Appendix D
Quantifying Current and Future Demand for Bicycling Facilities Through Cyclezone Analysis

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Quantifying current and future demand for bicycling is important for several reasons:

- To provide evidence of use. Showing that rates of use are increasing can be used as evidence for the increased commitment of resources for bicycling-related projects.
- To demonstrate the projected future benefits of increased usage in terms of environmental benefits (e.g., carbon-dioxide emission reductions) or reduced travel times. Reductions in motor vehicle trips translate into reduced congestion and reduced vehicle-miles traveled (VMT).
- To direct future investment. In highlighting areas with a latent demand for bicycle facilities, it is possible to target investments or programs into areas that demonstrate the most need or the greatest potential for increased bicycle usage.
- To choose strategies aimed at increasing cycling. The city can maximize the return on resource investments by understanding how conditions change throughout the landscape and customizing the approach to match existing conditions.

A variety of methodologies are used to measure cycling demand and associated benefits. This combined analysis forms a comprehensive picture of existing demand, potential future demand and the benefits derived from the predicted future use. Several tools are used for this analysis: commute pattern data from the US Census Bureau (2007 American Community Survey), as well as Mode Share/Mode Split Analysis and Air Quality Benefit models. A zonal analysis model, the Cycle Zone Analysis (CZA), is used to further refine the results and look at the specific geographic regions within the city.

Commuters on their way to work downtown

Existing Demand

Infrastructure Analysis – Cycle Zones

A cycle zone is an area of the city that possesses similar characteristics for cycling. Generally, a cycle zone is defined by features that represent significant barriers or crossing difficulties, such as Interstate 794. Cycle zones are also defined by census tracts, neighborhoods and areas that contain desirable destinations for cyclists, such as parks or neighborhood centers. In addition, cycle zone boundaries reflect a change in the character of a neighborhood (e.g. block size or street connectivity).

The goal of this effort was to use the analysis to project which areas have the greatest potential for cycling by looking at proximity to land uses, permeability of entry-exit barriers (e.g., freeway crossings), topography, connectedness of the street grid and quantity of available bikeways. This was done to better understand the relationship between cycling potential and environmental, health and air quality benefits. The Cycle Zone Analysis (CZA) tool allows planners, decision makers and advocates to better understand: (1) which parts of the city are best suited for capturing large numbers of cycling trips; (2) which have greater potential to generate additional trips; (3) which areas are best suited for strategic investments; and (4) which areas may need innovative bikeway treatments to maximize cycling potential. By breaking the city into zones that share similar characteristics, it is possible to capture and compare information. Table 2 shows the raw statistics- for each zone. See Appendix I for a detailed discussion of the analysis factors and methodology.

Table 3 shows the normalized scores for each factor. Normalization is a process that allows factors to be efficiently compared against each other. For many factors, this normalization was necessary due to differences in zone sizes (e.g., the difference in size between Zone 1 and Zone 5 makes it difficult to compare the total length of the roadway network, so a normalized measure of roadway network density, feet of roadway per acre was used). Other measures, such as the connectivity (measured by the Connected Node Ratio) were measured as a single zonal average.

Table 4 shows the normalized score and weighting for each zone. The Cycle Zone Analysis utilizes a number of quantitative measures to arrive at an overall 'potential' score. Factors considered in this analysis include connectivity, proximity to commercial land uses, permeability of barriers, road network density, and bikeway density.

Currently, zones 1 and 5 are the easiest to access, based on their high zone scores. Zones 3 and 4 scored the lowest, indicating that cyclists face substantial difficulties getting into and out of these areas. While this does not measure the challenges of cycling within a zone, it does suggest that people living within these zones or attempting to travel to destinations within these zones will face difficulties reaching their destination via bicycle. This may incite them to take another form of transportation. Zone 3 received the highest overall score, as well as scored the highest for road network density, bike network density, land use mix and connectivity. This indicates that cyclists have many routes to choose from and decent network connectivity, which increases their ability to select different routes. It should be noted that this analysis does not take facility conditions, such as motor vehicle speed and volumes into account, which may affect cyclist comfort on these facilities. Correspondingly, Zone 3 has the greatest bike network, further increasing its attractiveness to cyclists. The greatest challenge in this zone is traveling into and out of it.

Numerous trails and parks provide great riding in Milwaukee

Table 2: Cycle Zone Factors Raw Data

Cycle Zone Factors - Raw Data	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Acreage	16,253	13,192	5,641	7,230	4,331	15,215
Total Road Network Length (LF)	1,326,919	1,782,968	870,279	1,038,935	506,372	1,601,462
Total Bike Network (LF)	68,907	89,635	132,382	83,926	28,652	132,174
Total Intersections	1,333	2,732	1,295	1,583	883	2,445
4 or more Way Intersections	476	1,582	830	969	367	1,338

Table 3: Normalized Cycle Zone Factor Scores

Normalized Factor Scores	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Barrier Score / Perimeter Foot	6.0	3.0	1.0	1.0	6.0	4.0
Total Road Network Density (Ft/Acre)	81.6	135.2	154.3	143.7	116.9	105.3
Bike Network Density (Ft/Acre)	4.2	6.8	23.5	11.6	6.6	8.7
Connected Node Ratio (4-way)	0.4	0.6	0.6	0.6	0.4	0.5
Average Distance to Commercial (Network Feet)	3,711	1,046	742	813	1,654	1,041

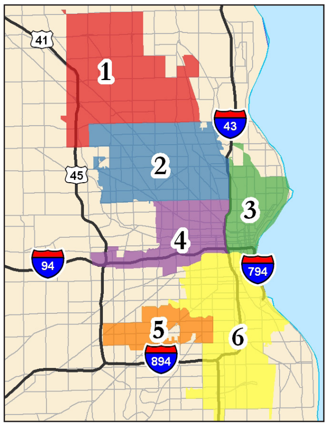
Table 4: Cycle Zone Scores

Factor Scores	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Barrier Score / Perimeter Foot*	20.0	10.0	3.3	3.3	20.0	13.3
Road Network Per Acre	10.2	16.9	19.3	18.0	14.6	13.2
Bike Network Density (per acre)	2.8	4.5	15.6	7.7	4.4	5.8
Connectivity	7.1	11.6	12.8	12.2	8.3	10.9
Land Use Mix	4.0	14.2	20	18.3	9.0	14.3
Composite Zone Score	**44.2**	**57.2**	**71.1**	**59.5**	**56.5**	**57.5**

Zone 1 scored the lowest overall, as well as for land use mix, connectivity and bike network density. However, this zone is very permeable.

Bicycle Commute Demand

A central focus of presenting commute information is to identify the current "mode split" of people that live and work in Milwaukee. Mode split refers to the different choices of transportation a person selects to travel to destinations, be it walking, bicycling, taking a bus or driving. One major objective of any bicycle facility improvement is to increase the percentage of people who choose to bike rather than drive or be driven. Every saved vehicle trip or vehicle mile represents quantifiable reductions in greenhouse gas emissions and can help reduce traffic congestion. The analysis is designed to provide a brief comparison of bicycle commuting in the city of Milwaukee to the surrounding county, as well as to state and national commuting patterns.



Zones 1 and 5 do not have significant barriers to entry while zones 3 and 4 are bounded by Interstate 43 and Interstate 794.

2007 U.S. American Community Survey

Journey to work and travel time to work data were obtained from the 2007 U.S. American Community Survey (ACS) for the City of Milwaukee, Wisconsin; Milwaukee County; the State of Wisconsin; and the United States. Journey to work data is shown in Table 5.

As shown, about 0.7% of all employed Milwaukee residents commute primarily by bicycle. This number is consistent with the percentage of bike commuters reported at the county and state levels, and is slightly higher than the national average. While the number of bicycle commuters in Milwaukee is consistent with other localities, the number of people walking, taking transit, and carpooling is consistently higher, as shown in Table 5. This could indicate an increased potential interest in transportation modes other than driving alone. Lack of increased cycling may be due, in part, to cold winter months, lack of bicycle infrastructure, or a lack of education, encouragement and enforcement programs, which help people to feel safe and excited about bicycle riding.

Census data does not include the number of people who bicycle for recreation or for non-work utilitarian purposes, students who bicycle to school, and bicycle commuters who travel from outside Milwaukee. This limits the analysis and likely undercounts true bicycling rates. Another limitation of this data is that it fails to capture multi-modal trips where bicycling was not the most significant portion of the trip. A more robust demand analysis discussed in the next section aims to more comprehensively measure bicycle travel, both utilitarian and recreational.

Table 5: Journey to Work Data

Mode	United States	Wisconsin	Milwaukee County	City of Milwaukee %	City of Milwaukee Number of People
Bicycle	0.5%	0.7%	0.6%	0.7%	1,742
Drove Alone	76.1%	79.8%	77.0%	72.0%	179,204
Carpool	10.4%	9.4%	9.7%	11.0%	27,378
Public Transit	4.9%	1.7%	5.7%	8.3%	20,658
Walked	2.8%	3.3%	3.3%	4.6%	11,449
Other	5.3%	5.1%	3.6%	3.1%	7,716

*Includes individuals that work at home

Source: U.S. American Community Survey, 2007 Table S0801

Aggregated Bicycle Demand

The Milwaukee bicycle demand model consists of several variables including commuting patterns of working adults, predicted travel behaviors of area college students and children, as well as a factor to account for other non-commuting bicycle trips that are either utilitarian or recreational. For modeling purposes, the study area included the census tracts within the city of Milwaukee, Wisconsin. The 2007 ACS data for the city was used to obtain the aggregated demand estimates for the entire city and was then broken down based on the percentage of population living in each cycle zone to obtain a measure of zonal demand. It should be noted that the percentage of the population living within each zone was calculated using the population per census tract from the 2000 Census, as this information is not provided with the ACS.

In addition to people commuting to the workplace via bicycle, the model also incorporates a portion of the labor force working from home. Specifically, it was assumed that about half of those working from home would make at least one bicycle trip from home during the workday. The 2007 ACS was also used to estimate the number of children in Milwaukee. This figure was combined with data from National Safe Routes to School surveys to estimate the proportion of children riding bicycles to and from school. College students constitute a third variable in the model, due to

Table 6: Estimates of Existing Daily Bicycling Activity in Milwaukee

Variable	City Wide	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Employed Adults, 16 Years and Older							
a. Study Area Population [1]	602,782	73,238	170,110	77,749	86,845	43,833	151,008
b. Employed Persons [2]	248,894	30,241	70,240	32,103	35,859	18,099	62,353
c. Bicycle Commute Mode Share [2]	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
d. Bicycle Commuters (b*c)	1,742	212	492	225	448	127	436
e. Work-at-Home Percentage [2]	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
f. Work-at-Home Bicycle Commuters [3] [(b*e)/2]	3,111	378	878	401	448	226	779
School Children							
g. Population, ages 6-14 [4]	86,120	10,464	24,304	11,108	12,408	6,262	21,575
h. Estimated School Bicycle Commute Mode Share [5]	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
i. School Bicycle Commuters (g*h)	1,722	209	486	222	248	125	431
College Students							
j. Full-Time College Students [6]	43,106	5,237	12,165	5,560	6,210	3,135	10,779
k. Bicycle Commute Mode Share [7]	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
l. College Bicycle Commuters (j*k)	4,311	524	1,216	556	621	313	1,080
Work and School Trips Sub-Total							
m. Daily Bicycle Commuters Sub-Total (d+f+i+l)	10,866	1,323	3,072	1,404	1,568	792	2,727
n. Daily Bicycle Commute Trips Sub-Total (m*2)	21,773	2,645	6,144	2,808	3,137	1,583	5,455
Other utilitarian and recreational trips							
o. Ratio of "Other" Trips in Relation to Commute Trips [8]	2.73	2.73	2.73	2.73	2.73	2.73	2.73
p. Estimated Non-Commute Trips (n*o)	59,440	7,222	16,744	7,667	6,116	3,087	10,635
Total Estimated Daily Bicycle Trips (n+p)	81,213	9,867	19,847	10,475	9,253	4,670	16,090

Notes:

Census data collected from 2007 U.S. Census, American Community Survey.

(1) As noted by the Mayor's Census Challenge. http://www.ci.mil.wi.us/Nov14CensusChallenge23916.htm (Accessed October 6, 2008)

(2) 2007 ACS, S0801. Commuting Characteristics

(3) Assumes 50% of population working at home makes at least 1 daily bicycle trip.

(4) 2007 ACS, S0801. Commuting Characteristics

(5) Estimated share of school children who commute by bicycle, as of 2000 (source: National Safe Routes to School Surveys, 2003).

(6) 2007 ACS, S1401

(7) Review of bicycle commute mode share in 7 university communities (source: National Bicycling & Walking Study, FHWA, Case Study #1, 1995).

(8) 27% of all trips are commute trips (source: National Household Transportation Survey, 2001).

the presence of several colleges and universities in the region. Data from the Federal Highway Administration regarding bicycle mode share in university communities was used to estimate the number of students bicycling to and from these campuses. Finally, data regarding non-commute trips was obtained from the 2001 National Household Transportation Survey, which estimates the number of bicycle trips not associated with traveling to and from school or work (e.g., running errands).

Table 6 summarizes existing estimated daily bicycling activity in Milwaukee for each zone and citywide. This table indicates that over 77,000 trips are made citywide on a daily basis. Over 10,000 people, or about 1.5% of the existing population, take at least one bicycle trip per day. It is likely this number is greater based on the number of "other" trips taken every day. As the "other" trips are measured as a ratio, it is impossible to know how many additional people are accounted for. Most bicycle commute trips are made by college students, as well as individuals making trips while working at home. School children make the fewest daily bicycle trips. The model also shows that non-commuting trips comprise the vast majority of existing bicycle demand. Zones 2 and 6 have the highest populations and therefore the greatest estimated number of bicycle trips. Zones 3, 4 and 5 have the highest population density and therefore account for the greatest number of trips originating in the smallest geographic space. It should be noted that bicycle trips were allocated based entirely on zonal population estimates and aggregated figures for the city.

Cyclist Attitudes and Ridership Statistics

In 2008, a random citywide survey, sponsored by the City of Milwaukee Department of Public Works and Bike Fed, was undertaken to measure bicycling-related attitudes and behaviors of Milwaukee residents.[1] Many of the survey questions were drawn from the 2002 National Survey of Pedestrian and Bicyclist Attitudes and Behaviors (NSPBAB), which enables a comparison of Milwaukee residents to a representative national sample. This survey provides a snapshot of current attitudes towards cycling, gives information about resident's perceptions of existing cycling conditions and generally estimates the amount of cycling activity during the summer months. A discussion of how this survey could be modified to provide a relative indication of mode share and a more direct comparison to the American Community Survey (ACS) or National Household Transportation Survey (NHTS) is included in Appendix E.

1 This survey was conducted by telephone and reached 434 city residents. Research was conducted by the Institute for Survey and Policy Research at the University of Wisconsin-Milwaukee.

Alterra at the Lake is a popular gathering place for cyclists

While the survey data cannot be directly correlated with the mode share analysis, this survey can augment the estimates from the demand models developed by Alta Planning + Design by highlighting key areas of concern that could be targeted for improvement. Addressing residents' concerns about cycling conditions in the city could lead to increased ridership from both new and existing cyclists by mitigating real and perceived barriers to bicycling in the City.

Key Findings and Statistics

Approximately 39% of Milwaukee residents reported riding a bicycle at least once during the summer months, compared to the national average of 27%. Though the information does not allow a direct integration into the existing model (which is based on mode share) it does support the assumption that people in Milwaukee currently bike more than people in other US cities.

About 92% of Milwaukee residents believe that riding is an enjoyable activity, and 72% responded that they would like to ride more often. Only 55% of residents reported satisfaction with the design of their local community for safe riding.[2] This indicates that the city may gain ridership by promoting bike facilities that increase cyclist safety and comfort. Residents

2 The national survey found that 48 percent of respondents were satisfied with the construction of their community for bicycle safety. The Milwaukee survey report notes that questions on the availability of specific facilities (e.g. bike lanes) were not included in the Milwaukee survey as they were in the national survey. This could have the effect of cuing respondents to think of specific facilities in their local community and create a reporting bias (either positive or negative) in the results.

would also benefit from education and encouragement programs, which would increase their knowledge and confidence about how to ride safely in traffic. Ridership may also be increased by providing bicycle facilities separated from cars and by striping additional bike lanes.

- About 34% of non-riders cited lack of access to a bike as their primary reason for not cycling, which is higher than the national survey result of 26%. This indicates that the city could increase ridership by instituting programs that increase residents' access to bicycles.

Potential Future Bicycle Ridership

Non-motorized travel translates into fewer vehicle trips, which results in a correlated reduction in vehicle miles traveled and auto emissions. The variables used as model inputs generally resemble the variables used in the demand model discussed earlier and represent a realistic, achievable goal of what the daily number of bicycle trips could be with a more complete bikeway system.

Table 7 summarizes data on potential future bicycle demand in the year 2030, assuming a more complete bicycle transportation network and concurrent program

Table 7: Potential Future Bicycle Demand

Variable	City Wide	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Employed Adults, 16 Years and Older							
a. Study Area Population [1]	619,838	75,310	174,923	79,949	89,302	45,073	155,281
b. Employed Persons [2]	255,938	31,097	72,227	33,011	36,874	18,611	64,117
c. Bicycle Commute Mode Share [2]	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%
d. Bicycle Commuters (b*c)	11,517	1,399	3,250	1,485	1,659	837	2,885
e. Work-at-Home Percentage [2]	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
f. Work-at-Home Bicycle Commuters [3] [(b*e)/2]	3,199	389	903	413	461	233	801
School Children							
g. Population, ages 6-14 [4]	88,558	10,760	24,992	11,422	12,759	6,439	22,185
h. Estimated School Bicycle Commute Mode Share [5]	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
i. School Bicycle Commuters (g*h)	2,657	323	750	343	383	193	666
College Students							
j. Full-Time College Students [6]	44,326	5,385	12,509	5,717	6,386	3,224	11,105
k. Bicycle Commute Mode Share [7]	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
l. College Bicycle Commuters (j*k)	4,433	539	1,251	572	639	322	1,111
Work and School Trips Sub-Total							
m. Daily Bicycle Commuters Sub-Total (d+f+i+l)	21,806	2,649	6,154	2,812	3,142	1,586	5,463
n. Daily Bicycle Commute Trips Sub-Total (m*2)	43,612	5,299	12,307	5,625	6,283	3,171	10,926
Other utilitarian and recreational trips							
o. Ratio of "Other" Trips in Relation to Commute Trips[8]	2.73	2.73	2.73	2.73	2.73	2.73	2.73
p. Estimated Non-Commute Trips (n*o)	119,060	14,466	33,599	15,356	17,153	8,658	29,827
Total Estimated Daily Bicycle Trips (n+p)	162,671	17,115	45,907	18,169	23,437	11,829	40,752

Notes:

Census data collected from 2007 U.S. Census, American Community Survey.

(1) As noted by the Mayor's Census Challenge. http://www.ci.mil.wi.us/Nov14CensusChallenge23916.htm (Accessed October 6, 2008) This number has been vetted by the City and accepted by the US Census Bureau as the official population estimate for Milwaukee. Assumes .07% growth over six years (obtained by looking at population increase between 2000 Census and 2006 ACS).

(2) Assumes same percentage of population in work force from 2007 AC. Mode share based on current mode share observed in Portland, Oregon.

(3) Assumes 50% of population working at home makes at least 1 daily bicycle trip. Assumes same percentage of population works from home (2007 ACS)

(4) 2007 ACS, S0801. Commuting Characteristics. Assumes same percentage of school aged children (2006 ACS)

(5) Assumes Portland bike to school mode share 3% as observed in 2007

(6) 2007 ACS, S1401 Based on same share of population in college (2007 ACS)

(7) Review of bicycle commute mode share in 7 university communities (source: National Bicycling & Walking Study, FHWA, Case Study #1, 1995). Assumes no change in college bike to school mode share.

(8) 27% of all trips are commute trips (source: National Household Transportation Survey, 2001). Assumes no change in ratio of commute trips to non-commute trips.

development to encourage use is implemented. Data for future city of Milwaukee population, employed persons, and commute mode shares were used for this analysis. In terms of daily bicycle trips, assumptions regarding the proportion of persons working at home reflects those used in the current demand model. Due to the unstable nature of vehicle flows during congestion conditions, eliminating even a few drivers from the road during peak commute hours can significantly reduce congestion. This analysis also assumes a proportional increase of "other" trips in relation to commute trips.

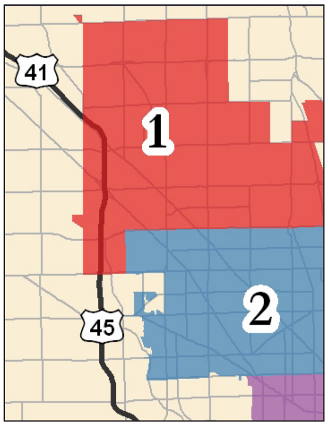
One significant assumption is a future proposed bicycle mode split of 4.5% of workers. While this may seem ambitious, it is certainly achievable with a concerted, strategic effort, as indicated by mode splits observed in Portland, Oregon and Minneapolis, Minnesota. These cities reported mode splits of 3.9% and 3.8% or workers, respectively, according to the 2007 American Community Survey data.

Discussion and Analysis of Future Bicycle Demand

A combination of the Cycle Zone Analysis and the demographic analysis of the Mode Share/Mode Split Analysis results in a robust picture of conditions in each section of the city. The remainder of this section briefly discusses each zone and suggests strategies to increase cycling in each area.

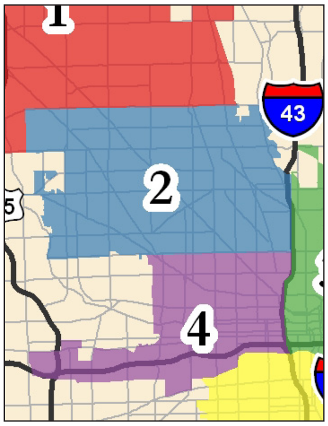
This analysis reflects elements that can be changed fairly easily, such as bikeway density, in addition to elements that may require large investments of time or capital, such as reducing barriers at a zone boundary. Finally, several factors, such as connectivity, only change over many years.

Zone 1



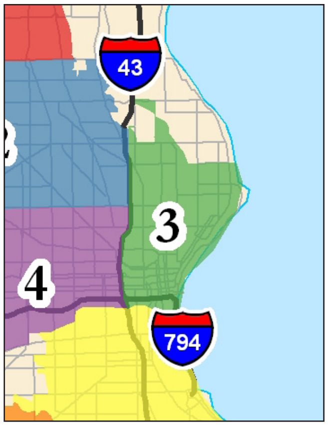
Zone 1 has the lowest overall cycle zone score, as well as the lowest score for all factors except barriers. This area is characterized by long travel distances to commercial destinations, low mode network density, and poor connectivity. This zone has good external access, indicating that improvements made within the zone have the potential to benefit many cyclists. This should be balanced by the internal factors that caused this zone to score poorly. About 70,000 people reside in this zone, which is one of the largest in size. This zone may have excellent long-term potential and may be a good area to target for longer-term improvements. Strategies could include increasing both connectivity and increasing overall destination density in the long-term. Shorter term, land use patterns may make this area a good candidate for bicycle boulevard style facilities.

Zone 2



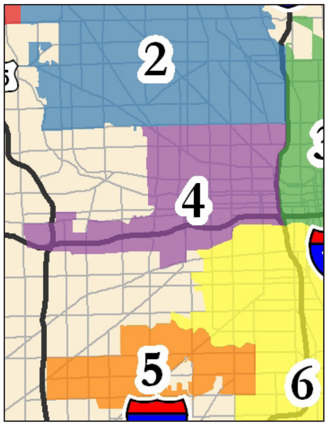
Zone 2 includes residential areas north of downtown. This zone scored poorly for bike network density, but moderately well for all other factors, with the exception of road network density. The connectivity measure indicates a decent level of choice for cycling routes. This zone holds a significant share of the city population and has the highest average population density. This zone may benefit most from short term improvements, such as increasing the density of bicycle facilities.

Zone 3



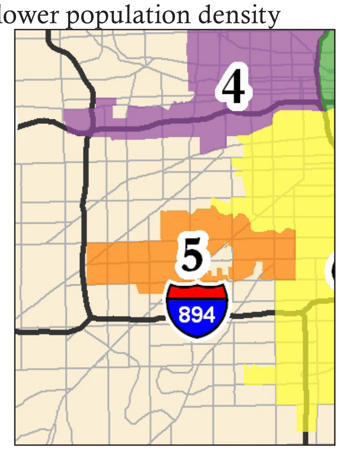
Zone 3 includes the downtown area of Milwaukee. This area contains a moderate portion of the population, but scores the highest for all factors with the exception of barriers. Cycling conditions within this zone are already good, as characterized by this model, with room left for improvement. One strategy to improve this zone is to look at increasing access into this zone across Interstate 43. This may represent a long term strategy of incorporating dedicated facilities into overcrossing or undercrossing projects. One benefit of focusing on reducing barriers is the beneficial effect felt in neighboring zones. Also, reducing barriers allows more cyclists greater access to existing amenities and may lead to greater increases in cyclist numbers. Zone 3 may benefit from education and encouragement programs targeting people who work in the downtown area, including working with employers on incentive programs and increasing linkages to transit.

Zone 4



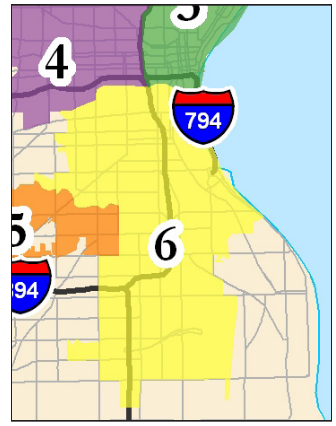
Zone 4 borders downtown Milwaukee. Interstate 43 on the east side of the zone represents a significant barrier to travel and accessibility of amenities in the downtown area. Zone 4 has a moderate population density. Short-term strategies to maximize cycling include options such as increasing facility density. In many cases, this could be as simple as striping bike lanes on existing facilities. Zone 4 is a place where increasing cycling may be fairly easy in a short to moderate timeframe, based on its proximity to downtown, mix of land use, connectivity and road network density. This would be a good zone to target increasing linkages with transit as well as encouragement programs.

Zone 5



Zone 5 is characterized by lower population density and good permeability, with moderate connectivity and road network density and low bike network density. Due to its geographic location within the city, good strategies for this zone could include a focus on travel within the zone by increasing the bike network density and facility improvements designed to increase people's comfort while bicycling. This zone has good permeability along the boundary shared with zone 6.

Zone 6



Zone 6 is a large zone bordering the south side of downtown Milwaukee. This zone holds a significant share of the city's population, with a population density slightly less than that of downtown. This area scored well for land use mix and moderately well for all other factors. Zone 6 is a place where increasing cycling may be fairly easy in a short to moderate timeframe based on its proximity to downtown, mix of land use, connectivity, and road network density. This would be a good zone to target increasing linkages with transit as well as encouragement programs.

Potential Future Reductions in Greenhouse Gas Emissions

Additional assumptions were used to estimate the number of reduced vehicle trips and vehicle miles traveled, as well as vehicle emissions reductions. In terms of reducing vehicle trips, it was assumed that 73% of bicycle trips would directly replace vehicle trips for adults and college students. For school children, the reduction was assumed to be 53%. To estimate the reduction of future vehicle miles traveled, a bicycle roundtrip distance of eight miles was used for adults and college students, and one mile for school children. These distance assumptions are standard and used in various non-motorized benefits models. The vehicle emissions reduction estimates also incorporated calculations commonly used in other models, and are identified in Appendix F: Existing and Potential Future Air Quality Benefits by Cycle Zone.

Table 8: Citywide Potential Future Air Quality Benefits

	Bicycle Network	
Vehicle Travel Reductions	No Expansion	Completed
Reduced Vehicle Trips per Weekday [1]	8,287	15,304
Reduced Vehicle Trips per Year [2]	2,162,946	3,994,289
Reduced VMT per Weekday [3]	56,441	112,948
Reduced VMT per Year [2]	14,731,016	29,479,487
Vehicle Emissions Reductions	No Expansion	Completed
Reduced PM10 (tons per weekday) [4]	1,039	2,078
Reduced NOX (tons per weekday) [5]	28,153	56,339
Reduced ROG (tons per weekday) [6]	4,098	8,200
Reduced CO2 (tons per weekday)	24	48
Reduced PM10 (tons per year) [8]	271,051	542,423
Reduced NOX (tons per year) [8]	7,347,831	14,704,368
Reduced ROG (tons per year) [8]	1,069,472	2,140,211
Reduced CO2 (tons per year) [8]	6,261	12,529

Note: VMT means Vehicle Miles Traveled. This table shows estimated potential future benefits based on two scenarios:

Future population increase assuming no changes to the bicycle network. These benefits are estimated based on existing bicycling mode share

Future population increase assuming a completed bicycle network. These benefits are estimated based on assumed mode share increases

(1) Assumes 73% of bicycle trips replace vehicle trips for adults/college students; 53% reduction for school children.

(2) Weekday trip reduction multiplied by 261 weekdays per year.

(3) Bicycle trips: assumes average roundtrip of 8 miles for adults/college students; 1 mile for school children. Pedestrian trips: assumes average roundtrip of 1.2 miles for adults/college students; 0.5 mile for school children.

(4) PM10 reduction of 0.0184 tons per mile.

(5) NOX reduction of 0.4988 tons per mile.

(6) ROG reduction of 0.0726 tons per mile

(7) C02 reduction of 0.000425 tons per mile.

(8) Weekday emission reduction multiplied by 261 weekdays per year.

Estimating future benefits required additional assumptions regarding Milwaukee's population and anticipated commuting patterns. According to the 2006 ACS, approximately 245,000 people are currently employed in the region. A future workforce population of 253,000 was used to reflect projected population changes. Regarding commuting patterns, bicycling mode share was increased to address higher use potentially generated by the addition of new bikeway facilities and enhancements to the existing system. The estimated proportion of residents working from home was also not changed. These assumptions were discussed in the previous section.

Table 8 summarizes potential future air quality improvements associated with bicycling in the City of Milwaukee. This table shows estimated potential future benefits based on two scenarios:

- Future population increase assuming no changes to the bicycle network. These benefits are estimated based on existing bicycling mode share noted in Table 5.
- Future population increase assuming a completed bicycle network. These benefits are estimated based on assumed mode share increases noted in Table 7.

Based on population growth and no expansion of the bicycle network, cycling will remove about 7,900 weekday vehicle trips, eliminating over 53,000 vehicle miles traveled. Given a complete network, it is estimated that bicycling will remove about 15,000 trips and eliminate over 112,000 vehicle miles traveled. Bicycling prevents over 30,000 tons of vehicle emissions from entering the ambient air each weekday. Bikeway network enhancements are expected to generate more bicycling trips in the future. This growth is expected to improve air quality by further reducing the number of vehicle trips, vehicle miles traveled and associated vehicle emissions.

It should be noted that this model only addresses commute-related trips. Unlike the demand models, this model does not account for air quality improvements associated with recreational non-motorized travel, as the greatest impacts to air quality are generated from commute trips.

Off-street trails can provide access across barriers such as major roadways