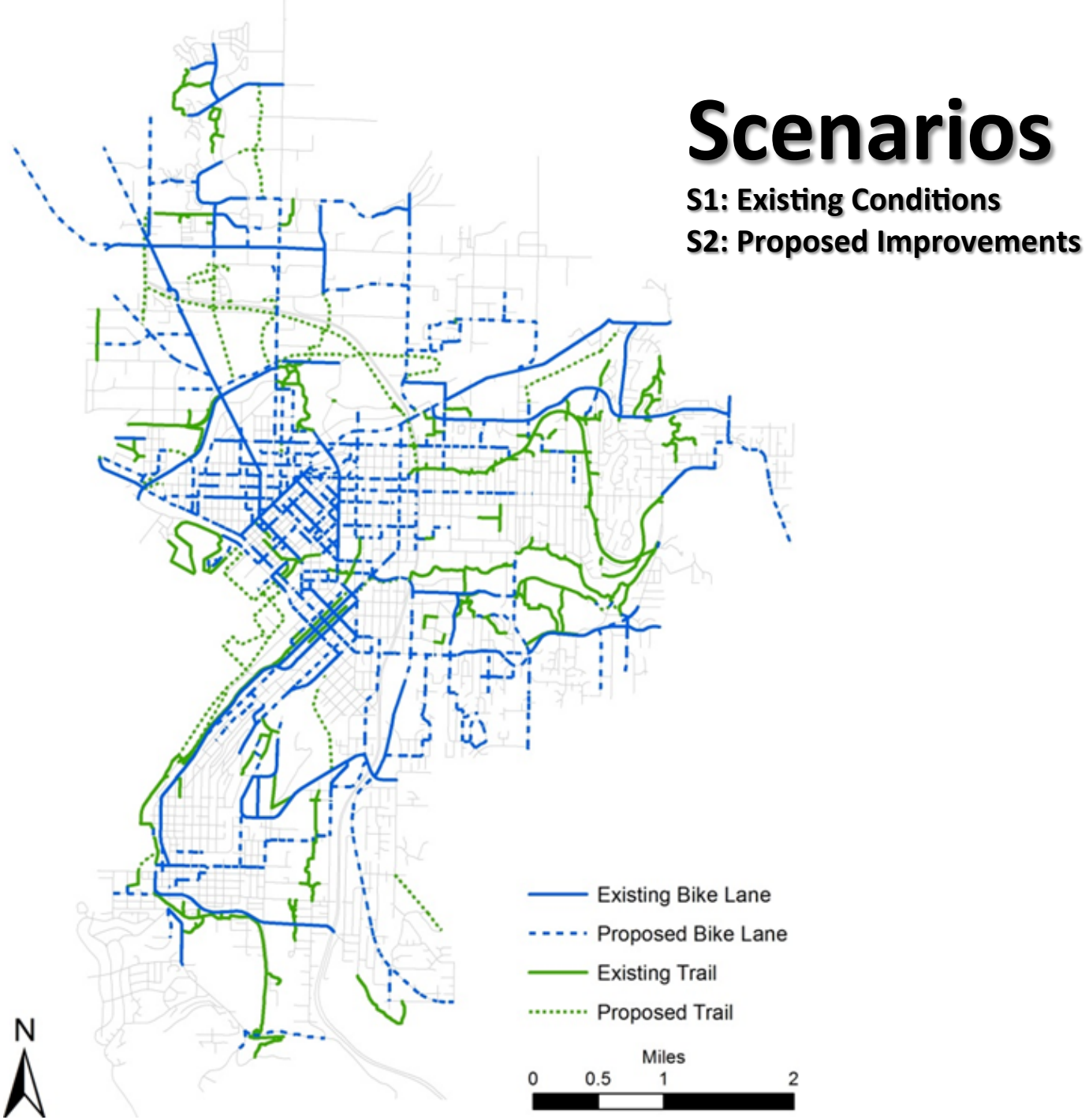
# Step 2. Calculate Exposure



# Scenarios

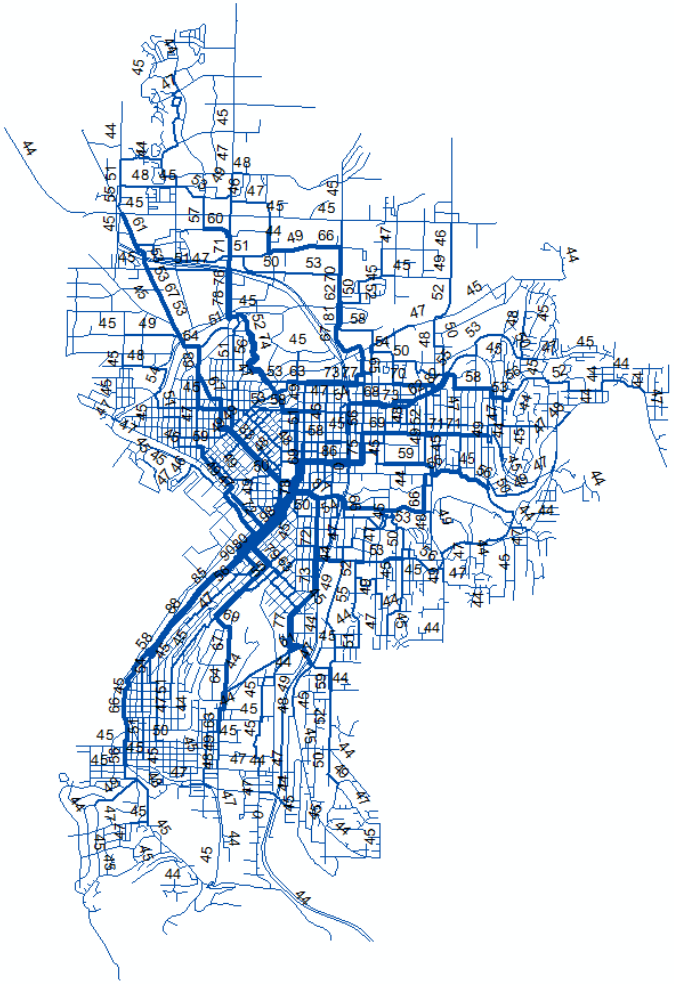
**S1: Existing Conditions**

**S2: Proposed Improvements**

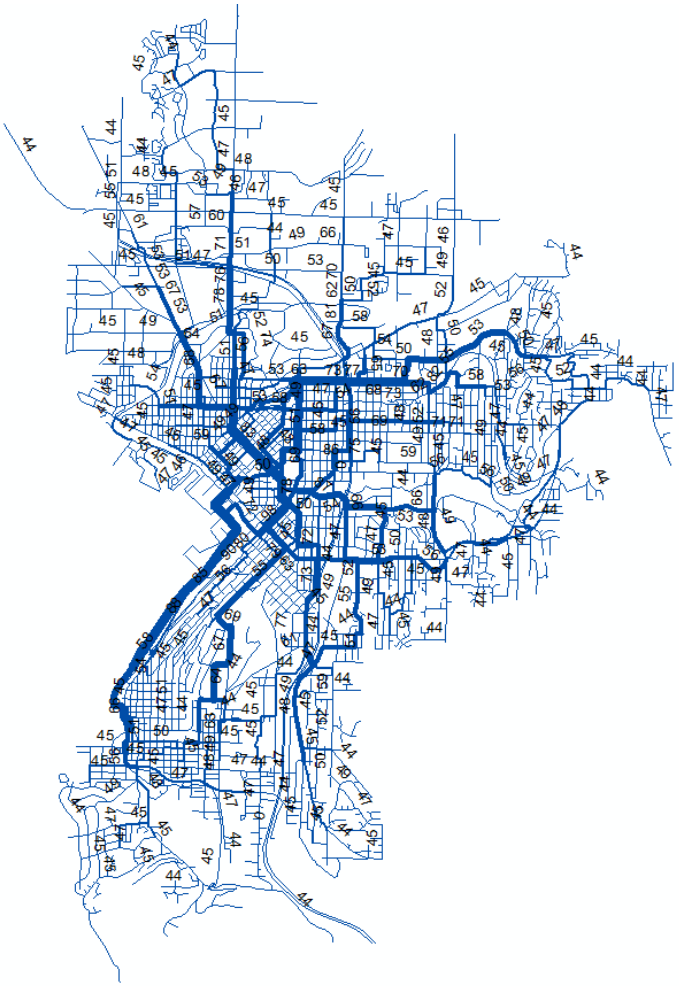


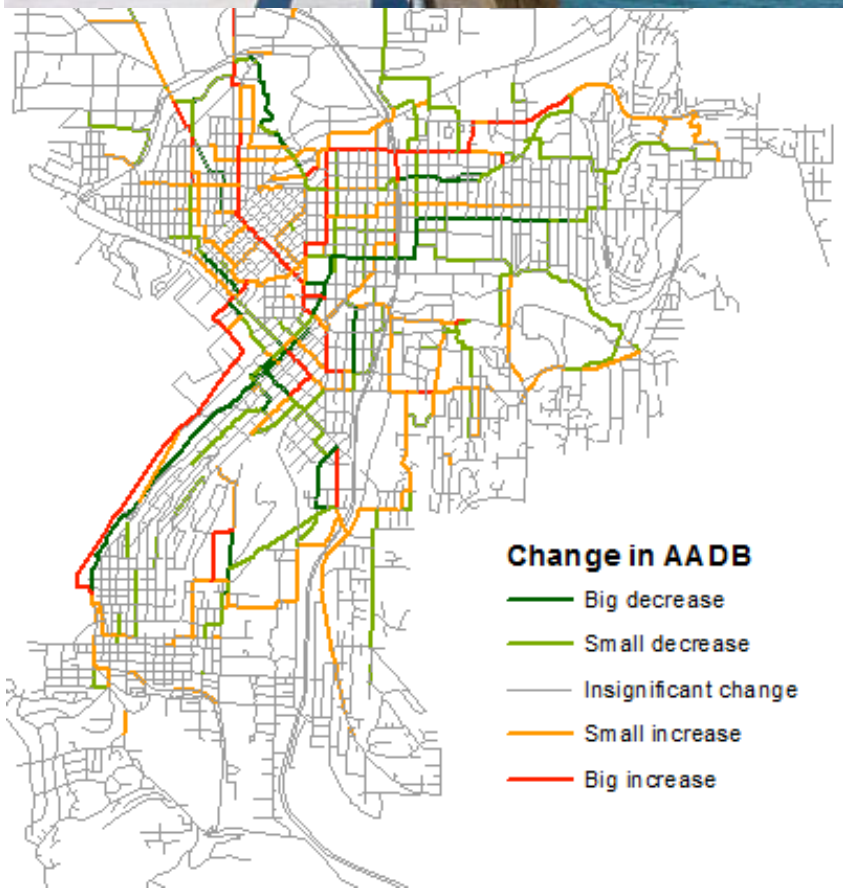
# AADB

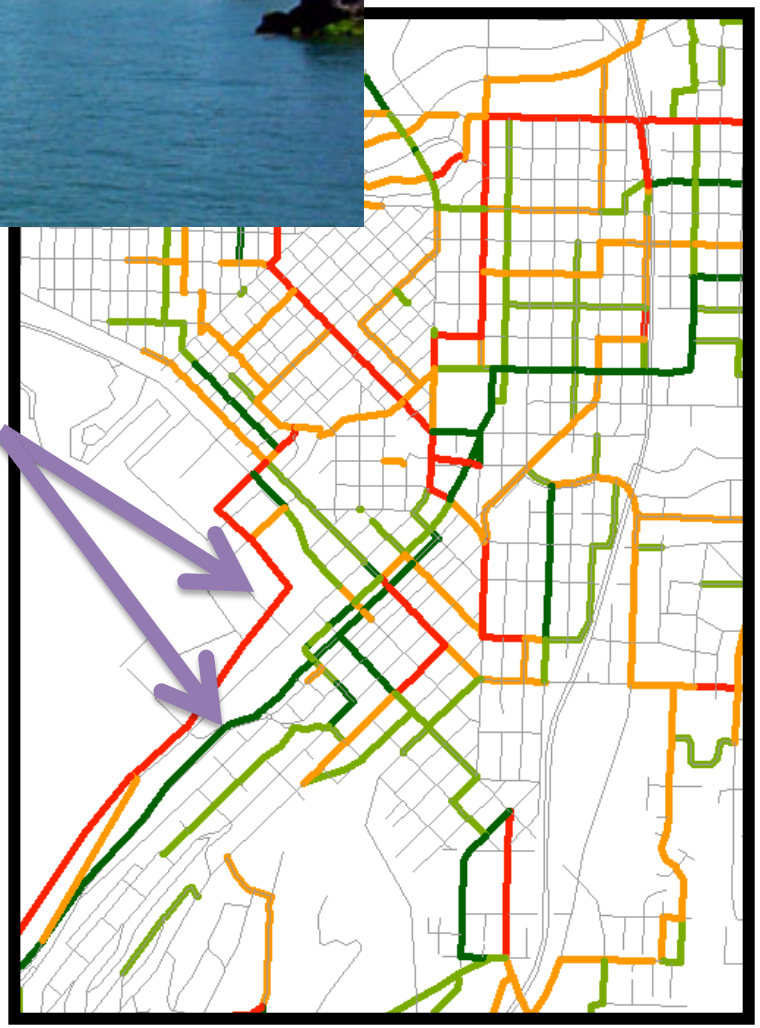
Scenario 1 (Existing)



Scenario 2 (Proposed)




Change in AADB
Big decrease
Small decrease
Insignificant change
Small increase
Big increase



# Exposure Along Street Segments

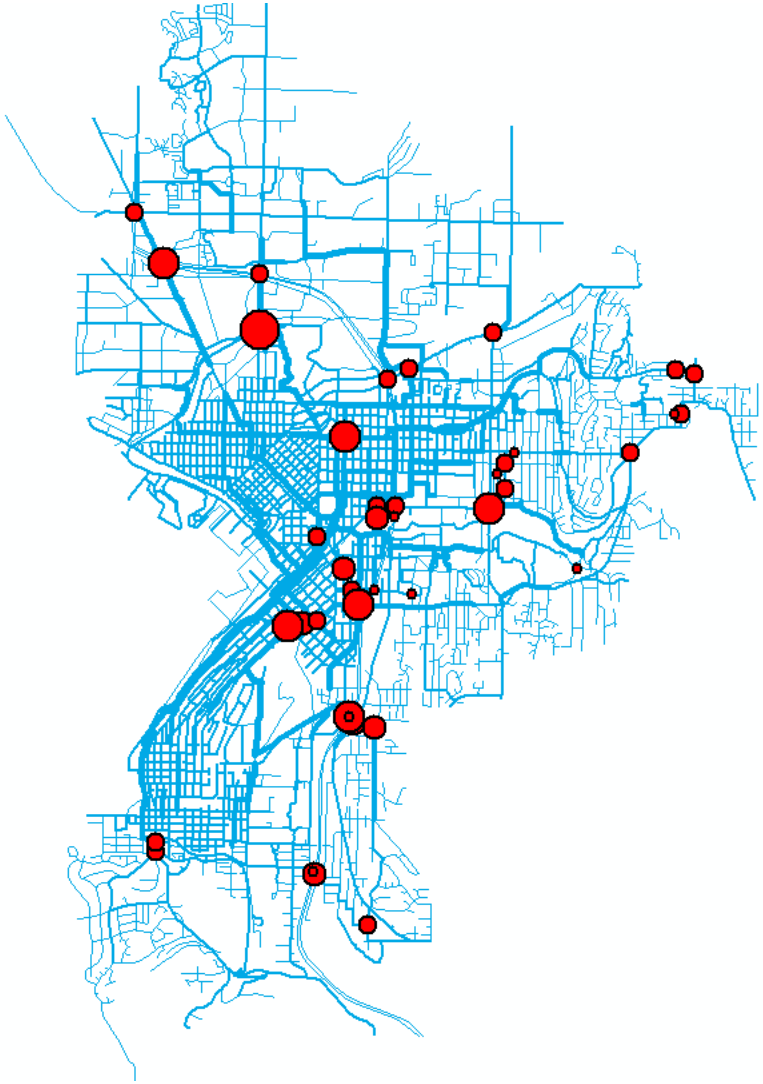
| Dangerous Situation | Metric Conditions | Scenario 1: Existing Conditions (Annual BMT) | Scenario 2: w/ Proposed Improvements (Annual BMT) | Change (Annual BMT) | Percent Change |
|---|---|---|---|---|---|
| Mixed cycling in harsh traffic | No bike lane<br>Vehicle volume<br>> 3,000 AADT | 666,000 | 272,000 | -394,000 | -59% |
| Dedicated ROW in harsh traffic | Bike lane<br>Vehicle volume<br>> 8,000 AADT | 97,000 | 250,000 | 153,000 | 158% |
| Cramped space | Veh. lane width < 12 ft<br>Vehicle volume<br>> 1,000 AADT<br>Vehicle speed limit<br>> 20 mph | 307,000 | 180,000 | -127,000 | -41% |
| Dooring and vehicle parking | Vehicle parking<br>turnover > 4 per hr | 2,646,000 | 2,746,000 | 100,000 | 4% |
| Frequent access points | Access points<br>> 30 per mile | 3,923,000 | 3,847,000 | -76,000 | -2% |
| Steep grade | Grade > 4% | 197,000 | 197,000 | 0 | 0% |
| Wrong-way riding | Wrong-way riding occurrence | 134,000 | 145,000 | 11,000 | 8% |
| Infrequent cyclers | Cyclist volume < 15 AADB | 1,151,000 | 1,096,000 | -55,000 | -5% |

# Exposure at Intersections

| Dangerous Situation | Metric Conditions | Scenario 1: Existing Conditions (Annual Bicyclists) | Scenario 2: w/Proposed Improvements (Annual Bicyclists) | Change (Annual Bicyclists) | Percent Change |
|---|---|---|---|---|---|
| Crossing harsh intersections | Cross street vehicle volume > 2,000 AADT | 7,114,000 | 6,647,000 | -467,000 | -7% |
| Right hook | Vehicle right turns > 1,000 AADT | 605,000 | 577,000 | -28,000 | -5% |
| Left sneak | Oncoming thru vehicle volume > 2,000 AADT | 7,516,000 | 7,523,000 | 7,000 | 0% |
| Thru clip | Oncoming left-turn vehicle volume > 1,000 AADT | 615,000 | 613,000 | -2,000 | 0% |

# Hot Spot Analysis

**Right Hook Exposure**



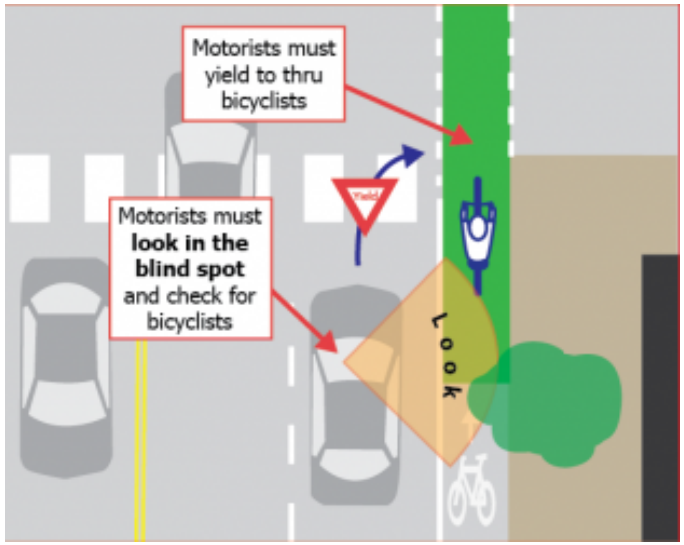
# Future Work

1. Create Safety Performance Functions (SPFs) based on exposure.

Expected Number of Right Hook Accidents = $\beta_0 + \beta_1$(right hook exposure)

2. Create Crash Modification Factors (CMFs) to for improvements.

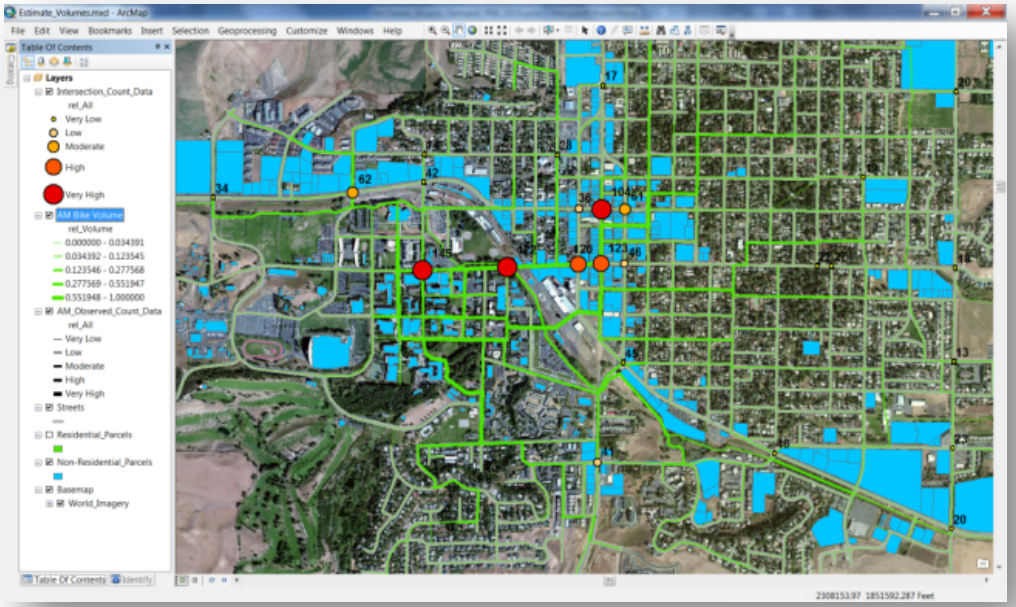
green paint => 12% reduction



# Conclusions

**New tools are…**

- **Inexpensive and easy to use,**
- **Require commonly available GIS data, and**
- **Can produce very good results.**




Thank you…
…Questions??
Mike Lowry, PhD, PE
University of Idaho
(208) 885-0139
mlowry@uidaho.edu

# Tool 1: Calculate Bicycle Level of Service

**Callister, D. and Lowry, M. (2013). "Tools and Strategies for Wide-scale Bicycle Level of Service Analysis."** ***ASCE Journal of Urban Planning and Development*****, Vol. 139, No.4, p. 1-8.**

# Tool 2: Calculate Community-wide Bikeability

**Lowry, M., Callister, D., Gresham, M. and Moore, B. (2012). "Assessment of Communitywide Bikeability with Bicycle Level of Service."** ***Transportation Research Record: Journal of the Transportation Research Board*****, 2314, pp. 41-48.**

# Tool 3: Estimate Bicycle Volumes

**McDaniel, S., Lowry, M., and Dixon, M. (In press). "Using Origin-Destination Centrality to Estimate Directional Bicycle Volumes."** ***Transportation Research Record: Journal of the Transportation Research Board*****, Scheduled publication 2014.**

# Tool 4: Assess Dangerous Situation Exposure

**Cool, S. and Lowry, M. (Forthcoming). "Quantifying dangerous situation exposure for bicyclists" Scheduled Submission June, 2014.**