2008 BICYCLE MASTER PLAN UPDATE,
CITY OF MANHATTAN, KANSAS

by

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Abstract

In 1998, the City of Manhattan, Kansas and Kansas State University jointly developed a City of Manhattan Bicycle Master Plan. This plan created a vision for bicycling in the community, established goals and designated streets to be improved with bicycle facilities. The Master Plan also developed recommendations to incorporate bicycle facility planning into the growth of Manhattan. This plan created a solid political foundation that showed that bicycling matters in Manhattan, Kansas. However, the 1998 Bicycle Master Plan lacked specifics on how to incorporate these recommendations and routes into the existing and future street system.

The 2008 Bicycle Master Plan Update attempts to address the shortcomings of the 1998 Master Plan and incorporate the growth and expansion of the City since 1998. The initial step of the Bicycle Master Plan Update was to calculate a Bicycle Safety Index. The Bicycle Safety Index was modeled after previous research conducted on the City of Manhattan, where street and land use attributes, such as road surface materials, street width, traffic volume, presence of angled-parking and traffic speeds were weighted and calculated in a spatial environment using GIS software. The result was a rating of all streets in Manhattan based on their suitability for safe bicycle travels.

Using the results of the Bicycle Safety Index, specific routes were developed based on their proximity to bicycle destinations, such as commercial areas, schools and parks. Routes were created by using ESRI's Network Analyst software. Routes proposed by the software were evaluated by a windshield and handlebar survey to ultimately determine the appropriateness of each route.

Following the determination of the proposed routes, specific facility recommendations for each street segment were proposed based on the traffic volume, vehicle speeds, street widths and the geometry of the segment. General recommendations and funding options were created to assist in the advancement of the goals and objectives originally initiated in the 1998 Master Plan. The result is a Master Plan that can be used by City Planners to incorporate bicycle transportation into the City and a map for bicyclist to travel from one place to another in the City safely.

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Dedication

I would like to dedicate this Masters Report to my wonderful wife and my beautiful sons. Without your never ending support, patience and commitment, none of this would be possible!

CHAPTER 1 - Introduction and Background

Introduction

There are a number of reasons why America's cities should devote time and resources to create bicycle master plans and build the infrastructure necessary to allow residents to safely and conveniently ride a bicycle as a mode of transportation. These reasons include: increasing obesity rates, increase in fuel prices, negative impacts on the environment, and the constant increase of traffic congestion. Dedicating a community's time, resources and energy to allow its residents to shift from being dependent on the automobile to having the options to walk or bicycle to work or the store can have a dramatic impact on the concerns stated above. "It is estimated that nearly two thirds of U.S. adults aged 20 to 74 are over weight and 31% are obese" (Lavizzo-Mourey and McGinnis, 2003). Lavizzo and McGinnis attribute a large portion of the overweight epidemic to physical inactivity. They estimate that "at least 60% of adult Americans do not meet the surgeon general's minimum target for physical activity, defined as 30 minutes of moderate-to-vigorous activity most days of the week" (Lavizzo-Mourey and McGinnis, 2003). Pucher, Komanoff and Schimek estimate that 48% of trips for all modes of transportation in America are shorter than 3 miles (Pucher, Komanoff and Schimek, 1999). Based on this estimate, if a person would choose to ride a bicycle at 12 miles per hour instead of driving a car for the 3 mile trip, that person would be close to meeting the recommended daily amount of physical activity – 30 minutes for the round trip, and reap the health benefits of meeting the surgeon general's recommendations.

Supporting and promoting the use of bicycles as a mode of transportation can also have an important impact on a community's environment. Because Americans are so dependent on the automobile, it is nearly impossible to research and estimate the direct impact that switching to a bicycle for commuting can have on air and water quality. What can be accomplished is to view the automobile's emissions into the environment compared to the fact that the bicycle has no emissions. Burrington and Heart estimated in 1998 that 64% of carbon dioxide and 35% of nitrogen oxide found in air pollution was created from automobile exhaust (Burrington, and Heart, 1998). They also estimated that 250 million gallons of oil leak from cars in America, which then pollute the ground and water sources. Viewing the negative impacts on the environment caused by the personal car, promoting the use of bicycles as a mode of transportation will be a dramatic benefit to a community's environmental health.

With $3.35 as the price for a gallon of gasoline in 2007, using a bicycle to commute to work or to run errands can positively affect the pocketbook. The maintenance cost to keep a bicycle working smoothly is minimal, with only the need to replace tubes, chains and keep the gears and bearings lubricated. In comparison, the operational and maintenance cost for a car is much more expensive. For a typical car, to fill the tank up at the pump once a week costs approximately $45, plus the occasional $30 oil change. You also have to have a driver's license, car insurance and pay the annual license tags and vehicle taxes, not to mention the high cost of repairing the vehicle if and when it breaks down. Based on the costs associated with operating and maintaining a personal vehicle, riding a bicycle, as a utilitarian mode of transportation, is a simple way to save money.

The positive impacts on traffic congestion created by bicycling for utilitarian purposes can not be directly studied because of the enormous dependency on the personal car. Krizek attempted to study the impact bicycling would have on vehicle congestion. But due to the lack of information, he was forced to use assumptions based on existing conditions of the number of miles of crowded roads and relatively few miles of bicycle lanes and trails. Using the existing conditions and assumptions, Krizek determined that the reduction in vehicle congestion caused by a realistic modal shift from vehicles to utilitarian bicycling "will be small at best" (Krizek, 2004). Krizek's findings should not be seen as a reason to give up on bicycle master planning and improving the infrastructure devoted to bicycling as a mode of transportation. His findings should be a viewed as all the more reason to plan and build for utilitarian bicycling to break the dependence on the automobile. Because of these reasons, past studies and other local factors, cities such as Davis, California, Ann Arbor, Michigan and Madison, Wisconsin have all realized the need to encourage more residents to use a bicycle to travel throughout their respective cities and made conscious efforts through award winning plans and implementation.

The City of Manhattan, Kansas is no exception. In 1998, the City, in combination with Kansas State University, developed a Bicycle Master Plan (The City of Manhattan, 1998) in response to the growing number of adult residents who use a bicycle as a mode of transportation to work, school or to run errands. The 1990 U.S. Census showed that Manhattan, Kansas had one of the largest percentages of the population in Kansas with 4-year colleges or universities that used a bicycle to travel to work or school (1.01%) (American FactFinder, 1990). Since the 1998 Bicycle Master Plan was adopted, the 2000 U.S. Census has shown that the City of Manhattan has sustained a relatively high percentage of adult residents who used a bicycle as a mode of transportation (.85%) when compared to similar cities in Kansas (American FactFinder, 2000). Table 1.1 shows the Manhattan's percentage of the population who bicycle to work compared to other cities in Kansas with 4-year colleges or universities.

Table 1.1 Percentages of Bicycle Commuters in 4-Year Colleges Cities in Kansas (1990 & 2000)

	1990 Population	Residents Who Bike to Work	Percentage of Bike Commuters	2000 Population	Residents Who Bike to Work	Percentage of Bike Commuters
Emporia	25,512	74	0.29%	26,702	129	0.48%
Hays	17,767	36	0.20%	20,031	29	0.14%
Lawrence	65,608	429	0.65%	80,083	557	0.70%
Leavenworth	38,495	168	0.44%	35,304	91	0.26%
McPherson	12,422	70	0.56%	13,782	66	0.48%
Manhattan	37,712	382	1.01%	44,823	381	0.85%
Ottawa	10,667	23	0.22%	12,044	11	0.09%
Pittsburg	17,775	54	0.30%	19,316	83	0.43%
Salina	42,303	90	0.21%	45,634	97	0.21%
Topeka	119,883	189	0.16%	122,045	65	0.05%
Wichita	304,011	389	0.13%	343,997	291	0.08%
Winfield	11,931	24	0.20%	12,228	13	0.11%

Source: U.S. Census, 1990 and 2000. www.factfinder.census.gov

Michael Baltes (1996) has found a positive correlation between the percentage of bicycle commuters in a particular city and the percentage of college age residents (17-29) in that same city. Similar results were found when comparing the twelve Kansas cities that have four-year colleges located in them (See Table 1.2). In 1990, an R-value of .752 shows that a positive correlation exists between the percentage of college students and the percentage of bicyclists for the twelve Kansas cities. In 2000, the positive correlation is strengthened with an R-value of .816 for the twelve comparison cities, further proving Baltes' findings. Using Baltes' findings, the high number of Manhattan residents that are college students supports the justification for a Bicycle Master Plan that can benefit the current bicycle commuters and develop strategies to encourage new bicycle commuters. Table 1.2 lists the number and percentage of college age students in the City of Manhattan (shown in grey).

Table 1.2 Percentages of College-Aged Residents in 4-Year College Cities in Kansas (1990 & 2000)

	1990 Population	College Age Residents (17-29)	Percent of College Age Residents	2000 Population	College Age Residents (17-29)	Percent of College Age Residents
Emporia	25,512	7,395	28.99%	26,702	7,973	29.86%
Hays	17,767	4,105	23.10%	20,031	6,133	30.62%
Lawrence	65,608	28,057	42.76%	80,083	32,822	40.98%
Leavenworth	38,495	7,068	18.36%	35,304	6,339	17.96%
McPherson	12,422	2,475	19.92%	13,782	2,512	18.23%
Manhattan	37,712	15,777	41.84%	44,823	21,929	48.92%
Ottawa	10,667	2,218	20.79%	12,044	2,385	19.80%
Pittsburg	17,775	4,962	27.92%	19,316	6,278	32.50%
Salina	42,303	8,363	19.77%	45,634	8,141	17.84%
Topeka	119,883	23,752	19.81%	122,045	22,466	18.41%
Wichita	304,011	63,663	20.94%	343,997	65,878	19.15%
Winfield	11,931	2,454	20.57%	12,228	2,628	21.49%

Source: U.S. Census, 1990 and 2000. www.factfinder.census.gov

Manhattan, Kansas Bicycle Master Plan

The 1998 Bicycle Master Plan was prepared for Kansas State University and the City of Manhattan, Kansas by Landplan Engineering, Kansas City, Missouri, and Bicycle &, Inc. Planning Consultants, Bolingbrook, Illinois. The consultant team worked with staff from the City Manager's Office, Parks and Recreation Department, Public Works Department and the Fire Department. The University was represented by staff members from the Facilities Planning Office, Student Housing and Dining Services, Public Safety and the State's Division of Architectural Services.

The Bicycle Master Plan was officially adopted by the City Commissioners on December 11, 1997. This plan researched, analyzed and proposed a variety of routes, bicycle parking facilities and general roadway design options to promote and enhance recreational and commuter bicycle traffic. The vision of the Bicycle Master Plan was:

> To create an environment where it is safe, convenient and fun to bicycle for personal transportation and recreation within Manhattan, Kansas (The City of Manhattan, 1998). Six broad goals were created to further the vision set out by the planning committee.

These goals were: 1. Send the Message that Bikes Belong; 2. Shift Mode Use for Daily Trips; 3. Improve Access; 4. Improve Safety; 5. Enhance Recreational Opportunities;

6. Maximize Funding Opportunities. Several objectives were associated with each goal that provided broad implementation strategies or concerns (The City of Manhattan, 1998).

The Master Plan conducted a detailed analysis of the conditions that existed during the study period in 1997. At the time, approximately 10 miles of the Linear Trail System existed. The multi-use trail, which is still in use today, utilized the Kansas River levee at the eastern and southern edges of town traveled through the Wildcat Creek Corridor via public easements and used a portion of the abandoned Rock Island Railroad Corridor. At the time of the study, the Linear Trail System was approximately 10 feet wide, constructed of limestone screening and began on Casement Road (east side of Manhattan) and ended at Anderson Avenue at the intersection of Wreath Avenue (west side of Manhattan). Hudson trail, located at the northwest edge of Manhattan, was a 3,500 foot multi-use trail that ran from Kimball Avenue along Hudson Avenue to Churchill Street. A portion of the Hudson Trail was located within the abandoned Hudson Avenue Right-of-Way at the time of the study. The Hudson Trail is still present and has been expanded to the north as residential developments progressed northerly. No on-street bicycle facilities were present within the City limits at the time of the 1998 Bicycle Master Plan.

The plan also stated a number of conditions that impacted the success of safe and convenient bicycling in Manhattan. The list included:

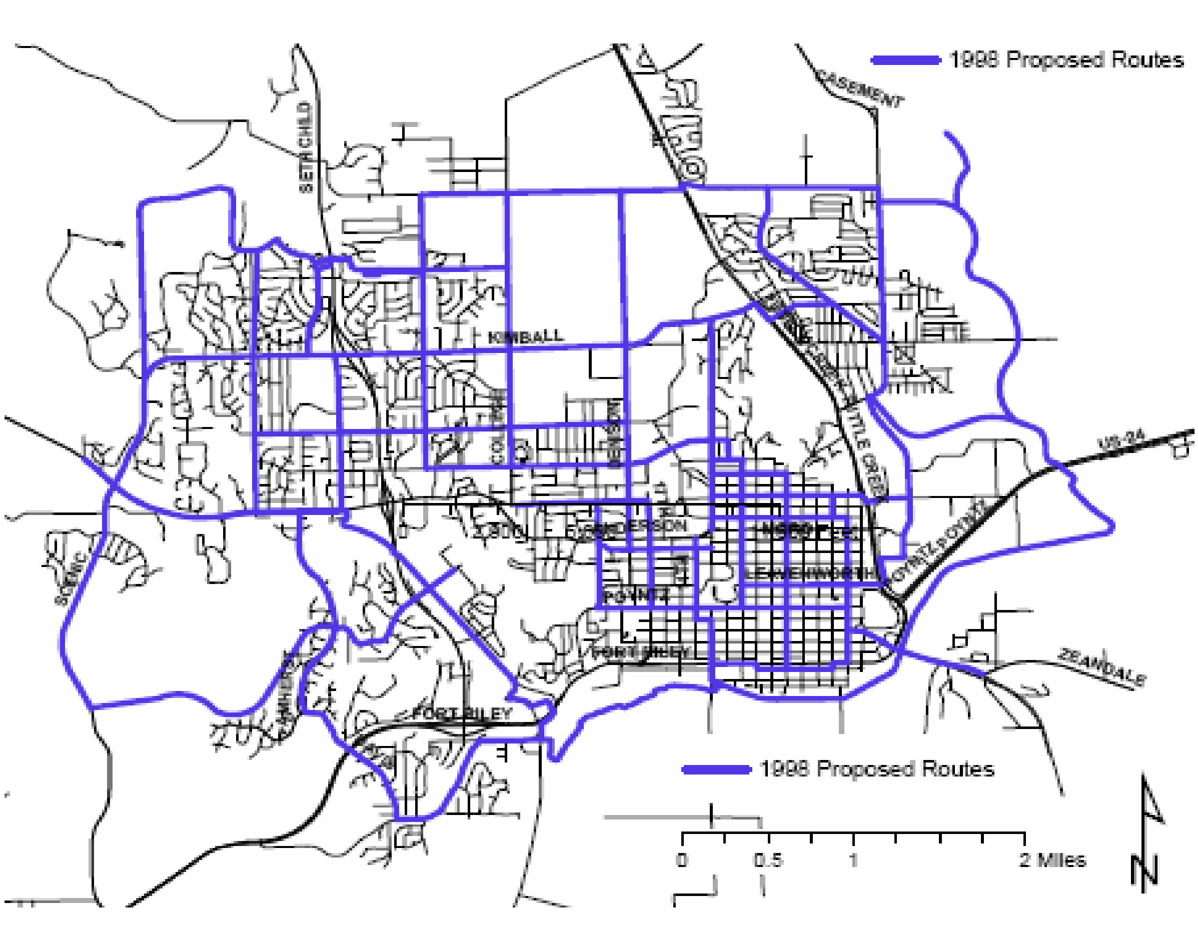
- Extremely hilly areas of the City posed severe topographical constraints to cycling;
- Several parts of the City were isolated from the central area by major roadways (including Northview, Stagg Hill and near Cico Park);
- Streets near campus were often heavily used for parking;
- Primary streets that provide the most direct access throughout the City are the most heavily traveled by motor vehicles.
- Manhattan has experienced significant westward growth in the recent past, with no signs of abatement. These new streets and growth patterns offer potential for the inclusion of bicycle-friendly improvements (The City of Manhattan, 1998)

Based on the existing conditions of the City, projected residential, commercial and industrial growth and input from the planning committee members, four major plan recommendations categories were created: 1. Completion of the Linear Park Trail, 2. Development of inter-City bicycle facilities, 3. Bicycle Parking, 4. Policies for Future Growth.

The basis for the bicycle routes proposed in the 1998 Master Plan was a "wheel and spoke" concept, where the Linear Park Trail was the wheel and streets leading into the heart of the City were the spokes. At the time, the Linear Trail Park system only encircled approximately half of the City. In 1998, no continuous trail system reached the north, northeast or west areas of town. The major recommendations for this section of the plan were to continue construction of the trail system so it would create a large circle around the City.

The Master Plan proposed a series of "spokes" or a "combination of trails, shared-use roadways, and bicycle lanes that would serve to transport bicycle users from the community to the Linear Park Trail, as well as between various origins and destinations within the City" (The City of Manhattan, 1998). To accomplish this recommendation, City streets were to be accessible to bicycle travel. This was to be accomplished through education, signage of designated bicycle routes, removal of bicycle unfriendly road features, such as parallel drainage gates, retro-fitting existing streets for new bicycle lanes and incorporating minimum standards for bicycle travel into new street constructions. The Master Plan recommended that the Public Works Department adopt standards such as AASHTO Guide for the Development of Bicycle Facilities to ensure that new road construction and scheduled major street upgrades included bicycle friendly designs. This category of the recommendations also created a detailed map showing the proposed bicycle "spoke" routes throughout the City (Please refer to Figure 1.1).

Figure 1.1 Map of 1998 Bicycle Master Plan Proposed Routes



It should be noted that several routes ran on streets with heavy traffic or crossed heavily traveled intersections, which would imply that a dedication to the creation of bicycle lanes and intersections that integrated bicycles users would be required.

Bicycle Parking was the third category of the recommendations. This series of recommendations revolved around the creation of standards and regulations that would ensure bicycle parking facilities (i.e. bike racks) were available in all non-residential areas. This section proposed a number of innovative bicycle parking designs as well as proposed zoning regulations that required new non-residential developments to provide bicycle parking based on a ratio of vehicular parking required.

The final category of recommendations dealt with providing adequate bicycle routes and facilities for new developments throughout the City. This area of recommendations revolved around the adoption of street and subdivision design standards. The proposed roadway design standards provided a variety of options based on the hierarchy of City streets to ensure adequate space is provided for bicyclists traveling with vehicles. The subdivision standards provided concepts to ensure that land uses incorporated features that were advantageous for supporting and encouraging bicycle commuting, including mixed land uses, higher residential density on smaller lots and sufficient connectivity between cul-de-sacs and adjacent developments. This section also introduced the concept of providing development incentives for adding bicycle facilitates within a subdivision. These incentives include allowing higher residential densities for the installation of new trails.

The 1998 Bicycle Master Plan also provided analysis of existing conditions for the Kansas State University campus and provided a number of recommendations based on these existing and anticipated conditions. Since KSU operates outside of the City of Manhattan's jurisdiction, this report will only focus on factors dealing with the City's bicycling community. The Plan's recommendation for KSU will not be discussed. However, this report recognizes the impacts that Kansas State University has on the bicycling community and the conditions and recommendations for the City will include these factors.

Purpose

As shown, the 1998 Bicycle Master Plan states the existing and potential benefits to the public health, economy and built environments, as well as creates a solid framework to build a bicycle friendly community. Because of Manhattan's large population of college-age residents, the 1998 Master Plan meets the needs of the City's young residents that want to (or have to) ride a bicycle to school and work. Although the Master Plan helped to create public and political support to improve bicycle travel throughout Manhattan, it fell short in addressing the specific routes and roadway designs needed to incorporate the Bicycle Master Plan into the City's operating procedures. The Manhattan Area Transportation Strategy: Connection to 2010 long-range transportation plan (The City of Manhattan, Kansas, 2000) clearly addresses the Bicycle Master Plans short-coming by stating "What the Bicycle Master Plan is lacking are specific recommendations on how each bicycle route will be provided…" Specifically, the Master Plan did not provide enough detail as to how bicycle facilities would be incorporated along sections of City streets that have heavy vehicular traffic (i.e. Anderson Avenue, Kimball Avenue) and at intersections with unique characteristics due to geometry or traffic volume.

The City of Manhattan has experienced a tremendous population boom since the creation and adoption of the Bicycle Master Plan. In 2000, the decennial census counted 44,831 people living within the city limits (American FactFinder, 2000) and the 2006 population estimated for the City of Manhattan was 50,737 people (American FactFinder, 2006), an increase of nearly 6,000 new residents in only 6 years. This increase in population has caused Manhattan to expand its city limits further to the west and northeast, further necessitating an updated look at the 1998 Bicycle Master Plan. Because of the amount of growth since 1998 and the shortcoming of the Plan's route details, several proposed routes have become extremely dangerous for a bicyclist to maneuver. Although these proposed routes; namely Kimball Avenue, McCall Road, Claflin Avenue and the intersection of Miller Parkway and Fort Riley Boulevard provide the most direct access to existing and future origins and destinations, they are inappropriate for safe bicycle travel.

This report will update the 1998 Bicycle Master Plan to include the new developments throughout the City of Manhattan since 1998. Additionally it will incorporate new bicycle route planning methodology, design specifications for the proposed bicycle routes and implementation strategies to achieve the goals and objectives of the Bicycle Master Plan.

CHAPTER 2 - Earlier Research

Past research to determine the factors that influence the decision to commute by bicycle to work or school can be placed into two broad categories: link-level factors and route-level factors. Link-level factors are those that pertain to the environment between two intersections along a bicycle route. For example, bicycle lane width, traffic volume and vehicle speeds are all link-level factors. Route-level factors are attributes of the entire bicycle route and/or road network. These factors include trip length or travel time and bicycle facility continuity.

As a whole, route-level factors studies differ from link-level studies in two ways. First, link-level factor studies are more quantitative in nature, using measurements of traffic accidents and measured field studies to determine route choice factors. Route-level factor studies typically use surveys or study participant questionnaires to determine why bicycle routes are chosen. Secondly, route-level factors studies also incorporate details about link-level factors into the research, whereas, research on factors at the link-level rarely analyze the bicycle route as a whole. The focus of this section is to analyze these two categories to determine what factors make a quality bicycle facility, as well as develop combined methodology to identify specific bicycle routes for the City of Manhattan.

Bicycle Route Planning at the Link-Level

The factors that influence bicycle commuting at the link-level include the design of bicycle facilities, vehicle traffic characteristics, vehicle parking characteristics, presence and location of bicycle parking, quality of the riding surface, and the grade of the bicycle route (Allen-Munley, Daniel, & Dhar, 2004; Aultman-Hall, Hall, & Baetz, 1997; Ehreth, 2004, Harkey, Reinfurt, & Knuiman, 1998; Landis, Vattikuti, & Brannick, 1997). The majority of previous research has focused on how link-level factors influence route choices. These factors are also incorporated into the design standards and general guidelines created by the American Association of State Highway Transportation Officials (AASHTO) and the Institute of Transportation Engineers (ITE).

Link-level studies provide quantitative research to create measurable indicators for level of service or a safety index for bicycle travel. Aultman-Hall, Hall and Baetz (1997) analyzed two separate community bicycle surveys in Guelph, Ontario, Canada to compare the shortest-path routes between each origin and destination to determine bicyclists' travel behaviors. In this quantitative study, the team revealed cyclists prefer the shortest route possible, which were typically major roadways. The study also revealed that Guelph cyclists avoid steep grades, rail road tracks and congested areas. Cyclists prefer wider curb lanes and use traffic signals to cross arterial or collector streets.

Harkey, Reinfurt and Knuiman (1998) created a model that calculated a Bicycle Compatibility Index - BCI. This model rated road segments on factors that made it favorable to ride a bicycle. The factors used were: number of lanes; lane widths, traffic volumes, vehicle speeds; density of driveways; presence of sidewalks and adjacent land uses. Once the BCI was calculated for all road segments in the road network, a Level of Service (LOS) was created to grade the overall road and provide planners and engineers with a model customarily used in transportation planning. The efforts by the research team created a workable model that could be accepted by transportation engineers to evaluate the existing and future conditions for bicyclists using the road system.

One local example that incorporated the toolsets developed by previous link-level studies is the Bicycle Safety Index for the City of Manhattan created by Benedict J. Ehreth as his Graduate School Thesis at Kansas State University (Ehreth, 2004). His study combined GIS data, public input via a voluntary questionnaire and an expert panel to evaluate bicycle safety conditions on Manhattan's street system. With the help of an expert panel of local cyclists and transportation officials, a weighted formula was created that incorporated curb lane width, street slope, automobile traffic volume, automobile speed, presence of on-street angled parking for cars, presence of bike lane, surface material and adjacent land use. Each variable was converted to a numeric system (i.e. presence of bike lane – YES = 5, NO = 1), weighted and then added together to create Manhattan's Bicycle Safety Index. The primary tool to create this index was ESRI's Spatial Analyst extension which quickly and easily converts and calculates variables, then represents them spatially on a map. Ehreth's research was then applied to Manhattan's streets to create a list of recommendations through the City to create a safer environment for bicyclists. The model created by Ehreth was used to determine the safety for bicyclists on the current road network in Manhattan, Kansas.

In summary, the research conducted to determine the effects of link-level factors on bicycle commuter rates and safety used different factors and models and found a number of similarities, including:

- Roadway configuration was important to utilitarian bicyclists (factors included road lane width and number of intersections or driveways in a standard distance);
- The volume, vehicles speed and percentage of heavy vehicles played a major factors in the level of safety and compatibility for bicyclists;
- The presence of dedicated bicycle lanes with adequate widths were more preferable to separate bicycle paths);
- The type of riding surface (smooth, rough, concrete, brick, etc) was a minor factor;
- The presence of vehicles parking at an angle, parallel parking, or the restriction of parking was a important factor in determining the safety of bicyclists riding along side parked cars;
- Adjacent land uses were also considered as a way to determine origin and destination.

The findings from the link-level research provide important quantitative analysis for the creation of safe and effective bicycle facilities for a community. These authors also provide route planners tools to evaluate existing and future routes for its safety and functionality. By following or incorporating the indices from previous research, route planners can determine the safest route segments, prioritize route segments that need to be improved and predict and monitor segment safety for bicyclist when road improvement project are proposed.

Route-Level Factor Studies

Route level factors refer to the attributes that are most important to bicyclists when analyzing the entire route. These factors include trip length, travel time, the number of delays due to traffic lights and how continuous is the bicycle route (Allen, Rouphail, Hummer, & Milazzo, 1998; Baltes, 1996; Hochmair, 2004; Hunt & Abraham, 2007; Jackson & Ruehr, 1998; Moritz, 1998; Morris, 2004; Nelson & Allen, 1997; Stinson & Bhat, 2004; Tilahun, Levinson, & Krizek, 2005). Most route-level studies use qualitative evaluations of a bicyclists' choice in routes. There are two broad categories that route-level studies fall into – revealed preference (RP) surveys, and stated preference (SP) surveys to study an entire routes performance to encourage bicycle commuting.

Revealed Preference Surveys

RP surveys gather information on actual route choices made by bicyclists. Research using RP surveys asked participants to log actual routes used during a specific time on a map or in a journal along with notes about the route (perceived safety, etc), demographic information (gender, age, income, etc.) and bicycle characteristics (number of years commuting by bicycle, type of bicycle, helmet use, etc.). The advantage of this survey model is that the data gathered represents route preferences and trip selection in an actual environment. The limitation of this research model is its challenges in collecting data. RP surveys require participants to keep a running log of bicycle routes, which results in small sample sizes and limit the study area. Data entry and analysis is also a challenge for RP surveys. Researchers must tabulate all routes provided by study participants. Unfortunately, these routes may not correspond to actual roads or routes available to bicyclists, resulting in these route entries to be invalid, further limiting the sample size. Howard and Burn (2001) used the revealed preference survey model to determine bicycle commuter's preferable routes in Phoenix, Arizona. They found that commuting bicyclists see trip length and time as significant factors that have a negative effect on the attractiveness of bicycling. The study also found that bicyclists' preference to riding in a designated bicycle lane slightly diminishes the trip time and length factors. In other words, bicyclists are willing to ride an extra 4.1 minutes on a designated bicycle lane than riding with traffic alone. The study also found that secure bicycle parking close to the rider's destination played a significant role in the choice to ride a bicycle as a mode of transportation.

Shafizadeh and Neimeier (1997) used the RP survey model in a 1993 study conducted in Seattle, Washington to determine route level attributes that were deemed valuable to bicycle commuters. They found that commuting time by bicycle tended to be longer for those with higher income and older cyclists. They also found that research participants would rather bicycle longer distances on bicycle paths or routes than on a city streets shared with vehicles. Aultman-Hall, Hall and Baetz (1997) used an RP survey model and geographical information system data to cross-reference the qualitative results of the survey with link-level attributes, such as traffic volumes and traffic signals to further determine what constitutes a "good" route for bicycle commuters. The major findings from these studies are that bicycle commuters preferred a more direct or the shortest route available on the existing road network.

Although these separate research projects created slightly differing results, the overall conclusions were:

- Commuter bicyclists prefer direct routes to work rather than using a separate trail or path that may be perceived safer, but is longer and out of the way.
- Commuter bicyclists tend to avoid hills and major roads with high traffic volumes.
- Commuter bicyclists prefer signalized intersections to cross busy intersections when compared to similar intersections with no signalized traffic controls.
- Older individuals and those with higher incomes are less sensitive to travel time.

Stated Preference Surveys

Stated preference survey models give survey participants a series of hypothetical, comparative situations to determine the ideal route. These surveys use descriptive narratives photos or videos to compare specific factors associated with the route. The research typically uses hand distributed or mailed surveys and/or online surveys to gather information. The benefit of SP surveys are that they have the ability to reach a large sample size, especially when using the internet via emails and list servers, and they can be tailored to specific route factors. The drawback to SP surveys is that it limits the number of variables that can be researched, greatly reducing the comprehensiveness of the study. Several researchers have attempted to overcome this disadvantage by including several different types of survey instruments with different types of variables to increase the study's comprehensive view.

Stinson and Bhat (2003) used a stated preference survey to evaluate both link-level and route-level factors in determining a quality bicycle commuting route. The results of their study revealed that low travel times was the most important factor in choosing a bicycle route, followed by the preference of using residential streets to major or minor arterials. The survey also showed that participants would avoid bridges unless there was a separate bike lane or a bridge dedicated to pedestrian and bicycle traffic. As a follow-up study, Stinson and Bhat used an internet study to "examine the factors that influence the decision of commuters to bicycle to work." This study revealed that the "dominant deterrents to bicycle commuting are unpleasant weather and inadequate daylight" (Stinson, and Bhat, 2004). The study also revealed that participants chose not to bicycle to work because of the need to run errands during or after work that would require a car. Respondents also stated that perceived safety of bicycling to work and the lack of secure bicycle parking facilities were deterrents to riding a bicycle to work (Stinson, and Bhat, 2004).

Mortiz asked the League of American Bicyclists to respond to a questionnaire created to determine among other things, purposes of bicycle trips, total distance cycled, demographics, accidents and commuting habits. Mortiz's survey results showed "the 'average' respondent was a 48 years old, married, male professional who rode 4670 km (2901 miles) in the study year". Just over 9 percent of the survey respondents reported to be in a serious accident (resulting in $50 or more in damages) for the study year. In the analysis of the survey results, Mortiz created a relative danger index. Based on the crash information and commuting habits provided, the danger index revealed that streets with a designated bicycle lane were safer than streets without a bicycle lane). Tilahun, Levinson & Krizek used a stated preference survey to see if bicycle commuters were willing to trade a "higher travel time as a cost incurred when choosing a better facility" (Tilahun, Levinson & Krizek, 2005). The base route was a street with no bike lane and on-street parking. The trade-off of commute time was attached to different types of bicycle facility attributes (i.e. bike lanes, off road trails and on-street parking.) Tilahun and his colleagues found that respondents were willing to travel up to twenty minutes longer to ride on a street with a designated bicycle lane than the base route and only approximately 5 minutes longer on an off-road bicycle trail (Tilahun, et. al., 2005).

These studies have revealed that commute time is the most important factor when considering a bicycle route, followed by the quality of the road surface, vehicular traffic volumes and the type of bicycle facility being used. The information derived from route-level studies gives overall goals and objectives to route planners when creating routes. By starting with the ideal route in a bicycle commuter's eyes, the route planner can than incorporate real life factors and constraints to develop a realistic plan that will meet the needs of the bicyclist and automobile drivers.

Other Study

One final study has chosen to analyze data collected from the U.S. Census. Morris analyzed the 2000 U.S. Census to determine if the presence of an urban bicycle trail increased the response of bicycling to work on the U.S. Census form (Morris, 2004). The study focused on 13 cities with designated urban bicycle/pedestrian trail and used data collected at the Census block group level. Morris' study found that in 9 of the 13 cities, residents who live within .5 miles of an urban bicycle/pedestrian trail were more likely to bicycle to work than if they lived outside of the ½ mile buffer. Morris determined that "bike sheds" exists in proximity to a trail that attracts people to use a bicycle to commute to work or to run errands. This information can be incorporated in the final evaluation of a bicycle master plan to determine if the largest number of residents is within a 'bike shed," with the hope that the proximity to a bike route will encourage recreational and commuter bicycling.

Summary and the Relationship to Current Project

Past research on link-level and route-level factors have provided a wealth of insight into the attributes that make up a safe and well used bicycle commuter route. Link-level studies ultimately developed models that rated the "bicycle-friendliness" of road segments and created level of service measurements that could be used by transportation planners and engineers to evaluate existing and future bicycle conditions. The factors that link-level studies focused on were: roadway configuration; vehicular traffic volume; vehicle speed; percentage of heavy vehicles; presence of dedicated bicycle lanes and widths; road surface; vehicles parking; and adjacent land uses were all considered and incorporated into the safety indices and level of service grades.

Route-level studies viewed factors dealing with the entire route, a more holistic approach. These studies found that distance, directness and time traveled were the most important factors, followed by traffic volume and the presence of adequate bicycle parking facilities. The road's surface materials and quality were also important factors. One other study to note was Morris' research on the idea that the presence of a bicycle route in proximity to one's home may encourage people to use a bicycle as a mode of transportation. His findings are encouraging when developing a bicycle master plan as the proper placement of a bicycle route, should increase the number of cyclists going to and from work or on errands (Morris, 2004).

Each type of research model brings important information in determining the scope of this project. The Manhattan Bicycle Master Plan update will attempt to combine all major findings from past research to develop a bicycle route network that will meet the needs of commuter bicyclists, vehicle drivers, the public, and City departments that must design, build and pay for any bicycle facility improvements.

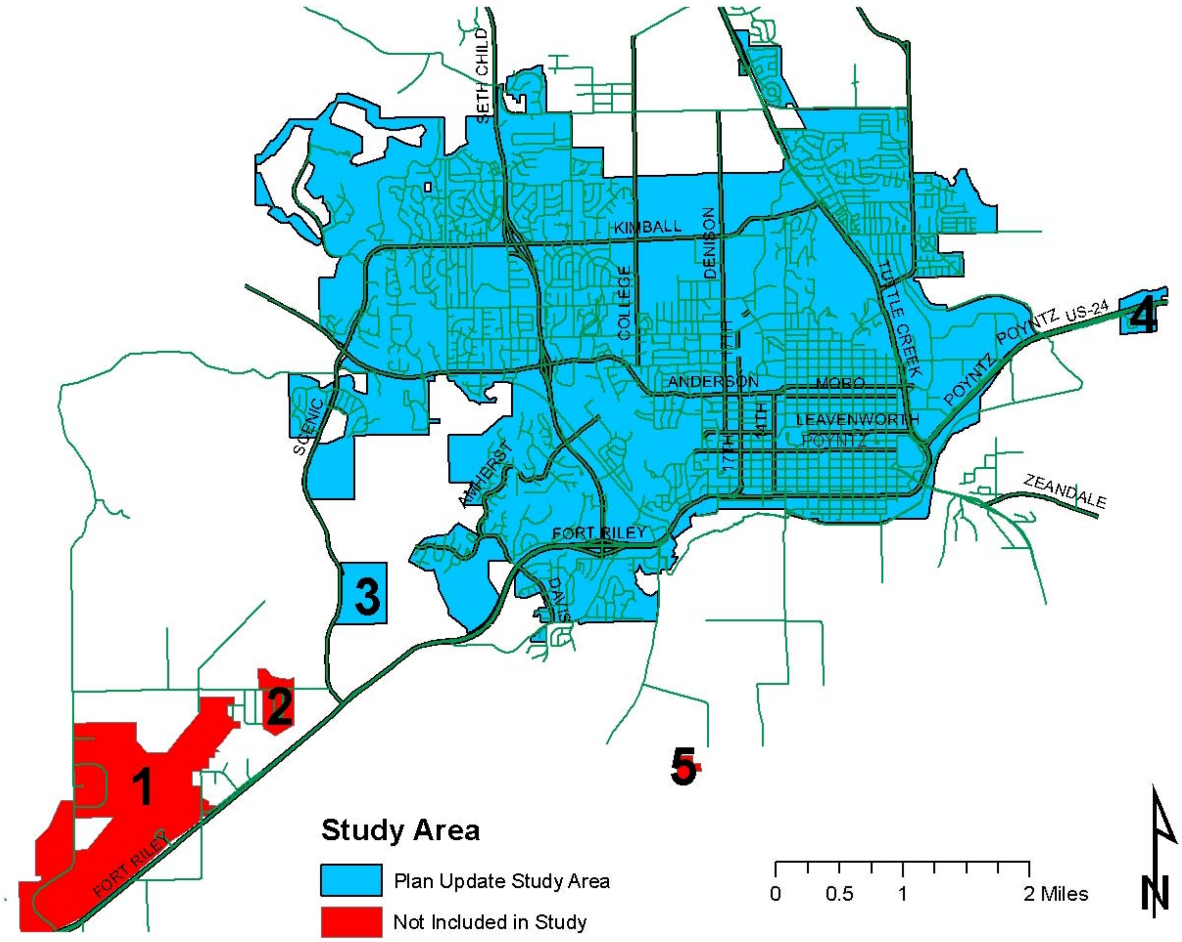
CHAPTER 3 - Methodology

The City of Manhattan's 1998 Bicycle Master Plan was used as a base study and plan to integrate bicycle transportation throughout the City. The updated report includes two sections; the first reassesses and/or updates existing routes outlined in the 1998 Master Plan as well as includes new developments throughout the City. These new developments required new bicycle routes and/or reconfigured past routes to incorporate the new developments. The second section of the updated plan focuses its attention on specific implementation strategies to bring the vision of the Bicycle Master Plan to reality.

Study Area

The City of Manhattan is comprised of the city limits proper, which is approximately 10,350 acres in area, and five outlying areas that have been annexed into the City, but are not adjacent to the City. These areas included the Airport and adjacent industrial and commercial areas (1), a new industrial park (2) and a new residential subdivision (3) to the west, a new commercial center (4) to the east and the solid waste transfer station (5) south of the City limits. These island annexed areas included a total area of approximately 1,200 acres. Since these outlying areas are not adjacent to the City and, with two exceptions, the City's growth would not reach the edges of these areas in the foreseeable future; they were not included in the study (See Figure 3.1 for the location of each area that corresponds to the description above). The two exceptions are the new commercial and residential centers. Scenic Meadows is a 114 acre subdivision located on the east side of Scenic Drive. The Miller Ranch and Lee Mill Heights neighborhoods have been slowly growing towards this new subdivision. A Master Plan is in place for the area between the established neighborhoods within Manhattan Proper and Scenic Meadows. The second area, Heritage Square, is a large 61 acre commercial center located along U.S. Highway 24 in Pottawatomie County. Residential neighborhoods in this area have been established and preliminary discussions have been made to annex these residential areas adjacent the commercial center. Since both of these areas presumably will become part of the main body of the City of Manhattan, they will be included in this research.

Figure 3.1 Map of Bicycle Master Plan Study Area



Methodology Basis

The basic premise of the Bicycle Master Plan is that all streets should be utilized by the bicycling commuter. To utilize the existing street system safely and effectively, bicyclist must practice "vehicular cycling" (Forester, 1984). Forester describes "vehicular cycling" as the concept that cyclists should practice and obey traffic laws applicable to drivers of vehicles and should also be treated by other drivers and by the law as drivers. For example, a vehicular bicyclist would ride with the flow of traffic, stop at all traffic signals and intersections and properly signal left and right turns.

Bicycling research has grouped cyclists into three design categories: Group A – Advanced Bicyclist, Group B – Basic Bicyclist, Group C – Child Bicyclist (Harkey et al., 1998; Landis et al., 1997).

- Group A is described as a group that includes experienced adult riders who operate under most traffic conditions, typically riding on collector and arterial streets. These riders generally prefer direct access to destinations via the street system, desire the opportunity to operate at maximum speed with minimal delays, and are best served by sufficient operating space on roadway shoulders, on streets with wide curbs, or bicycle lanes.
- Group B are cyclists who generally are causal riders or new adult/teenage riders who are less confident and capable of operating in traffic without special provisions for bicycles. They usually prefer comfortable access to destination, either on low-speed, low-volume streets or on designated bicycle facilities.
- Group C is the user group that includes pre-teen riders who do not yet have a driver's license and whose roadway use is limited to residential streets with low motor vehicle speed limits and volumes. They generally require comfortable access to key destinations that surround residential areas, including schools, parks and shopping areas.

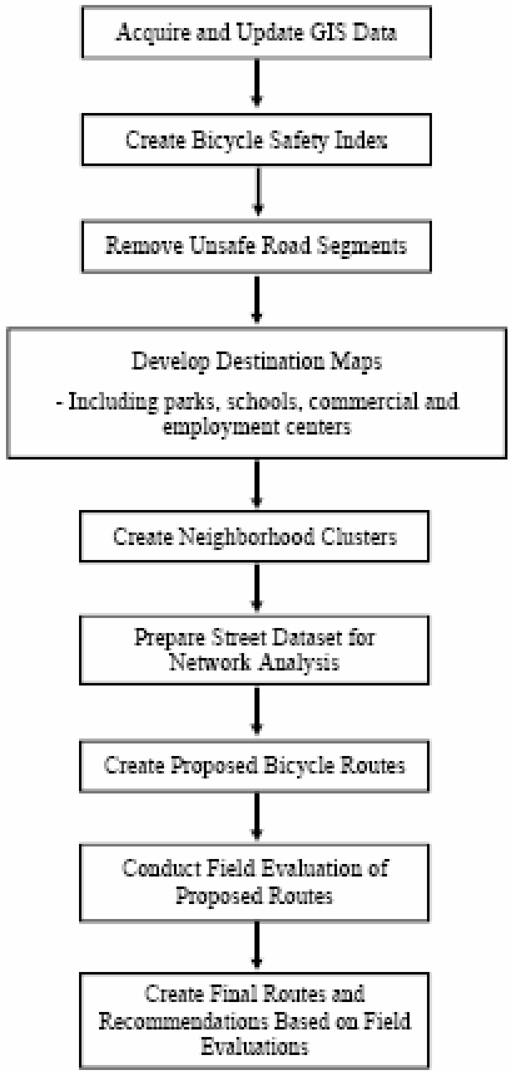
For the purpose of this research, only Groups A and B will be served. Group C's needs to travel via a bicycle to area schools are being addressed through the City of Manhattan's Safe Routes to Schools program in partnership with the State of Kansas Department of Transportation.

Bicycle Route Planning

The 1998 Bicycle Master Plan created a sound methodology to develop bicycle routes throughout the City of Manhattan – the "hub and spoke" approach. The Master Plan update utilized the same approach proposed in the 1998 Master Plan, where the Linear Park Trail, once completed, would create the outer ring of the transportation system. The spokes consist of existing streets and trails throughout the city to provide direct access to major commercial and employment centers, schools, parks, medical centers and other public facilities.

The Bicycle Master Plan update followed several steps to develop the final bicycle routes that are safe and meet the needs of commuter bicyclists according to previous research. Figure 3.2 provides an outline of the major steps taken to develop the proposed routes.

Figure 3.2 Methodology Outline



Acquire and Update GIS Data

A majority of the analysis and route generation was done using ESRI's Arc Editor 9.1 GIS software. This software was used to create, adjust and analyze various spatial data gathered from the City of Manhattan, Riley County and the U.S. Census Bureau. A number of data layers were used to develop a base layer to represent the City and create a foundation to visually show the intermediate steps and the final products. These data layers included the City limits, the Manhattan Urban Service Area (the area on the outskirts of the City that can adequately be served by City water and sewer), Manhattan parcel data and the City's street network.

ESRI's Spatial Analysis was used to develop a model to evaluate the City's road system. The Spatial Analysis was used to show the City's topography by calculating the percentage of slope from elevation points across the City. The analysis tool was also used to evaluate each road segment's perceived safety based on factors generated from previous research. Attributes from the City's Street system was used in the road safety evaluation. The Spatial Analysis tool also was used to visually represent the City's topography.

Network Analysis, a GIS add-on tool, was used as the main analysis tool to develop the optimum bicycle routes throughout the City of Manhattan. Network Analysis is an ESRI Arc View 9.2 extension that analyzes spatial data to assist in route planning, provide directions and find the closest facility. By using street attributes, such as length and speed, along with point data for origins, stops (destinations) and barriers, Network Analysis can quickly find the most suitable routes. The GIS software calculates the shortest or quickest distance to a stop or destination depending on the parameters of the analysis. The advantage of using such software is the increase in productivity by allowing the specific software to designate optimum routes and to produce step by step directions and trip characteristics – distance and minutes traveled.

Create Bicycle Safety Index

To determine the real and perceived safety of Manhattan's streets, a simple Bicycle Safety Index was created by using a link-level model developed by Ehreth in 2004 for the City of Manhattan for his Thesis (Ehreth, 2004). Ehreth's model used the City of Manhattan's street network's attributes and the percent slope of the City's topography in a GIS environment to quantitatively grade each road segment based on factors considered to impact the real and perceived safety of bicyclists who share the road with vehicles. The Spatial Analysis tool was used to create a digital representation of the City's elevation points (over 41,178 different elevation points throughout the City) and then to calculate those elevations points into percent slope to represent the differing grades across the City (See Map 3.2 (*Figure 0.3*)). The Ehreth model was run with the Spatial Analysis tool on the existing street network that included a number of new and upgraded streets throughout the City. This dataset included the spatial layout of all streets within and around the city limits, street names, functional classification of all streets, posted speed limit, street surface, surface width, length of each street segment, vehicle parking restrictions (i.e. parking on both sides, no parking on one side, or no parking on both sides), presence of angled-parking along the street and curb lane width (Please see Map 3.2 – 3.9

(*Figures 0.4 through 0.9*)) As stated in the review of previous studies, these link-level factors are important in determining a street segment's compatibility and safety for bicycle commuters. The percent slope and individual street attributes were weighted and multiplied together using the Spatial Analysis spatial calculator to create the raw Bicycle Safety Index for each road segment. The raw calculations were then reclassified into five categories: "Very Safe", "Fairly Safe", "Moderately Safe", "Fairly Unsafe", and "Very Unsafe." The complete Bicycle Safety Index calculations can be seen in Map 3.10 (*Figure 0.10*).

Remove Road Segments Unsuitable for Bicyclists

After the Bicycle Safety Index was created for all streets, only those streets that were given a rating of "Very Safe", "Fairly Safe" and "Moderately Safe" was considered for the Bicycle Route Master Plan Update. The road segments that were rated as "Fairly Unsafe" and "Very Unsafe" were removed from the analyst. The intersection between safe and unsafe roads remained in the analysis to provide a complete and continual street network.

Develop Destination Map

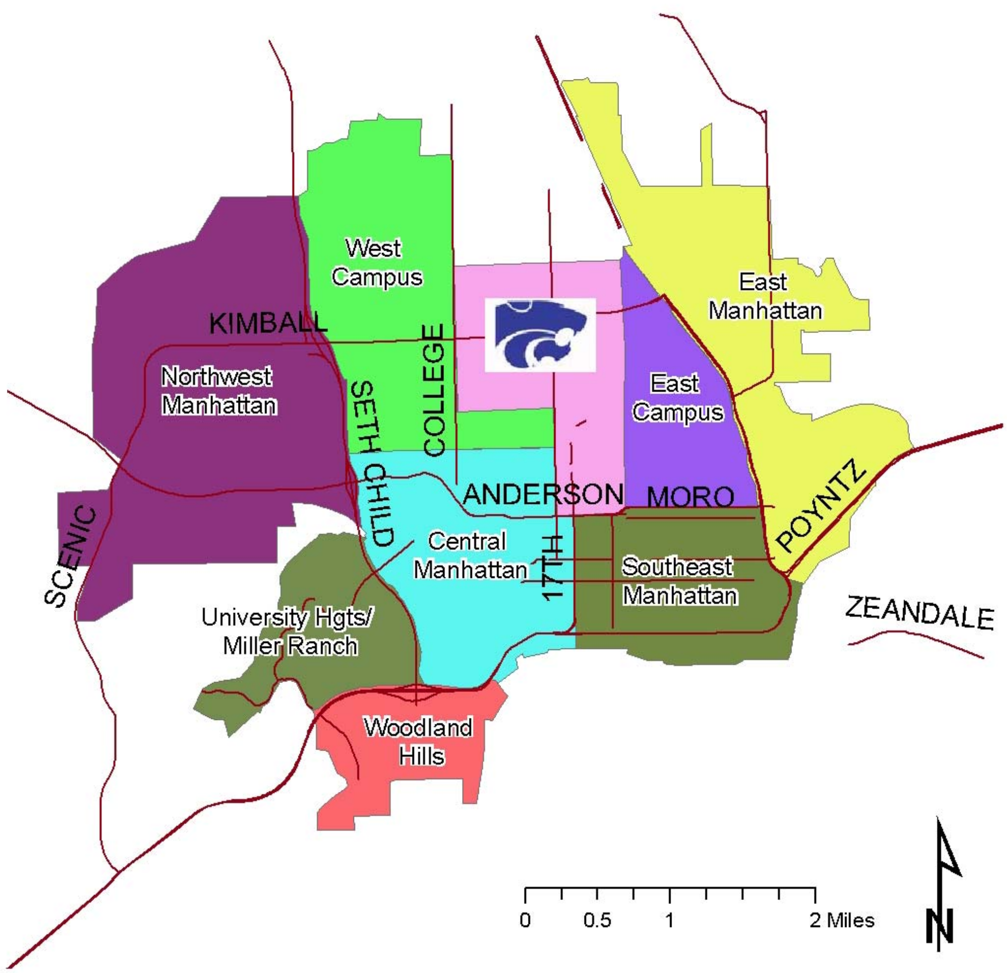
Destinations, or stops as they are referenced in the Network Analysis software, were mapped using GIS software. These stops are locations through the City that one can realistically assume a bicycle commuter would travel to work or to run errands. These stops included (but was not limited to) schools, parks, commercial and employment centers. Several data sets obtained from the City of Manhattan's Geographic Information System database were used to create the destination layer. The destination layer was comprised of commercial and industrial land use zones gathered from the City's Zoning District data, school sites (including Kansas State University, Manhattan Technical College and American Baking Institute), and designated City parks (please see Figure 0.11).

Create Neighborhood Clusters

Once all of the destinations were located and mapped, the City was divided into different neighborhood clusters based on geographical features (i.e. major streets that divide adjacent areas, streams or steep slopes). The key to the Bicycle Master Plan Update was to focus on the neighborhoods to create routes usable by the average or below average bicyclist who would like to commute to work, to run errands or go to appointments. At the neighborhood level, direct or nearly direct routes can be dedicated to guide riders to major destinations within the cluster. The local view of the City also gave a better perspective of the street to avoid any dangers or undesirable route conditions that would deter prospective riders. The eight neighborhood clusters (Please see Figure 3.3) are:

- East Manhattan
- East Campus
- Southeast Manhattan
- West Campus
- Central Manhattan
- Northwest Manhattan
- Miller Ranch/University Heights
- Woodland Hills

Figure 3.3 Neighborhood Clusters



Efforts were made to make each neighborhood cluster similar in size and population. Table 3.1 shows the size of each neighborhood cluster, 2006 population estimates as well as demographic estimates.

Table 3.1 Neighborhood Demographics

Neighborhood Clusters Population Estimates	Acreage	Total Population	Male	Female	Ages 5-17	Ages 18-21	Ages 22-29	Mean Age
Northwest	2,368	7,315	3,668	3,647	1,475	535	1,164	29.0
Miller Ranch/ University Heights	643	1,937	949	988	231	61	82	29.2
Woodland Hills	495	2,014	1,027	987	299	151	431	21.9
West Campus	1,395	8,211	4,097	4,114	1,014	1,638	1,718	33.6
East Campus	660	3,399	1,823	1,576	159	1,305	1,221	24.8
East Manhattan	1,608	5,651	2,834	2,817	1,100	420	1,201	21.2
Central Manhattan	1,252	6,775	3,830	2,945	480	2,788	1,494	30.0
Southeast Manhattan	930	5,988	3,208	2,780	479	1,370	2,003	23.5
Source: U.S. Census, 2000. www.factfinder.census.gov								

Some areas of Manhattan are extremely isolated in regards to being dissected by major arterial roads. The Woodland Hills cluster, for example, is relatively small with a smaller number of residents. K-18/Fort Riley Boulevard and K-113/Seth Childs Road isolate the area from other residential centers, making it impossible to add the area to a larger cluster and maintain the idea of connectivity.

Prepare Street Dataset for Analysis and Create Proposed Routes

As previous research showed, bicycle commuters prefer a route that is relatively short in terms of distance and time (Allen, Rouphail, Hummer, & Milazzo, 1998; Baltes, 1996; Hochmair, 2004; Hunt & Abraham, 2007; Jackson & Ruehr, 1998; Moritz, 1998; Morris, 2004; Nelson & Allen, 1997; Stinson & Bhat, 2004; Tilahun, Levinson, & Krizek, 2005). The existing street data set was updated to create a feet per second measurement for each road segment so that the Network Analysis extension was able to calculate the time it would travel from point A to point B. The assumed speed of the bicyclist to create the feet per second measurement was 11 mile per hour. The City's existing and proposed trail network, location of bridges and traffic signals throughout the City of Manhattan were included in developing the proposed routes.

ESRI's Network Analysis extension was used with the City's street network data set (minus the "Fairly Unsafe" and "Very Unsafe" rated road segment) to create the proposed routes in each neighborhood cluster . Each route used traffic signals to cross major streets where available and avoid bridges when appropriate. Using the destination points and street network, the extension tool created routes that were the shortest distance between all points. The output from the analysis was adjusted where needed to create a safe and consistent route throughout the neighborhood cluster. Particular attention was given to how the proposed route was situated so that the optimum number of residents would be in proximity to a neighborhood route. As Morris (2004) showed in his analysis of the 2000 U.S. Census, a trend emerged where residents who lived within .5 miles of an urban bicycle trail were more likely to bicycle to work or to run errands that if they lived outside of the .5 mile "bike shed" (Morris, 2004;). The assumption was that living in proximity to a dedicated bicycle route would encourage residents to commute to work by bicycle. A similar .5 mile buffer was created around each proposed bicycle route to evaluate if the routes encompass the greatest number of Manhattan residents possible.

Once the optimum bicycle routes were created, based on proximity to destinations and the Bicycle Safety Index within each neighborhood, they were then connected to the adjacent neighborhoods to create entry and exit points. The neighborhood by neighborhood approach ultimately connected to the Linear Trail and created the "spokes" of the "wheel and spoke" concept.

The overall goal was to create safe and relatively short routes to school, work and other destinations throughout the City of Manhattan. A windshield and bicycle handlebar survey was conducted to grade each proposed route for comfort (i.e. road surface), ease of travel (i.e. slope of the route, number of stop signs and traffic signals), perceived safety (i.e. traffic volume and space to ride) and relative distance and time to ride the route. A short form was used that incorporated a simple 1 to 5 Likert scale to evaluate each route. Space also was provided to gather comments and suggestions for the route. (Appendix A). Following these evaluations, the proposed routes were adjusted where needed. Once the final routes were designated, a bicycle route map was created for the entire City of Manhattan. These maps show the designated routes and location of destinations and a distance chart to and from each destination.

The Bicycle Master Plan update also developed recommendations and priorities to implement the plan. If the technical route planning was conducted accurately, the implementation strategies can be developed and will help to ensure that the routes chosen can be designed, budgeted and built to provide bicyclist in Manhattan the safest routes possible. These implementation strategies were based on overall city and site specific needs to advance the purpose and goals of the Bicycle Master Plan.

CHAPTER 4 - Findings

Bicycle Safety Index

The Bicycle Safety Index (BSI) developed by Ehreth (2004) to evaluate Manhattan's street for the safety for bicyclists in 2001 was recreated for the current street system. The exact formula was used to weight the importance of different variables of the street and the surrounding environment. The Bicycle Safety Index created with this research produced similar results (Map 3.10 (*Figure 0.10*)). The results of the BSI calculations showed that a majority of Manhattan's streets (68%) were rated as "Very Safe", "Fairly Safe" or "Moderately Safe." All local residential streets were calculated to be safe for bicyclists to travel on. These "safe" ratings were primarily due to the low traffic volume, no angle parking and low vehicle speeds. Areas in the older neighborhoods and on the east side of town also had the advantage of being relatively flat, a characteristics desired by the average bicycle rider.

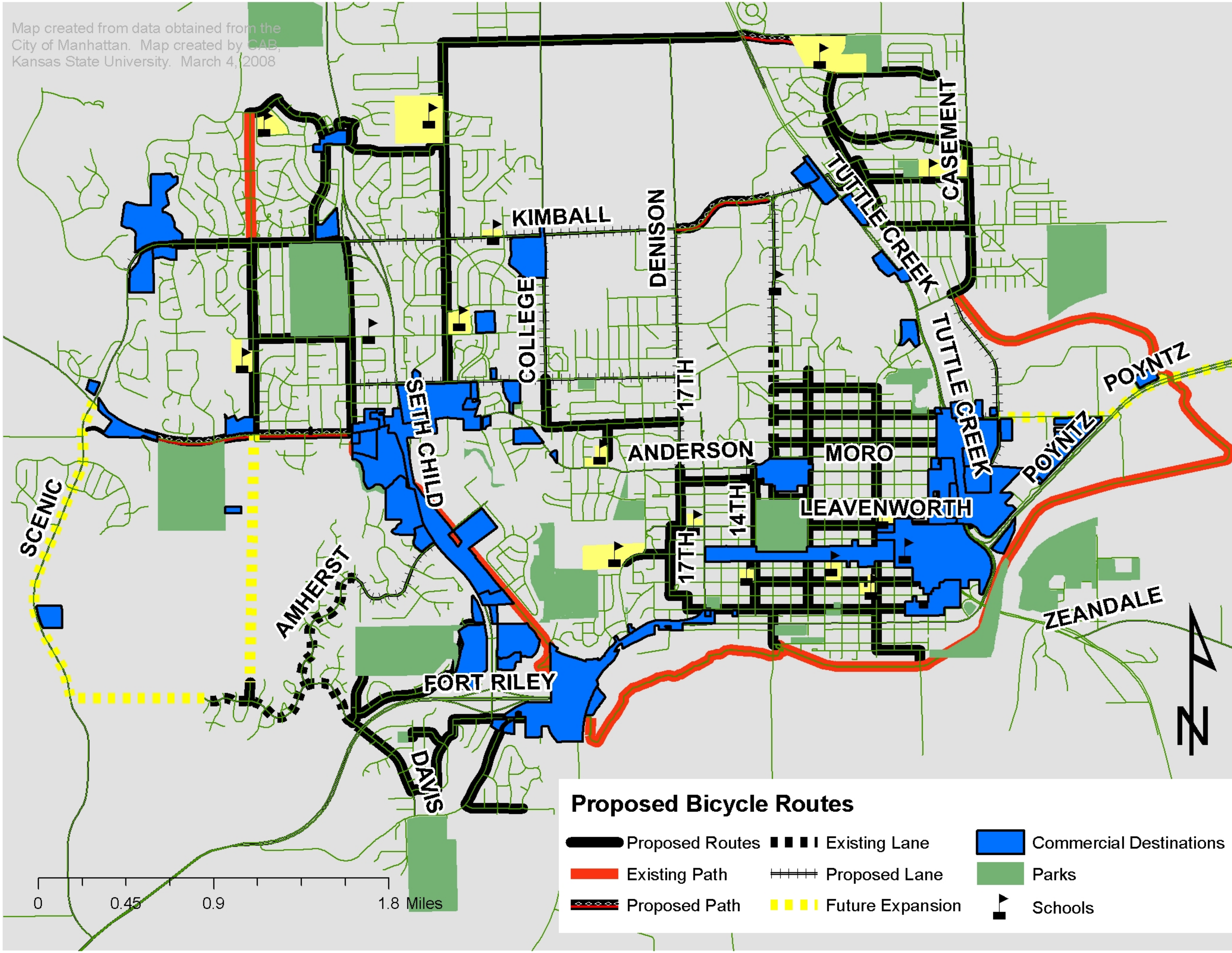
The streets that were rated to be inappropriate for bicyclists were four-lane roads with high traffic volumes and vehicle speeds. These "Unsafe" streets include Fort Riley Boulevard, Tuttle Creek Boulevard, Seth Childs Road and Kimball Avenue. Sections of Claflin Road were calculated to be "Unsafe" because of the steep hills between Seth Child Road and College Avenue. 17th Street was calculated to be unsafe because of the high traffic volume and the narrow road width, which limits the amount of room available for both bicyclists and vehicles. Other streets, some of which were local, residential streets, were given a "Fairly Unsafe" rating because of steep grades or unsuitable road surfaces, such as gravel or brick. Those streets include Westport Road, Manhattan Avenue, Hudson Avenue, Stagg Hill Road and Fairland Street. Although the grade of these streets were not ideal, if the road surface, traffic volumes and posted vehicle speeds were acceptable, they should be considered for possible bicycle facilities.

Based on the results of the BSI, the safest areas to ride were in the older neighborhoods with the flatter grade, lower vehicle speeds and traffic volume. The grid pattern of the older neighborhoods also improves the safety for bicyclists by forcing drivers to be more aware of the environment because of the higher density of residences, the proximity of the houses to the street and the higher number of street intersections when compared to the modern subdivision design. The modern subdivision has a lower density, with the houses placed further back from the street on larger lots. The street designs in newer subdivisions used a "lolli-pop" design with curved streets and a number of cul-de-sacs, which results in longer street segments and fewer intersections, which equates to higher vehicle traffic speeds.

Proposed Bicycle Routes

Figure 4.1 shows a complete map of the proposed routes for the Bicycle Master Plan Update for the City of Manhattan. The proposed routes were created by ESRI's Network Analysis extension based on the Bicycle Safety Index calculations to ensure that the routes were safe for bicycle riders. In some instances, no other alternative was available but to use a street segment that was determined to be less than desirable. In these situations, a substantial bicycle facility must be provided to ensure the safety of bicyclists and vehicle drivers. Over 40 miles of bicycle routes, lanes and paths were proposed to create a continuous bicycle network to allow residents of Manhattan to ride to work, school or to run errands.

The windshield and handlebar survey resulted in minor adjustments to the proposed routes. These adjustments included re-organizing the route along Yuma Street in the Southeast Manhattan cluster and South Delaware in the Central Manhattan cluster. A route proposed by the Network Analysis software on Dickens Avenue east of Seth Childs Road was eliminated because of the wide, un-signalized intersection at Seth Childs Road and Dickens Avenue. This intersection is not suitable for bicycle to cross and thus the entire route from Wreath Avenue to College Avenue was eliminated. These changes are reflected in the final map of the Proposed Bicycle Facilities (Figure 4.1).



Map 4.1: Manhattan Bicycle Master Plan Update
Proposed Bicycle Facilities

Route Plans for Each Neighborhood Clusters

Each neighborhood cluster had its own unique characteristics that made determining the proposed bicycle routes challenging within the neighborhood cluster as well as connecting the routes to the adjacent neighborhood clusters.

Central Manhattan

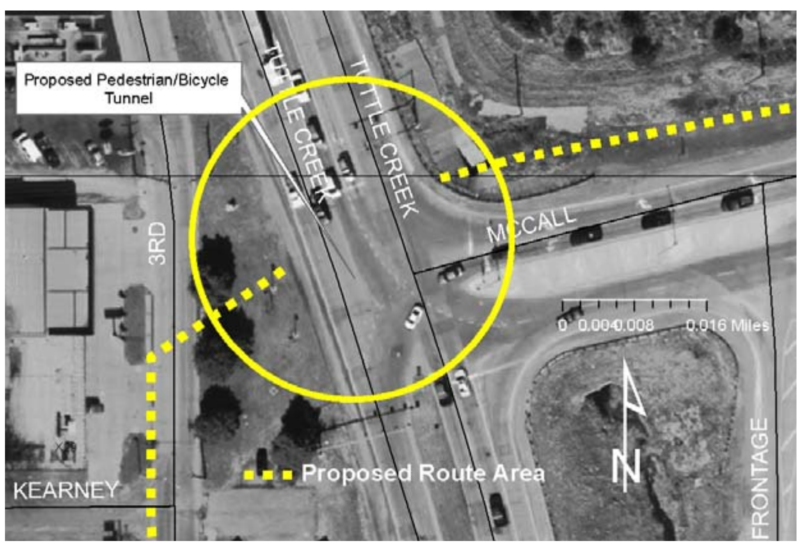
The Central Manhattan neighborhood cluster is comprised of primarily single-family residential neighborhoods, with more dense apartments, fraternity and sorority residential uses closer to the University campus. The terrain throughout the neighborhood cluster is steep and hilly, creating winding, short streets in the older neighborhoods. Some small segments of the road network in this neighborhood cluster still have the historic brick streets, which add to the ambience of the older neighborhoods. The winding, curvilinear street system creates a challenge in establishing a continuous bicycle network. Only one (1) street, Denison Avenue, was used as a north and south throughway for bicycle travel. College Height was determined to be an acceptable east and west route by the Network Analyst software because it is located near Lee Elementary School and Kansas State University campus. All other routes determined by the software are short segments to route bicyclists to the High School on Poyntz Avenue or to connect riders to the Southeast Manhattan neighborhood clusters. The Linear Trail is located on the western edge of the cluster. However because of Wildcat Creek and the steep hills near the creek; no access is immediately available for residents in the neighborhood cluster, with the exception of residents in the Red Bud Estates trailer court. The nearest trail head is located near Stagg Hill road to the south or the trail head on South Manhattan Avenue to the southeast of this cluster.

East Campus

The East Campus neighborhood cluster is adjacent to Kansas State University and bordered by Bluemont Avenue to the south, Kimball Avenue to the north and Tuttle Creek Boulevard to the east. The cluster follows a grid design that provides a high number of access points to the University campus and to the Southeast neighborhood cluster to the south. Tuttle Creek Boulevard has limited access to local residential streets because of its designation as state highway (U.S. Highway 24). The only way to access the East Manhattan neighborhood cluster across Tuttle Creek Boulevard is by intersections at Bluemont Avenue, Kimball Avenue and Marlatt Avenue further to the north. Below grade bicycle crossings have been proposed at the Marlatt intersection and near the McCall Road/Tuttle Creek Boulevard Intersection. The Marlatt Avenue bicycle crossing would improve access for residents in the East Manhattan cluster, but should not substantially impact residents in the East Campus cluster because of its distance away from the core residential areas of the cluster. The below grade crossing at McCall Road would provide residents in the East Campus neighborhood cluster safe access to the large commercial center along McCall Road, which includes a number of new restaurants, Wal-Mart and other retail businesses.

Figure 4.2 Marlatt Avenue and Tuttle Creek Boulevards

Figure 4.3 McCall Road and Tuttle Creek Boulevards



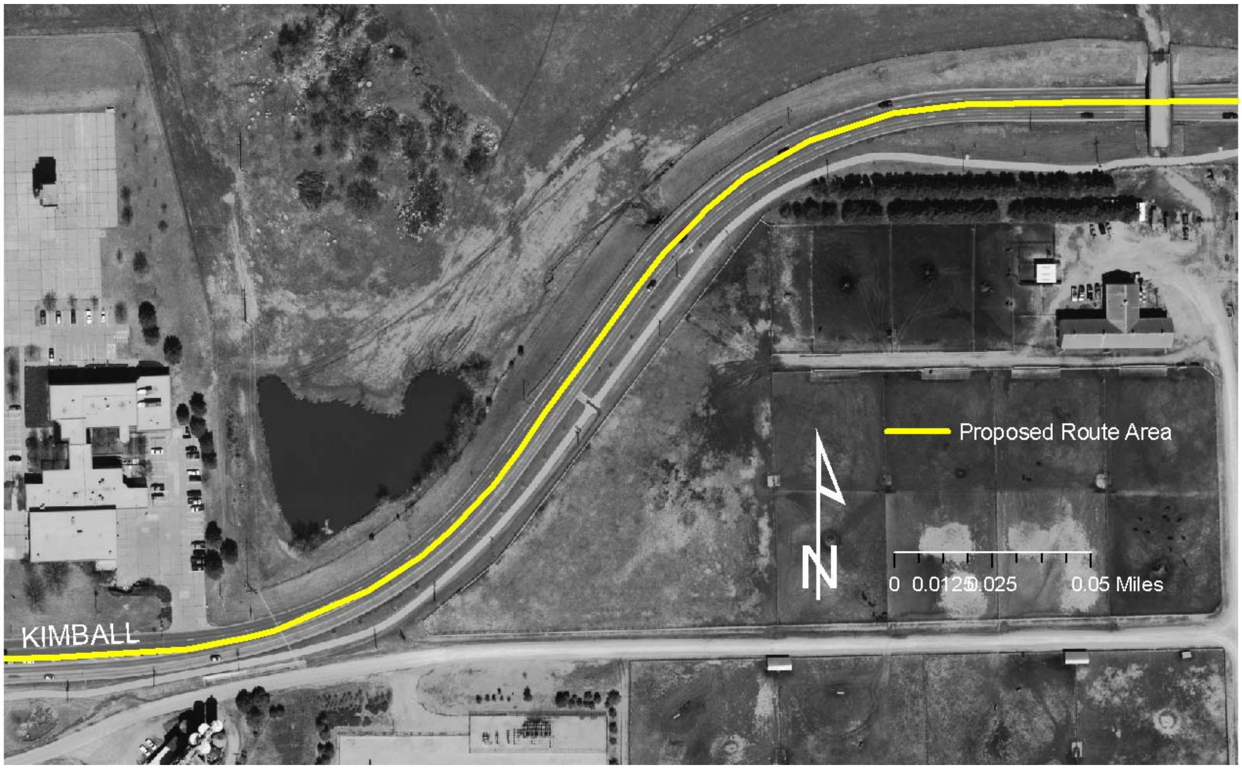
Attention should be given to improving the crossings at Kimball Avenue and Bluemont Avenue. At the present time, these intersections are very wide with no substantial bike lanes or pedestrian lanes. Improving these intersections would create a safer environment for bicyclists and pedestrians to reach the residential neighborhoods and major commercial center to the east of Tuttle Creek Boulevard.

Besides access to the east, the neighborhood cluster does not pose any major barriers to developing bicycle routes. The grid system, narrow local, residential streets and low to medium residential density are all beneficial characteristic for the development of bicycle facilities. The grid system provides a number of access points to adjacent developments, including the Aggieville Business District and the new Manhattan Market Place on 3rd and 4th Streets. The grid design also slows traffic because of the high number of intersections. The narrow local residential streets also decreases traffic speeds, however the narrower streets and parallel parking increase congestion and reduces the space available for bicyclists. The residential density and type of residents also plays an important part in the decision to develop bicycle facilities. The East Campus neighborhood cluster has a high number of college-aged residents living within it. As Michael Baltes has shown, a higher percentage of college age people, ages 17-29, increase the usage of bicycles on the roadway (Baltes, 1996). The 2000 U.S. Census showed that the census tract that matches the East Campus cluster was comprised of approximately 74% college age residents (17-29 years of age). The older neighborhoods create a more dense residential use, which gives a better return on investment when improving the bicycle environment.

Two drawbacks to the East Campus neighborhood are that the streets are congested with on-street parallel parking close to the campus and that a lot of trash, especially broken glass tends to be present on the streets. Parking should be limited to only one side of the street or ideally prohibited on proposed bicycle routes to allow for bicyclist and motorists to share the roadway. Also, routine cleaning and maintenance should be done on the proposed bicycle route streets for safety reasons, which is a large deterrent to commuting to school or work.

One area that is not necessarily in the East Campus neighborhood cluster, but rather is adjacent to it, is the section of Kimball Avenue from Manhattan Avenue to Denison Avenue. This road segment has a moderately steep grade and has a relatively sharp curve in the middle of the segment. With four lanes of traffic traveling at 45 miles per hour, the presence of a traditional bicycle lane would be extremely unsafe. When viewing this segment during the windshield survey, it was determined that a substantial improvement would need to be created to provide for safe bicycle travels. Chapter 5 will describe this improvement in more detail.

Figure 4.4 Kimball Avenue Roadway – Dangerous Section



East Manhattan

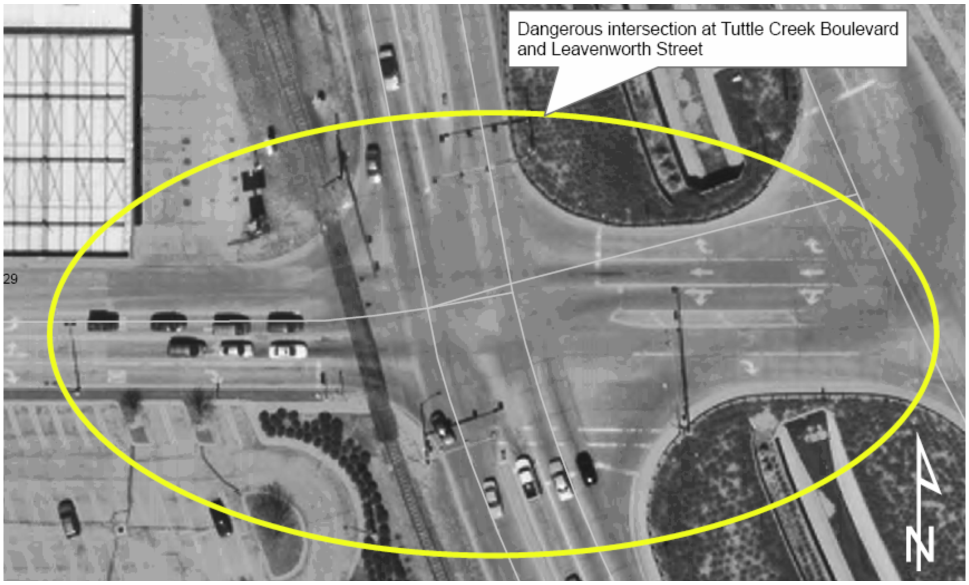
The East Manhattan neighborhood cluster has a mix of a number of older and newer residential developments on the east side of Tuttle Creek Boulevard. The cluster also includes the commercial developments along Tuttle Creek Boulevard and the industrial uses adjacent to McCall Road. Located in the cluster are a number of large neighborhood parks and Northview Elementary and Eisenhower Middle Schools.

Tuttle Creek Boulevard, Casement Road, Marlatt Avenue and the Linear Trail on top of the Blue River levees form the boundaries of the neighborhood cluster. As mentioned previously, the neighborhood cluster is split in half between low and medium residential neighborhoods in the north and commercial and industrial uses to the south. The flat terrain created by the Blue River Valley is ideal for easy bicycle riding. The residential areas is a mix of grid pattern developments in the older residential neighborhoods and curvilinear and cul-de-sac streets that form around the Marlatt Ditch drainage channel in the newer developments. The combination of different street and development designs created a unique challenge in connecting the two areas together. Fortunately, Casement Road provides an adequate north-south access throughout the neighborhood cluster.

In the commercial and industrial area, the large lots and developments require very few roads. The roads that are provided are heavily used by cars and heavy trucks. A large portion of the Linear Trail system is located on top of the Blue River levees, which is on the edge of the commercial and industrial areas. The Linear Trail provides a safer route around the heavy traffic in the commercial/industrial area when traveling south and west to adjacent neighborhood clusters, however it is not a direct route and the surface of the trail is mainly limestone screenings which is undesirable during or immediately after inclement weather. Because of the different traffic characteristics and land uses, a number of bicycle facilities have been proposed to create a safe bicycle environment.

As mentioned in the East Campus neighborhood cluster development, a number of below grade-separated bicycle crossing have been proposed. These routes will dramatically increase the access to the rest of the City for bicyclists. The proposed bicycle routes also attempts to connect the East Manhattan cluster with the Southeast Manhattan neighborhood cluster, which includes the Manhattan Town Center mall and the central business district along Poyntz Avenue. This is proposed at the Leavenworth Street/Tuttle Creek Boulevard intersection just north of the mall. The current intersection configuration is relatively large with three lanes going west and east bound (left turn/through lane, a through lane and a right turn lane). As Leavenworth Street intersects with the Frontage Street, a left lane and right lane is present. The intersection is confusing and is difficult to maneuver with a bicycle. A new intersection design should be proposed to create a safer environment for this important bicycle route connection.

Figure 4.5 Intersection of Tuttle Creek Boulevard and Leavenworth Street



Northwest

The Northwest neighborhood cluster is large in area with rolling hills. The cluster is bounded by Wildcat Creek to the south and Seth Childs Road to the east. Located in the cluster is the heavily traveled Anderson Avenue and Kimball Avenues. The street system within the neighborhood cluster is mostly curvilinear with short cul-de-sacs. However a number of straight north-south streets exist that provide for quality continual routes to all areas of the residential neighborhoods. The neighborhood cluster is comprised mostly of low density residential development, with commercial centers located on the eastern edge of the cluster along Kimball and Anderson Avenues. A new, small commercial node is being constructed near Colbert Hills along Kimball Avenue. A number of large regional parks are in the Northwest cluster, including Cico Park and Anneberg Parks. Hudson Trail is located in the northwest area of the cluster, which supplies a nice north-south route from Kimball Avenue to Bergman Elementary School off of Churchill Street. The northern portion of the Linear Trail is located at the south end of Wreath Avenue. The Linear Trail provides a safe and relatively direct route to the neighborhood commercial centers along Seth Child Road, which includes the Seth Child Theaters and Target.

Wreath and Hudson Avenues provide quality roads to travel north and south between Anderson and Avenue and Kimball Avenue. Dickinson Avenue is a good street to provide east and west travels through the middle of the cluster. However, all three of the streets have sections that are long and steep.

Figure 4.6 Slope on Dickens Avenue (Looking East)

Figure 4.7 Slope on Dickens Avenue (Looking West)

Figure 4.8 Slope of Hudson Avenue (Looking North)

The largest challenge in creating adequate bicycle routes in this neighborhood cluster is the major arterials – Kimball Avenue and Anderson Avenue. Both of the four-lane streets give direct routes to the east and west, but the speed and volume of traffic is restrictive for safe routes. Although the Bicycle Safety Index calculated these streets to being “Fairly Unsafe” with areas that were calculated to be “Very Unsafe”, these streets must be utilized as bicycle routes to provide a continuous bicycle network. This is evident along Anderson Avenue, where there is no other alternative but to use the street to provide bicycle access to the sports fields and the fishing lake at Anneberg Park.

Another challenge that the City must face is how to provide safe crossing from this neighborhood cluster to the neighborhood clusters to the east. A grade-separated bicycle/pedestrian tunnel is present near Gary Avenue to provide an easy and safe route under Seth Child Road to Susan B. Anthony Middle School. At the present time, no reasonable alternative is available, but to use at grade crossings at traffic lights at Claflin Avenue and use a bicycle lane along Kimball Avenue. The intersection of Dickens Avenue and Seth Child Road presents a very challenging problem. The intersection provides a direct route to Manhattan Area Technical College and Cico Park for residents in the West Campus cluster and access to the University and medical offices for people in the Northwest cluster. A traffic signal at the intersection would not be warranted because of its proximity to the Claflin Avenue intersection traffic signal. The potential exists to provide a wide and secure pedestrian/bicycle refuge island in the middle of the roadway so that people crossing the four-lane road would have a place to stop and wait for traffic instead of attempting to cross the entire width of the arterial in one action. However, the speed and volume that exists on this stretch of roadway are high enough to eliminate the route segment from the proposed network. If conditions along the intersections change in favor of installing a traffic signal or other intersection control devices, the bicycle route segment should be reconsidered.

Figure 4.9 Intersection of Dickens Avenue and Seth Child Road

Miller Ranch/University Heights

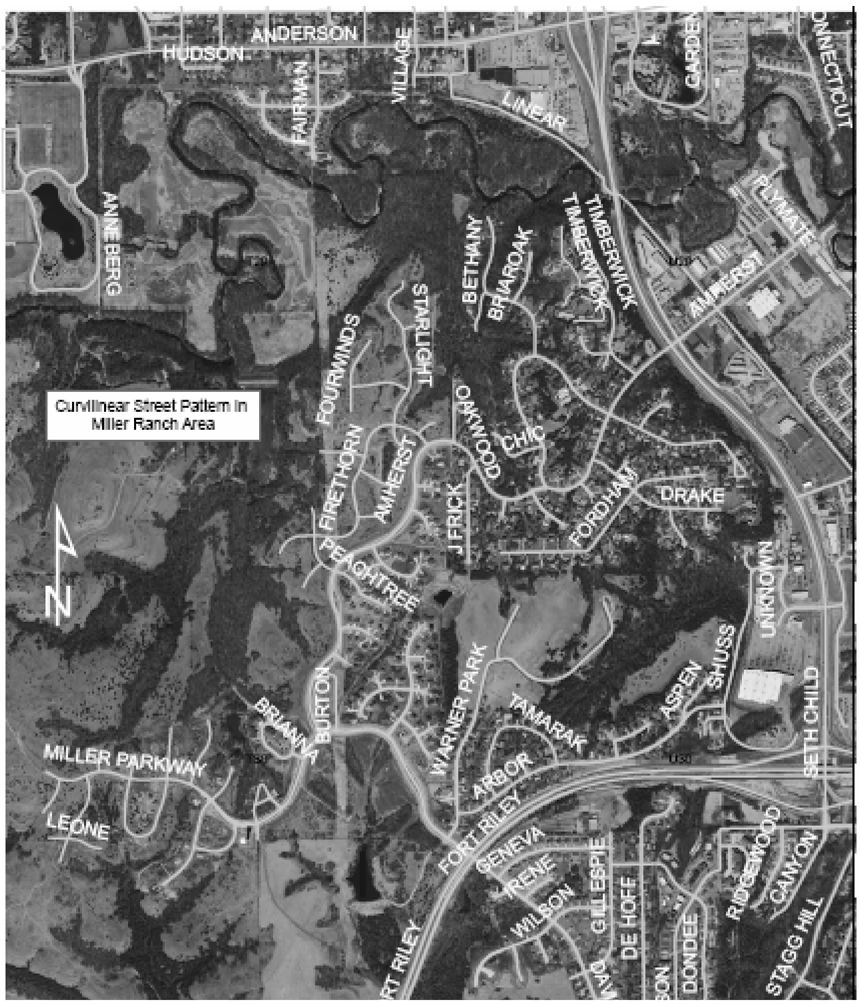
The Miller Ranch/University Heights neighborhood cluster is an isolated residential cluster on the west edge of the City. The cluster is separated from the rest of the City by Seth Childs Road, a four-lane arterial, and Fort Riley Boulevard, a four-lane arterial that transitions to a state highway to the west of the City limits. At the present time, only two streets provide access to the cluster from adjacent clusters – Amherst Avenue and Miller Parkway. The neighborhood has recently expanded to the west and north with the Lee Mill Heights and Barton Lake residential developments. If the open, raw land is converted to residential uses as projected, the neighborhoods will eventually connect to Scenic Drive further to the west via Miller Parkway and to Anderson Avenue via Wreath Avenue.

The largest challenges to developing bicycle routes throughout this neighborhood cluster are its isolation from other neighborhood clusters and the design of the street system. As stated earlier, limited access points currently exist to connect the cluster to adjacent neighborhood clusters. All of these access points require a bicyclist to cross a four-lane arterial. One of the access points, Seth Child Road and Seth Child Frontage Road (entrance to the Target commercial center), is a major intersection with multiple turning lanes onto Seth Child Road. This access point also dead ends into the Home Depot Commercial Center. The access point that provides connectivity to Woodland Hills is an intersection that is unsuitable for bicycles. The vehicle speed on the four-lane road at the Fort Riley Boulevard /Miller Parkway intersection is 45 miles per hour with heavy traffic volumes during the morning and afternoon peak hours. This intersection is proposed to be upgraded to provide a traffic signal at the intersection and ultimately a raised intersection for Davis Street and Miller Parkway. The interim traffic signal at the intersection should have an adequate green time to allow pedestrians and bicyclists to travel across the intersection. When the raised intersection is constructed, a separate bicycle path should be built for safe travel. The neighborhood cluster can gain access to the Linear Trail via Amherst Avenue on the east side of Seth Child Avenue, which would provide connectivity to other neighborhood clusters to the north and east. Special attention should be given to the timing of the Amherst Avenue/Seth Child Road traffic signal to allow a long enough green time for bicycles and pedestrians to cross the busy four-lane road.

Figure 4.10 Intersection of Amherst Avenue and Seth Child Road

Because of the area's terrain, many of the residential developments used the curvilinear streets and cul-de-sac design to match the contours of the land. This street network creates long, winding roads with several short cul-de-sacs intersecting the collector street. In the Miller Ranch/University Heights neighborhood cluster, Amherst Avenue is the only access to the east, but it does not provide a very direct route for motorists or bicyclists. The Miller Ranch subdivision and newer developments to the west have installed bike lanes to encourage bicycle usage. However, the bike lanes do not continue onto the University Heights neighborhood which limits connectivity.

Figure 4.11Development Pattern of the Miller Ranch Area



Low to medium residential uses is predominant in this neighborhood cluster. A large neighborhood commercial center is located on the east edge of the cluster, which includes Target and other retailers, including a number of restaurants and offices. However, the only way to access this commercial center from a majority of the residential uses is by traveling on Shuss Road, a two-lane gravel road. Warner Park, a large open space and pond is located in the cluster just east of Miller Parkway. Several small, neighborhood parks are proposed with new residential develops, but will be built primarily for the residents within the new developments. If and when Wreath Avenue is built to the north to connect to Anderson Avenue, the Miller Ranch/University Heights neighborhood cluster will have access to Anneberg Park. At the preset time, no public schools are located within this cluster; however, because of recent residential developments USD 383 has proposed to construct a new elementary school in the cluster.

Southeast Manhattan

Land uses in the Southeast Manhattan neighborhood clusters include low, medium and high density residential, the Central Business District, Aggieville Commercial District and office/business uses; making this cluster the most diverse in the entire city. The medium and high density residential areas congregate around Aggieville and the University south of Anderson Avenue, while the low density residential areas are situated further south and east in the cluster. Southeast Manhattan also has several schools, including Theodore Roosevelt Elementary School, East High School – 9^{th} Grade Center, Seven Dolar Catholic School and Woodrow Wilson Elementary School. Also located in the neighborhood cluster are City Park, Griffith Park, Longs Park and The Douglas Recreation Center. On the east edge of the cluster is the downtown redevelopment centers and the Town Center Mall. To the north of the mall, the redevelopment area will consist of medium and large box retailers and restaurants. Located in the redevelopment area south of the mall will be a movie theater, a conference center, a regional museum, small shops and restaurants. Because of the mix of residential, business commercial, retail, schools and recreations and the relatively flat terrain, the Southeast Manhattan neighborhood cluster will be ideal for bicycle travel.

The streets and neighborhoods were designed with a traditional grid system. As previously discussed, the grid system reduces and slows traffic, which is ideal for bicyclists. However, the roadways can become congested with parallel parked cars near the campus and

Aggieville, similar in nature to the East Campus cluster. The City should consider limiting parking to only one side of the street for roadways that are to be designated as bicycle routes or will receive upgraded bicycle facilities. Portions of Juliette Avenue are surfaced with pavers. These are historic in nature and add character to the area. The Bicycle Master Plan Update is not recommending the removal of these pavers, but rather suggesting that any broken, missing pavers or sections that are in disrepair in areas that bicyclists will be riding (areas closest to the curb) should be corrected as soon as possible.

There are similar concerns to the East Campus cluster over broken glass and trash along bicycle routes, which discourages and even creates dangerous riding conditions. To mitigate this issue, the City should routinely clean the streets along the bicycle routes to create a safer riding condition and improve the overall appearance of these neighborhoods. Other than the already mentioned concerns with the higher density neighborhoods and parking along the local, residential streets, no major obstacles or issues were discovered when conducting the windshield survey that would limit or discourage bicycle riders.

West Campus

Bounded by Claflin Road to the south, Seth Child Road to the east and Kansas State University to the west; the West Campus neighborhood cluster is a mix of low and medium density residential, commercial and medical uses. The density of residential uses increases as you move closer to the University campus because of the presence of college age residents. According to the 2000 U.S. Census (American FactFinder, 2000), the entire neighborhood cluster had 53% of its residents in the college age range of 18 to 29. A bulk of the 5,899 college residents live in the census tract closest to the University. Because of the residential make-up of the cluster, constructing adequate bicycle facilities are important to provide for the needs of the cluster's residents.

The residential developments in the cluster were created using curvilinear streets and very few cul-de-sacs. The curved street design does not allow for very direct routes to the major designations in the cluster or connecting to adjacent neighborhoods using local, residential streets. The most direct streets in a north-south or east-west direction are all heavily traveled streets with high speeds and traffic volumes. Both Kimball Avenue and Claflin Road are four-lane streets. College Avenue is a busy throughway because of the Manhattan Regional Hospital and large apartment complexes; Denison Avenue is an extremely congested north-south street because it runs adjacent to the University. All of these streets had sections that were calculated to "Very Unsafe" because of the terrain, traffic speed and/or traffic volume. Although the existing conditions are less than desirable for bicycle travel, these streets provide directness to major destinations, such as the University campus, recreation spaces and commercial centers in adjacent neighborhood clusters. The City should place emphasis on improving these roadways to improve the bicycling environment in the cluster as well as for the entire network.

Woodland Hills

The Woodland Hills cluster is one of the more isolated clusters in the study area. To the north and west of the cluster is Fort Riley Boulevard, a four lane arterial that eventually changes to a state highway. Also to the north of the Woodland Hills cluster is Seth Child Road, a four lane arterial that terminates at the edge of the cluster. No local, residential street connects to adjacent neighborhood clusters without crossing a major four-lane road.

The topography of the cluster also proposed several challenges. The northeast edge of the Woodland Hills quickly rises out of the floodplain to steep slopes over eight (8%) percent. The three main roads, Stagg Hill Road, Davis Drive and Allison Avenue, provide relatively good access to the entire neighborhood cluster with good surfaces and low traffic volumes. However, each of these streets has extreme slopes (See figures 4.12 – 4.14)

Located within the cluster is mostly low to medium residential uses. Located near Fort Riley Boulevard along Staff Hill Road are limited commercial uses, which include a new and used car lot, a restaurant and tavern and industrial and warehouse buildings. The Stagg Hill neighborhood park is located in the cluster and is easily accessible by foot or bicycle for most of the cluster's residents. The Woodland Hills cluster does have direct access to the Linear Trail which travels to the north and east. This access to the established trail does provide a safe route for bicyclists and pedestrians to other areas of the City, although it is generally not the most direct route.

Figure 4.12 Slope of Davis Drive

Figure 4.13 Slope of Allison Avenue

Figure 4.14 Slope of Stagg Hill Road

CHAPTER 5 - Recommended Plan and Implementation Strategies

The vision and goals created by the 1998 Manhattan Bicycle Master Plan are still relevant and applicable to the 2008 Master Plan Update. The Vision is “To create an environment where it is safe, convenient and fun to bicycle for personal transportation and recreation within Manhattan, Kansas” (The City of Manhattan, 1998). The 1998 Vision has continued to guide the 2008 Bicycle Master Plan Update for the City of Manhattan.

The Master Plan listed six major goals to support and improve the bicycling environment in Manhattan. The 1998 Bicycle Master Plan goals are- 1. Send the Message that Bikes Belong; 2. Shift Mode Use for Daily Trips; 3. Improve Access; 4. Improve Safety; 5. Enhance Recreational Opportunities; and 6. Maximize Funding Opportunities. Because the 1998 Bicycle Master Plan was never fully embraced by the City and executed, these general goals are still usable today. It should be noted that although the research conducted for the Update only focused on factors that affected bicycle commuters, the needs for recreational bicyclist should not be ignored. However, the needs of this cycling group has been addressed by other master plans developed by the City’s Park and Recreation Department and are outside of the scope of this plan.

General Recommendations

Using the Vision and six goals detailed in the 1998 Bicycle Master Plan as guidance, specific recommendations have been made for the 2008 Manhattan Bicycle Master Plan Update. The first section of recommendations is general in nature and is created to encourage Manhattan residents to use bicycles as a mode of transportation. These recommendations would be provided regardless of where or what type of bicycle routes are proposed.

Bicycle Coordinator

The first, and arguably the most important, recommendation is the establishment and maintenance of a bicycle coordinator position. The intent of this position is to help create an environment in the City of Manhattan that will accommodate and promote bicycling as a mode of transportation. The person in this position will coordinate with other departments in the City and with organizations throughout the community that will impact bicycle activities. The Bicycle Coordinator is a generalist position that will work with departments that deal with transportation, transportation facility design, comprehensive planning for the City, policy development, accident analysis, promotion and legislative matters. Ideally, the coordinator would be an avid bicyclist, but not necessarily an expert cyclist, that can relate with all types of bicycle riders. The role of the Bicycle Coordinator would be to plan for and promote the use of a bicycle for recreation and personal transportation. The Bicycle Coordinator position would be responsible for:

- Administering the Bicycle Plan;
- Establishing a Bicycle Advocacy Group to promote and encourage bicycling;
- Coordinating and integrating bicycle planning, roadway and trail designs with other programs and services;
- Providing advice and briefings to policy makers;
- Creating a bicycle route maintenance and spot safety program;
- Creating and providing educational programs on cycling safety;
- Collecting and analyzing bicycle data on a regular basis; and
- Pursuing funding for bicycle improvement projects and programs from a variety of government and private sources.

Encourage, Promote and Inform

The Bicycle Coordinator along with the Bicycle Advocacy Group will work to promote, educate and inform the benefits of safely bicycling to work, to run errands and for recreation. The promotional activities should emphasis three points – improve health, improve the environment and decrease the dependency on the personal automobile. Focusing on John Pucher and his colleagues' research that an estimated 48% of trips for all modes of transportation in America are shorter than 3 miles (Pucher, et. al, 1999), a marketing campaign can be created to illustrate the reasons to use a bicycle as a mode of transportation. Three miles is an easy and ideal distance to bicycle to work or to run simple errands. Riding 3 miles to and from work would also be close to meeting the recommended daily amount of physical activity –30 minutes - for the round trip. By taking the three mile round trip by a bicycle, the rider can reap the health benefits of meeting the surgeon general's recommendation.

Along with a marketing effort to encourage bicycling, an informational campaign should be developed to promote safe bicycling. A helmet usage campaign should be created to encourage safe bicycle riding. By cooperating with the police department, insurance companies and/or the local hospital, a successful campaign can be created to reward those who wear a bicycle helmet while riding and give away bicycle helmets to those who do not own one. Other educational and promotional activities that should be initiated by the Bicycle Coordinator are a "Share the Road" informational campaign and a "Bike Manhattan" user guide, which would include State and City traffic and bicycle laws, safety tips and the bicycle route map.

Finally, efforts should be encouraged by the City to organize mass rides to encourage bicycling. Mass rides typically pick one day a month (i.e., first Mondays or second Tuesdays) to encourage residents to ride to work or to gather and ride a designated route around the City. The City does not need to manage or coordinate these mass rides, but the City should offer encouragement and assistance to the ride organizers.

Bicycle Way finder Signs

The 1998 Manhattan Bicycle Master Plan suggested that a design and logo be created and integrated into the bicycle promotional materials and bicycle route signage. The suggestion for the design and logo should be carried out with the 2008 Master Plan Update. The design should be unique to the City of Manhattan. An obvious design would be the "Little Apple" design that the City of Manhattan has adopted. At a minimum, this logo should be incorporated in the route identification signs along each bicycle path, route and lane. Directional signage should also be used to provide information about the direction and distance to major destinations, such as Aggieville, Cico Park or the Central Business District (see Figure 5.1 for an example of the logo and directional design). It should be noted that each sign should meet the Traffic Controls for Bicycle Facilities standards created by the Manual on Uniform Traffic Control Devices (MUTCD, 2004).

Figure5.1 An Example of Bicycle Signage

Source: MUTCD, Chapter 9, 2003

Capital Improvement Project Evaluation

In order to gain public and political acceptance, bicycle facilities need to be viewed as a needed infrastructure element, just as roads, sidewalks, water and sewer systems are viewed. To achieve this acceptance, a quantitative and qualitative evaluation model should be developed to show the need, increased usage and safety that would accompany a bicycle facility expansion project.

Two such models have been created using differing approaches and factors to evaluate and rank future bicycle facility projects. The first, created by Lauren Bernheim, used U.S. Census data and GIS software to determine the bikability or "a measure of the potential of bicycle usage in a particular area if the proper infrastructure were in place" (Bernheim, 2005). Bernheim's bikability model was created for the City of San Jose, California and used six weighted factors that included proximity to a university, population density, employment density, job housing balance, auto access and proximity to the transit system. Using GIS software, proposed projects can be measured and prioritized based on its potential to increase ridership and create a transportation mode shift. The final product for the City of San Jose combined the bikability measurement with a difficulty rating, which rated the potential cost for each proposed route. The end result was a map of the City that allowed planners and City

Commissioners to easily see the routes that would be the most beneficial to bicyclists (Bernheim, 2005).

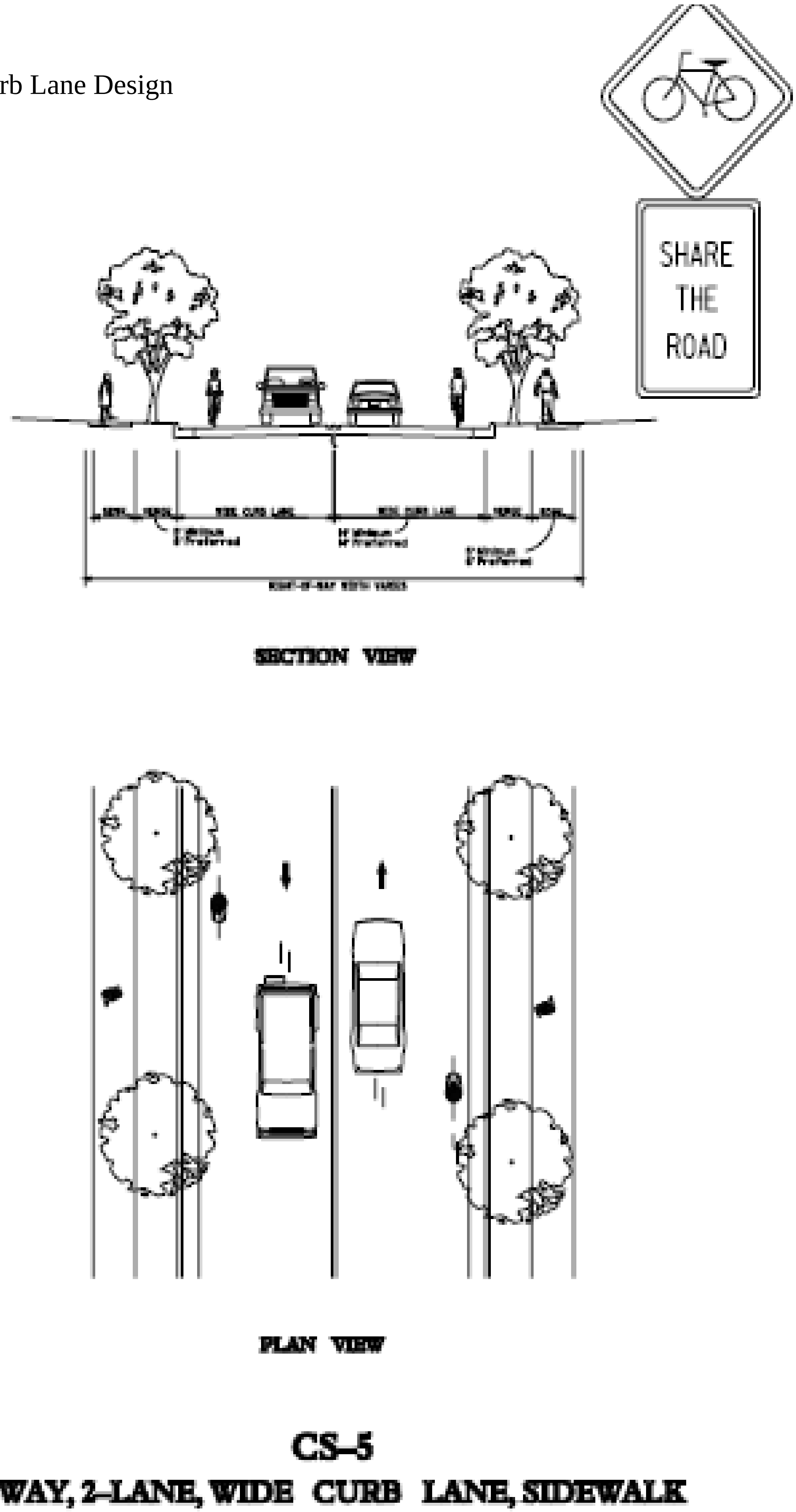
The second evaluation model was created for the main roads of Western Australia. Rob McInereny's model combined bicycle crash data, a cost to benefit ratio and qualitative measurements to prioritize proposed bicycle projects (McInerney, 1998). Data from reported bicycles crashes and bicycle/vehicle crashes were analyzed from the previous ten years. Specifically, the crash data was reviewed for relationships between the traffic speed, traffic volume, location of the accident and the severity of the injury. This crash data was then combined with a cost to benefit ratio that calculated the benefits of a proposed bicycle route (i.e. increased ridership and crash reduction) to the cost of the proposed route. Finally, an expert panel evaluated the proposed routes for their perceived level of service, continuity, attractiveness and comfort. By combining these three analyses, each route was prioritized based on the comprehensive evaluation. Either of these models, or a combination of the two, should be incorporated into the planning for future bicycle facility expansions.

Bicycle Facility Design Standards and Guidelines

It is recommended that the City of Manhattan adopt standards for bicycle facility design in order to address the minimum design and signage for new bicycle facilities. Three Federal documents that would be appropriate to adopt are: Federal Highway Association *Selecting Roadway Treatments to Accommodate Bicycles* as the criteria to select appropriate bicycle facilities and AASHTO's *Guide for the Development of Bicycle Facilities* as the criteria for geometric designs for all new roadways to accommodate bicycle riders. The City should also insure that Chapter 9 of the Manual on Uniform Traffic Control Devices – *Traffic Control for Bicycle Facilities* is the design standard for signage of new bicycle facilities. Using these design guidelines, it would be beneficial for the City to focus attention on three different types of bicycle facilities – shared roadways, bike lanes and bike paths – to improve the bicycle riding environment in Manhattan.

Shared roadways consist of having a wide curb lane that allows the bicyclist and motorist to travel in the lane. The wide curb lane can be defined as the right-most traffic lane that is wider than 12 feet. This is measured from the center line strip or center of the roadway to the gutter pan, not the face of the curb. Fourteen (14) feet is the minimum width of a curb lane to accommodate both a vehicle and bicycle. As traffic speed, traffic volume, percentage of heavy vehicle increases or unique roadway characteristics are present, the curb lane width must increase in size as well. Many practitioners feel that sixteen feet is the maximum width for the curb lane. If the curb lane is wider than 16 feet, drivers are given the opportunity to use the space reserved for bicycles as an illegal passing lane or turning lane, which dramatically increase the chance for bicycle/vehicle conflict. For a majority of the proposed bicycle routes in the Manhattan Bicycle Master Plan Update, the wide curb lane will be utilized in combination with adequate signage to accommodate bicyclists.

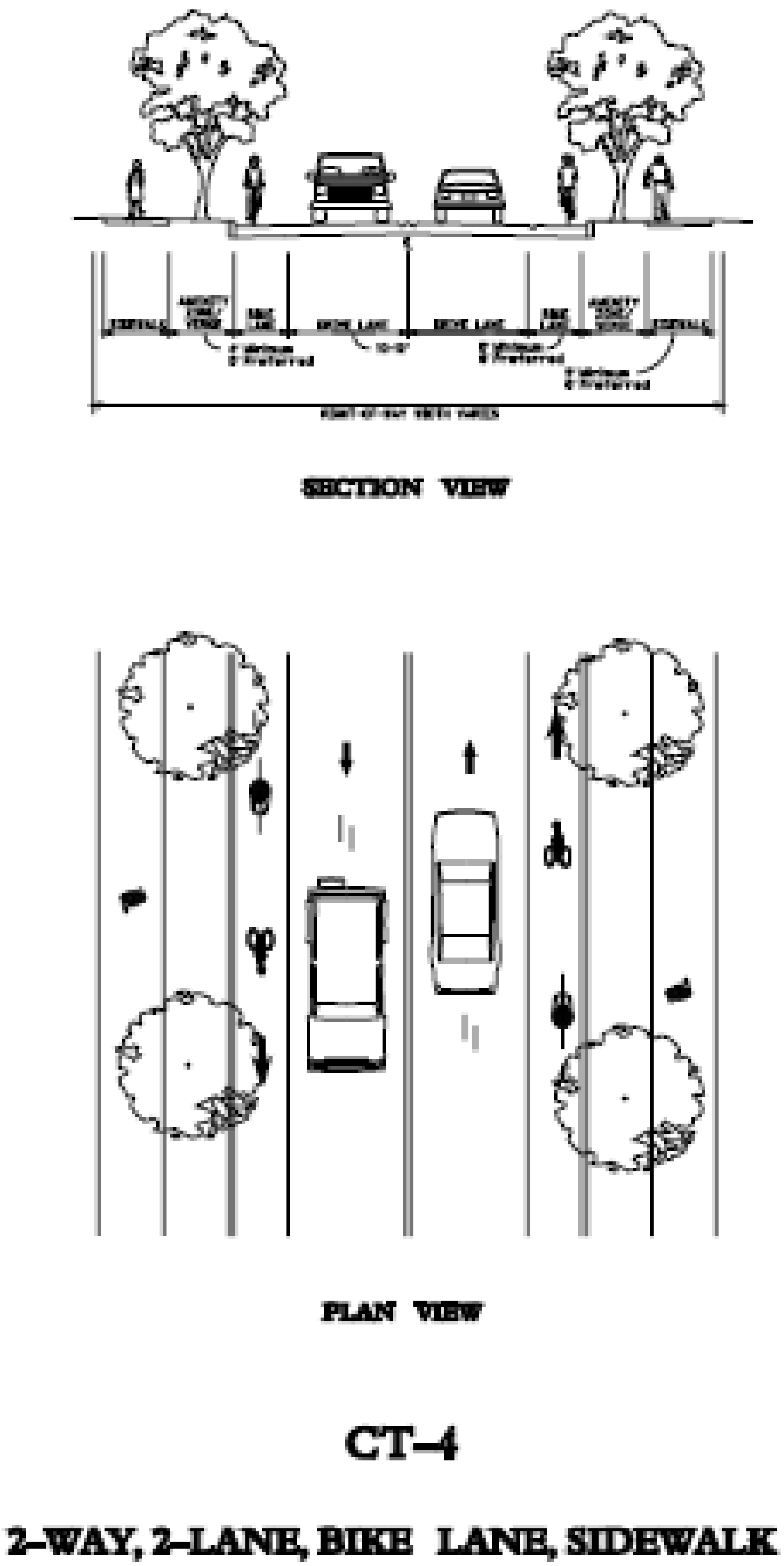
Figure 5.2 Wide Curb Lane Design



Source: Louisville Compete Streets Manual, Louisville, Kentucky, 2007

When traffic volume and traffic speeds are high or unique roadway characteristics are present, a bicycle lane is recommended to allow bicycle riders safe travels along the roadway. AASHTO's *Guide for the Development of Bicycle Facilities* defines a bicycle lane as "A portion of the roadway which has been designated by striping, signing and pavement markings for the preferential treatment or exclusive use of bicyclists." Bicycle lanes should always be one-way facilities carrying bicycle traffic in the same direction as the vehicle traffic. The minimum width for a bicycle lane is five (5) feet, measured from the face of the curb, with at least four (4) of the lane outside of the gutter pan. Certain conditions exist adjacent to the Kansas State University campus that would necessitate constructing a bike lane in the road right-of-way. A bike lane already is present on Manhattan Avenue, east of the University campus. Sections of Amherst Avenue and Miller Parkway in the southwest part of the City also have bike lanes.

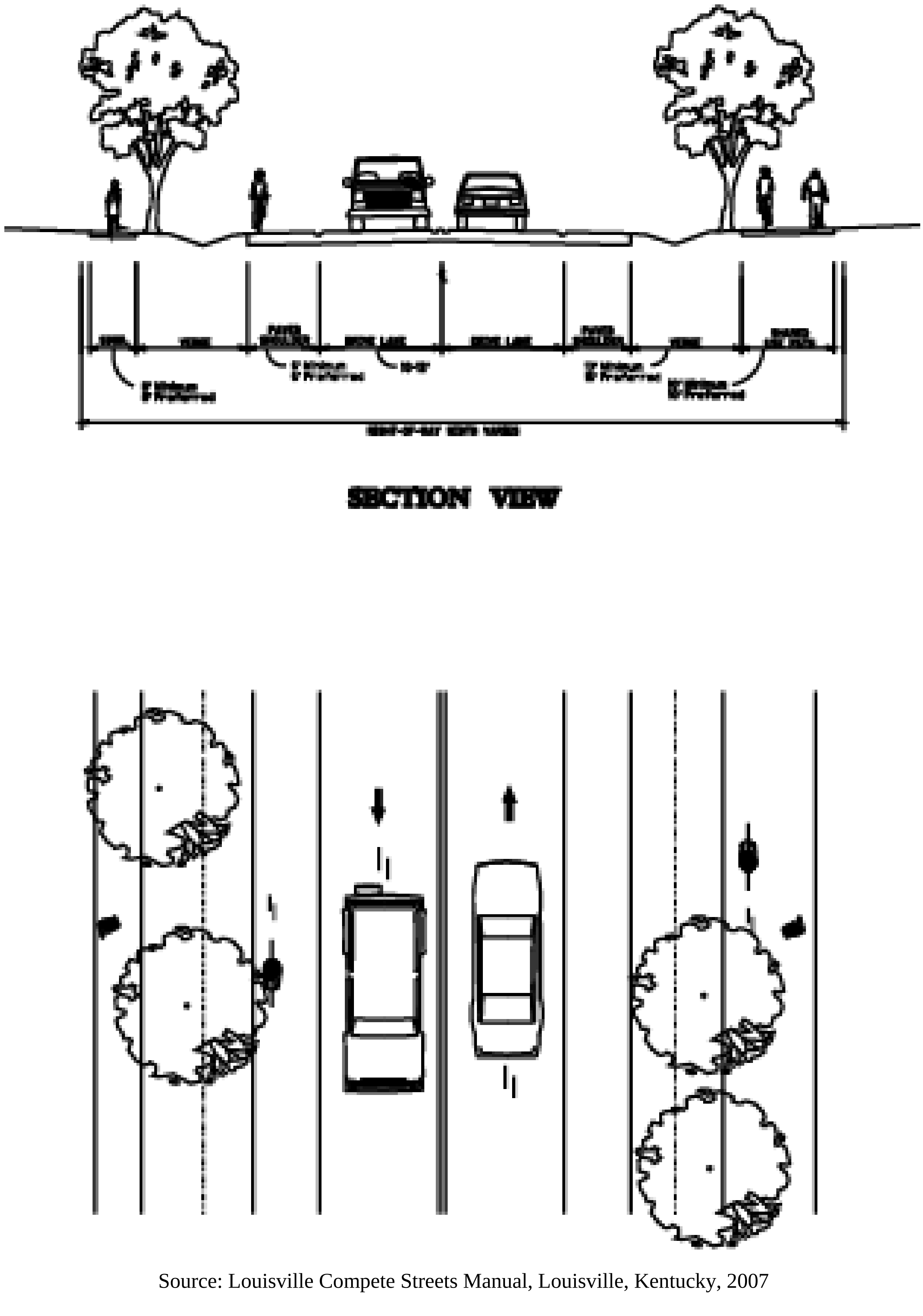
Figure 5.3 Bicycle Lane



Source: Louisville Compete Streets Manual, Louisville, Kentucky, 2007

Bicycle paths are constructed when the traffic volume and road geometry does not allow for a bike lane to be provided. Bike paths are built separate from traffic, typically adjacent to the roadway and allow for two-way bicycle traffic. Bike paths should be at least ten (10) feet wide. In situations were bicycle and pedestrian traffic is expected to be high or bicycle groups A and B/C will be intermingled, a path with a minimum width of twelve (12) feet should be provided to improve safety. AASHTO recommends that separate bicycle paths be constructed for more recreational uses that provide for slower speeds and more scenic views than paths dedicated for bicycle transportation. The City should avoid using crushed limestone or gravel as the bicycle path surface. Although considerably cheaper to install, the limestone or gravel surface is not an "all weather" surface and must be constantly maintained to provide a quality riding surface. The ideal surface is concrete or asphalt, with particular attention being given to the width and number of expansion gaps in the concrete surface. For riders of road bikes, a high number of large expansion gaps on a concrete path are annoying at best and painful in extreme cases. Sections of Anderson Avenue and Kimball Avenue are good candidates for Bike Paths due to their high traffic volume, vehicle speeds and roadway geometry, especially along Kimball Avenue, west of Manhattan Avenue.

Figure 5.4 Bicycle Path Design



Source: Louisville Compete Streets Manual, Louisville, Kentucky, 2007

At large, high volume intersections that use traffic signals or signalized intersections that have unique road geometry, a bicycle box is an ideal facility to increase the safety of bicyclists in the intersection. A bicycle box is an area designated for bicycles ahead of vehicles at a traffic signal. Using signage and pavement markings, vehicles must stop behind a stop line, which is where the bicycle box begins. Bicyclists are able to safely pass on the right of vehicles to overtake them and stage in the bike box during the red light (See Figure 5.5). A special green light designated for bicycles is activated in advance of the normal green light, which allows bicyclists to safely exit the intersection by either going straight or to make a left turn. The traffic signal should be upgraded to detect the presence of bicyclists in the bike box and a special green light should be installed that can easily depict when bicyclists and vehicles are allowed to travel through the intersection. The approximate cost to mark the pavement, install proper signage and upgrade the traffic signals is $4,000. It would be prudent for the City to also consider creating an information campaign to inform bicyclists and drivers of the functions and traffic laws associated with the bike boxes. The campaign should include newspaper press releases and ads, flyers, radio public service ads and possibly billboard signs to provide a wide coverage of the new intersection features.

Figure 5.5 Illustration of a Bicycle Box

Source: *"Get Behind It, The Bike Box"* brochure, City of Portland Oregon

Zoning and Subdivision Regulation Updates

Because Manhattan's terrain, development patterns and subdivision designs vary across the City, creating "one-size fits all" subdivision regulations that would meet the needs of bicyclist would be nearly impossible. A better alternative would be to educate developers about the importance of making new developments healthier, reduce traffic congestion and improve the environment by building pedestrian and bicycle friendly subdivisions. These designs include; sidewalks on both side of the streets, streets that are wide enough to accommodated both bicycles and vehicles, and construct pedestrian and bicycle paths where appropriate. Likewise, City Administration may want to take a more proactive approach to ensure the current developments have adequate bicycle facilities for the near and long-term. The 1998 Bicycle Master Plan provided sound recommendations to accommodate bicyclist's needs in new developments. They included:

- Encourage mix-use developments.
- Encourage smaller lot sizes and higher densities. *Cluster residential lots in areas of the City with steep hills will create a higher density and allow for less costly infrastructure and shorter streets, which is advantageous for bicyclists*
- Limit the use of residential cul-de-sacs or require the pedestrian/bicycle paths be installed at the end of cul-de-sacs that are in proximity to other streets or cul-de-sac to provide adequate pedestrian and bicycle connectivity.
- Commercial developments should consider providing access to bicycle routes and provide adequate parking.

If these four points can be incorporated into every new residential, mixed-use and commercial development, the City of Manhattan will grow into a bicycle friendly community that increases bicycle usage for transportation, improve bicycle safety and increase the quality of life for its residents by having a healthier, cleaner community.

Bicycle Parking Requirements

Creating miles of bicycle routes, lanes and paths will allow bicycle riders to travel from place to place easily. But, if bicycle riders do not have accessible, secure bicycle parking facilities available, the effectiveness of the bicycle network is wasted. The City of Manhattan should adopt uniform bicycle parking regulations as part of their off-street parking regulations in the Zoning Ordinance.

The following is an example of bicycle parking requirements taken from the City of Cambridge, Massachusetts (The City of Cambridge, 2007). This sample regulation is modified as an example for the City of Manhattan. The City's Administration, including staff members from the City Manager's Office, Community Development, Fire, Police, and Public Works Departments as well as the Bicycle Coordinator and the Bicycle Advocacy Committee should ultimately create a Bicycle Parking Ordinance that meets the needs of motorists, bicyclists, developers and business owners.

7-103 (E) Bicycle Parking. Off-street parking of bicycles shall be provided as follows:

(1) For multi-family residences there shall be one bicycle space or locker for each two dwelling units or portion thereof.

(2) For all other uses, , there shall be one bicycle parking space for each fifteen (15) automobile parking spaces or fraction thereof required in Section 7-103 (A) – (D), with a minimum of 4 and a maximum of 50 spaces. No bicycle parking is required where fewer than 15 automobile parking spaces are required.

(3) It is recommended that half shall be provided as long term parking, safe and secure from vandalism and theft, and protected from the elements. The other half shall be provided as short term (customer or visitor) parking, and it is recommended that the spaces be visible and convenient to building entrances.

(4) Uses allowed to have reduced parking by decision of the Board of Zoning Appeals shall nevertheless be required to provide bicycle spaces in the amount of one for each fifteen (15) automobile spaces or fraction thereof that would otherwise be required for such use in subsection 7-103 (A) – (D).

(5) No accessory bicycle parking shall be required to serve the following uses as listed in the Section 7-103. Required Parking Spaces: [Townhouse or elderly oriented housing, cemeteries, mortuaries, veterinary establishments, kennels, pet shops, distribution centers, auto body or paint shops, and automotive repair garages.]

7-103 (F) Design of Bicycle Parking Spaces. Bicycle parking spaces shall be provided in accordance with the amounts required by Section 7-103 and with the design regulations in this section 7-103 (F).

(1) Each bicycle parking space shall be sufficient to accommodate a bicycle at least six (6) feet in length and two (2) feet wide, and shall be provided with some form of stable frame permanently anchored to a foundation to which a bicycle frame and both wheels may be conveniently secured using a chain and padlock, locker, or other storage facilities which are convenient for storage and are reasonably secure from theft and vandalism. The separation of the bicycle parking spaces and the amount of corridor space shall be adequate for convenient access to every space when the parking facility is full.

(2) When automobile parking spaces are provided in a structure, all required bicycle spaces shall be located inside that structure or shall be located in other areas protected from the weather. Bicycle parking spaces in parking structures shall be clearly marked as such and shall be separated from auto parking by some form of barrier to minimize the possibility of a parked bicycle being hit by a car.

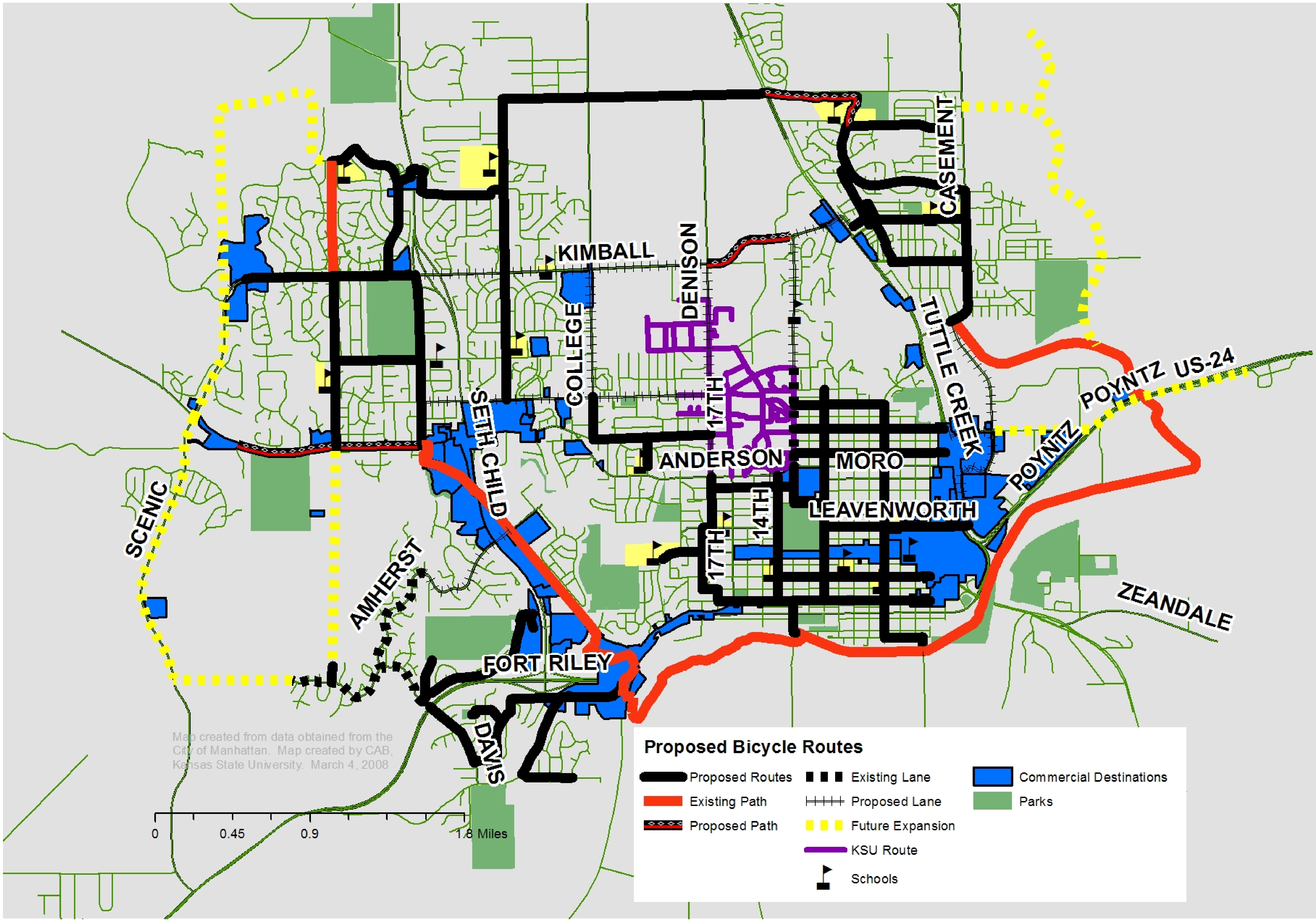
(3) Bicycle parking spaces shall be located near the entrance of use being served and within view of pedestrian traffic if possible, and shall be sufficiently secure to reasonably reduce the likelihood of bicycle theft. Any property owner required to have bicycle parking may elect to establish a shared bicycle parking facility with any other property owner within the same block to meet the combined requirements.

(4) The following uses are exempt from these requirements: Funeral parlor, undertaker, automobile repair or body shop, gas station, and car wash.

(5) These requirements may be varied by the Board of Appeals by Exception, based upon a determination that the proposed bicycle parking facilities will adequately address the purposes of this section.

Proposed Bicycle Routes

The research conducted for the 2008 Bicycle Master Plan Update has proposed a number of designated bicycle routes, using wide curb lanes, bicycle lanes were appropriate and separate bicycle paths were needed. Figure 5.1 is a map of the entire bicycle transportation network. The proposed network uses a variety of facilities to create a continuous network to allow residents to bicycle to work, school or to travel to shop, socialize or for appointments. The proposed routes are thus directed to major employment and commercial centers as well as through out each residential area.



Map 5.1: Manhattan Bicycle Master Plan Update
Proposed Bicycle Facilities

To make certain that each route met the objective of creating routes that let bicyclists go quickly and easily to the important designations throughout the City, a local view was created through neighborhood clusters, or groups of residential neighborhoods that share common traits and are separated from other neighborhoods by major streets or geographic features.

Central Manhattan

Two and one-half (2.5) miles of bicycle routes are proposed for the Central Manhattan neighborhood cluster. These routes follow College Avenue, Denison Avenue, College Heights Road, and Delaware Avenue to route bicycle riders to all school buildings in the cluster and within an average of 900 feet from the major parks, including Sunset Zoo. These bicycle routes will use the existing curb lanes. Each route segment should be properly marked with bicycle route and "share the road" signage.

A portion of Denison Avenue from Anderson Avenue north to Claflin Road is proposed to be built to include a bicycle lane with a width of five (5) feet. Proper pavement markings and signage should be installed with the bicycle lane to alert drivers that bicycles are present on the roadway in separate bike lanes. The length of the proposed bike lane on Denison is approximately .25 miles. Installing a bike box at Anderson Avenue and Denison as well as at the intersection of Denison Avenue and Claflin Avenue would provide a safe intersection environment for these students and other residents traveling to campus on a bicycle.

East Campus

An existing bicycle lane is located along Manhattan Avenue from Bluemont Avenue north to Pioneer Lane. The Bicycle Plan Update proposes that this bike lane be extended all the way to Kimball Avenue. The Bicycle Lane should be five (5) feet wide and is proposed to be approximately 1 mile in length. A bicycle lane is also envisioned along Kimball Avenue east to Tuttle Creek Boulevard. This bicycle lane will provide an important link for residents from the East Manhattan neighborhood cluster to the Kansas State Campus. The Kimball Avenue bicycle lane should be five (5) feet wide and will be approximately 1,500 feet long. These bicycle lanes should be properly marked with signs and pavement strips to alert drivers of the presence of bicyclists.

West of the intersection of Manhattan Avenue and Kimball Avenue, there is a stretch of road that proposes unique challenges for bicyclists. The area in particular (See Figure 5.7) is on a steep hill with a sharp “S” curve located in the middle of the incline. As a motorist, the road segment seems very narrow because of the relatively high speeds and curves. Placing a bicycle lane in this road segment would be highly inappropriate. The proposal for this tricky section of Kimball Avenue is to construct bicycle paths on both sides of the roadway. The paths will be one-way and follow the natural flow of traffic and would allow for a transition from the proposed bicycle lanes east and west of this road segment. For west bound bicycle traffic at the Kimball Avenue/Manhattan Avenue intersection, a wide ramp and bollards would be installed on the north side of the roadway, so bicyclist can enter the path from the south and east. This northern path would use an existing sidewalk where present and construct a six (6) feet wide path where the sidewalk is not available. At the end of the road segment in question, the path would then transition back to a bicycle lane at the corner of Kimball Avenue and Denison Avenue.   A similar design is proposed for east bound bicycle traffic at the corner of Kimball Avenue and Denison Avenue as well as the Kimball Avenue and Manhattan Avenue intersection. The southern path will widen the existing sidewalk by two (2) feet to improve pedestrian and bicycle safety.

Figure 5.7 Kimball Avenue between N. Manhattan Ave and N. Denison Ave.

It would be appropriate to install bicycle boxes and delayed traffic signals at the busy intersections at Manhattan Avenue/Bluemont Avenue, Manhattan Avenue/Kimball Avenue and

Kimball Avenue/Tuttle Creek Boulevard. The bike box will give bicyclists priority at the intersections and allow them to travel through or to make a left hand turn safer by eliminating conflicts with vehicles in the intersection.

The remainder of the proposed bicycle facilities in the East Campus cluster is bicycle routes that “share the road” on existing streets. The proposed bicycle routes use 11th Street and Juliette Avenue to travel north-south and Ratone Street, Thurston Street and Vattier Street to travel east-west. These routes are to be properly signed to tell motorists to “share the road.” On-street parking and the narrow local, residential streets create a slower traffic environment, which is ideal for commuting bicyclists. However, parking on both sides of the street effectively reduces the travel lane to one way, causing on-coming traffic to pull over and reducing the space available for bicyclists. The Bicycle Plan Update proposes that the local, residential street dedicated as bicycle routes limit parking to only one side of the street allow more room for both bicycles and vehicles to travel without conflict.

East Manhattan

Several different types of bicycle facilities are proposed to accommodate the changing traffic environments in the East Manhattan neighborhood cluster. As mentioned in Chapter 4, the neighborhood cluster is a mix of low to medium residential uses in the north and commercial and industrial uses in the south of the cluster. Because of the high number of local, residential streets in the north section, with relatively low traffic volume and speeds; bicycle routes are proposed using wide curb lanes. The routes along Casement Road, Walters Drive, Butterfield Road and Allen Road should be properly signed to direct bicyclist and warn motorist of the bicycle traffic. The total 4.25 mile of bicycle routes are proposed in the residential areas of the East Manhattan neighborhood cluster.

A bicycle path is proposed to run adjacent to the Eisenhower Middle School property and along Marlatt Avenue to connect to the below grade bicycle crossing at the Marlatt Avenue/ Tuttle Creek Boulevard intersection. This proposed path creates a much safer bicycling environment along the Marlatt Avenue right-of-way. The proposed bicycle path and below grade crossing is being designed by the City’s Engineering Department and will be funded by a Kansas Department of Transportation grant. There are no cost estimates available for the project at this time.

A short bicycle lane is also proposed at the intersection of Ewing Drive and Tuttle Creek Boulevard. The bike lane will only be 605 feet long, but will provide a smooth and safe transition from the bicycle lane proposed for Kimball Avenue in the East Campus cluster.

In the commercial/industrial area, a number of bicycle lanes are proposed to designate a safe zone for bicyclist while riding to work or to the retail centers. Bicycle lanes will be located on Hayes Drive near Wal-Mart and the new Limey Point restaurant area, as well as along the Frontage Road adjacent to Tuttle Creek Boulevard. The bicycle lanes should be six (6) feet wide to accommodate the high percentage of heavy vehicle traffic and should be properly marked. The bicycle routes for this area will be approximately 1.75 miles long. The East Manhattan neighborhood cluster also has a trailhead to the Linear Trail located in it. Bicyclists should be encouraged to use the trail when traveling to areas east of the Juliette Avenue to circumvent the vehicle traffic and for a more pleasant and safer route.

The installation of a bike box and traffic signals improvements should be considered at the intersection of Frontage Road and Leavenworth Street to improve the safety of bicyclists at the large and confusing intersection.

It would be wise for the City to consider areas in East Manhattan for long-range bicycle planning as more commercial developments occur in this area and given the discussion that the Blue Township in western Pottawatomie County could become part of the City of Manhattan. The first long range issue is to construct a grade-separated bicycle and pedestrian crossing under Tuttle Creek Boulevard near McCall Road. The grade-separated crossing would allow for better access to the restaurants and retail businesses along McCall Road. The other area to consider is how to create bicycle facilities that will give access to residents in the Blue Township if and when they are annexed into the City. The most likely route would be a bicycle lane or path along the McCall Road corridor that connects to a bicycle/pedestrian bridge over the Blue River. From the Blue River Bridge, a series of bicycle paths running adjacent to U.S. Highway 24 would be appropriate to reach the commercial and residential developments in the Blue Township. The designs of the actual routes and crossing improvements, timelines and cost estimates are not known, but the City should keep these long-range projects in mind with new developments and road construction projects.

Northwest

The residential neighborhoods that make-up the Northwest neighborhood clusters already have a number of bicycle facilities present that enhance bicycle riding and provide adequate access to adjacent neighborhood clusters. Hudson Trail is located in the northern area of the cluster, which is an approximately 3,600 foot long north and south trail from Kimball Avenue to Churchill Street. The cluster also has the pedestrian/bicycle tunnel under Seth Child Road near Gary Avenue and the Wreath Avenue Linear Trail Head along Anderson Avenue. To create a continuous bicycle network within the neighborhood cluster and the City, several different facilities are proposed. Approximately 3.8 miles of bicycle routes, using the existing wide curb lanes are proposed on Candlewood Drive, Wreath Avenue and Hudson Avenue. These streets provide excellent north and south access to a majority of the residential neighborhoods throughout the cluster. A bicycle lane along Dickens Avenue will provide the east – west access to the cluster and route bicyclists past Cico Park and near Amanda Arnold Elementary School.

A bicycle lane over 1.5 miles long on Kimball Avenue is proposed to link the residents with bicycle routes in the cluster, providing a route to the commercial centers at Grand Mere and Candlewood Shopping center and connect the Northwest neighborhood cluster with the adjacent neighborhood cluster. This bicycle lane should be six (6) feet in width to provide adequate space for bicyclists while riding on the four-lane arterial. Finally, a separate bicycle path is proposed along the south side of Anderson to connect to the Linear Trail Head at Wreath Avenue and Anneberg Park. The ten (10) foot wide path is preferred over a bicycle lane or other treatments because of the likelihood that children and their parents will ride their bicycles to the Linear Trail and/or Anneberg Park. With the presence of B/C Class riders, the separate trail is a much safer environment.

Looking toward the future, consideration should be given two (2) special areas as residential areas develop – Scenic Drive and South Wreath Avenue. Growth patterns in the City show that the area west of Miller Ranch towards Scenic Drive will develop. Two large subdivisions along Scenic Drive have already been established and are growing. Discussions have already been taking place as to how Miller Parkway will connect to Scenic Drive as well as the potential for South Wreath Avenue to cross the Wildcat Creek and connect to Anderson Avenue. As new residential developments come on line and connect the established neighborhoods of Miller Ranch to the new neighborhoods, the City should take every opportunity to incorporate proper bicycle facilities into the subdivisions and roadways, particularly on Miller Parkway and Scenic Drive.

Miller Ranch/University Heights

The small neighborhood cluster of Miller Ranch/University Heights arguably has the most established bicycle facilities of any neighborhood cluster in the City. The entire length of Miller Parkway has designated bicycle lanes and sections of Amherst Avenue that begins in the Miller Ranch neighborhood is also designated as a bicycle lane. The proposed facilities in this neighborhood cluster are to expand the bicycle lanes on Amherst Avenue to Seth Child Road and the Linear Trail entrance east of Seth Child Road and a few bicycle routes to connect the residents to Warner Park and the commercial center along Seth Child Road. The bicycle lane along Amherst Avenue will be approximately one (1) mile in length and provide a continuous route from Seth Child Road to Miller Parkway once complete. This route should be properly marked and signed to alert motorists of the bicycle traffic.

One and one-quarter miles of bicycle routes are also proposed along Warner Drive, Arbor Lane and Shuss Road to connect the Miller Park and Lee Mill Heights residents to the park and Seth Child Commons shopping center. Shuss road is currently a gravel road with no curbs or gutters. The City should invest in making this quarter mile road an urban street with proper curb and gutters to provide better access for vehicle and bicycles to the major neighborhood shopping center.

Installing a bicycle box at the traffic signal at Amherst Avenue and Seth Child Road provides for a safer environment at the traffic signal. Because the intersection at Amherst Avenue and Seth Childs Road tends to collect debris from storm water runoff, it would be important for the City's Street Department to keep this area clear. The gravel and trash that collects in this area posses a slip or skid hazard for bicyclist as they prepare to stop for the intersection. When the traffic signal is installed at the intersection of Miller Parkway and Fort Riley Boulevard, installing a bicycle box, with appropriate signal times, would be appropriate to create a safe environment at the new traffic signal. When the Kansas Department of Transportation expands Fort Riley Boulevard to an Expressway and constructs the proposed diamond interchange at Davis Drive and Miller Parkway, the City should insist on a separate bicycle path on the overpass to safely connect the two neighborhood clusters.

As mentioned in the Northwest neighborhood cluster description, City Planners should look for opportunities to develop new bicycle facilities in this neighborhood cluster to connect to residential developments on the edge of the City as this cluster grows in the future. Connecting Miller Parkway to Scenic Drive, Scenic Drive to Anderson Avenue and Anderson Avenue to South Wreath Avenue are long-range street projects that should incorporate bicycle lanes, paths or routes.

Southeast Manhattan

The Southeast Manhattan neighborhood cluster has the highest number of destinations among all clusters in the City. With four school buildings, multiple parks (including the City Park and the ball fields at Griffith Park), Aggieville, the Central Business District, the Town Center Mall and the Downtown Redevelopment Area in various stages of planning or construction (this areas includes the Manhattan Market Place along 4th Street). The neighborhood cluster is comprised of local, residential streets that are laid out in the grid pattern, which is ideal to bicycle travel because of the low traffic and vehicle speeds.

The proposed bicycle facilities within the cluster are comprised of bicycle routes that share the road with vehicles. Over 6.6 miles of bicycle routes are proposed throughout this neighborhood cluster. To ensure the safest environment for bicyclists and motorists, parking would be restricted to only one side of the street to provide adequate space for both vehicles and bikes to share the road. These facilities should be properly marked with route and directional signage and an emphasis on “share the route” signs to alert drivers of bicycle traffic.

Installing bicycle boxes at various intersections throughout the Southeast neighborhood cluster will help to ensure that bicyclists can cross and turn safely at major intersections. A bike box would be needed at the intersection of 14th and Anderson Avenue so students and other residents can gain access to Kansas State University. A bike box would be required at 11th Street and Bluemont Avenue to provide a safer intersection for residents who are crossing with a bicycle to go to City Park or to Poyntz Avenue. Other intersections that would need a bicycle box are Juliette Avenue and Bluemont Avenue, South Juliette Avenue at Fort Riley Boulevard and South Manhattan Avenue at Fort Riley to provide safe access to Griffith Park and the Linear Trail.

West Campus

Bicycle lanes and dedicated routes are proposed for specific streets in the West Campus neighborhood cluster. Bicycle lanes are proposed along Claflin Road, College Avenue, Denison Avenue and Kimball Avenue. Even though the Bicycle Safety Index did not rate these street sections favorably due to the traffic speed and volumes as well as the rolling hills, especially on Claflin Road, they are needed for their direct access to Kansas State University campus and other areas in the West Campus cluster. These bicycle lanes meet criteria established by the Federal Highway Association *Selecting Roadway Treatments to Accommodate Bicycles* to address the needs of B/C bicyclists in an urban section of road with no parking. The proposed routes will create a continuous network within the cluster to route bicyclists to or near all commercial and retail properties, and schools. The proposed bicycle lanes should be five (5) feet wide and properly marked and signed to warn motorist of bicycle traffic. The Kimball Avenue bicycle lane is approximately 1.6 miles long from border to border of the neighborhood cluster. In all, the Kimball Avenue bicycle corridor, which includes lanes and a separate path, will be approximately 4.1 miles long. The Claflin Road bike lane will be approximately 1.6 miles in length and stretch from approximately Denison Avenue to Wreath Avenue in the Northwest cluster. The Denison Avenue bike lane will begin at Anderson Avenue and run to Kimball Avenue. The bicycle lane on College Avenue will begin at Claflin Road and end at Kimball Avenue.

A bicycle route is proposed on Browning Avenue from Claflin Road to Marlatt Avenue. This route will use the wide curb lane to provide riders with safe access to the residential neighborhoods and Marlatt Avenue, which will also be a bicycle route. A bicycle route is also proposed along Gary Avenue toward the Northwest cluster. The bicycle route will then turn north on Meadowood Drive to utilize the bicycle/pedestrian tunnel under Seth Child Road. In total, there will be 4 miles of bicycle routes designated to direct bicyclist to area destinations and adjoining neighborhood clusters.

A bicycle box is to be installed at the intersection of Claflin Road and Seth Child Road. The timing of the bike box signalization should be long enough to allow a B/C rider to safely advance through a majority of the intersection before cars are allowed to cross.

Woodland Hills

Only bicycle routes are proposed for the Woodland neighborhood cluster. Because of the low residential density, low traffic speeds and low traffic volume, major bicycle facilities and improvements are not warranted at this time. The proposed routes along Allison Avenue, Stagg Hill Road and Davis Drive are primarily proposed to complete the bicycle network and provide directional way finders to the cluster's parks and the Linear Trail head. Because of the steep hills along the three bicycle routes, it would be important to install additional signs that warn drivers of slow moving bicyclists on the hill's incline. It would also be important to install signage for bicyclists to warn them of the steep road grade and excessive speeds on the decline of the hills, especially near stop signs where proper deceleration is needed to ensure a safe stop. As mentioned in the Miller Ranch/University Heights neighborhood cluster description, when the traffic signal is installed at the Fort Riley Boulevard intersection, a bicycle box, with appropriate signal times, should also be installed to create a safe environment at the new traffic signal.

Beyond the Neighborhood Clusters

As Manhattan grows to the east into Pottawatomie County and to the west towards Scenic Drive, the City should focus their efforts to include bicycle facilities with the new residential and commercial developments. When McCall Road is expanded to a 5-lane arterial, it would be wise for the City to take advantage of the spaces provided in the road right-of-way to create adequate bicycle/pedestrian path. If and when the U.S. Highway 24 Bridge is ever widened to accommodate the extra traffic coming from residents in Blue Township, a bicycle/pedestrian path should be incorporated in the design for safe crossing of the bridge separate from the vehicle traffic. A more costly alternative would be to construct a separate bicycle/pedestrian bridge across the Blue River to gain access to the existing and expanding developments in Pottawatomie County. Either bridge crossing can then be connected to the Linear Trail Head at the Blue River and the proposed bicycle facility at McCall Road.

As the western City limits expand, the existing Miller Parkway bicycle route should be extended westward as well. A bicycle path along Scenic Drive or through the rolling hills of the adjacent neighborhoods could be established with future expansion to provide bicycle access to the residents of new developments and Stone Point and Highland Ridge. The design of the future Wreath Avenue extension should also include bicycle facilities to create a continuous network.

Project Phasing and Capital Improvement Plan

The previous section discussed the proposed improvements in each neighborhood cluster. Although the proposed bicycle network was constructed on a neighborhood by neighborhood basis to create the ultimate bicycle network, the reality is that the City can not construct the network is the same manner. The more logical process to meet the needs of the bicycling community is to set priorities for bicycle facilities and include the projects in the City's Annual Capital Improvement Plan in phases. Whenever possible, the proposed facilities should be dovetailed with proposed street or utility projects that will impact the same street or neighborhood. Because projects submitted for the Annual Capital Improvement Plan can be unexpected due to of community demand, changes in policies or because of an emergency, it is impossible to predict how and when a bicycle facility project can be partnered with another facility plan. For this reason, Appendix B is created to give planners a cost estimate for each proposed facility in each neighborhood cluster for budgetary purposes.

The project phasing plan is based on the premise that Kansas State University is the largest trip generator for bicycles and the emphasis should be placed on creating safe and continuous routes leading to this major destination. Other major destinations that are given priorities are the Central Business District and the new commercial developments along 4th Street and McCall Road. The Bicycle Master Plan Update has created three (3) phases that consist of five (5) years each, for a total of fifteen (15) years to complete the entire bicycle network. Figure 5.8 shows which bicycle facilities are proposed with each phase.

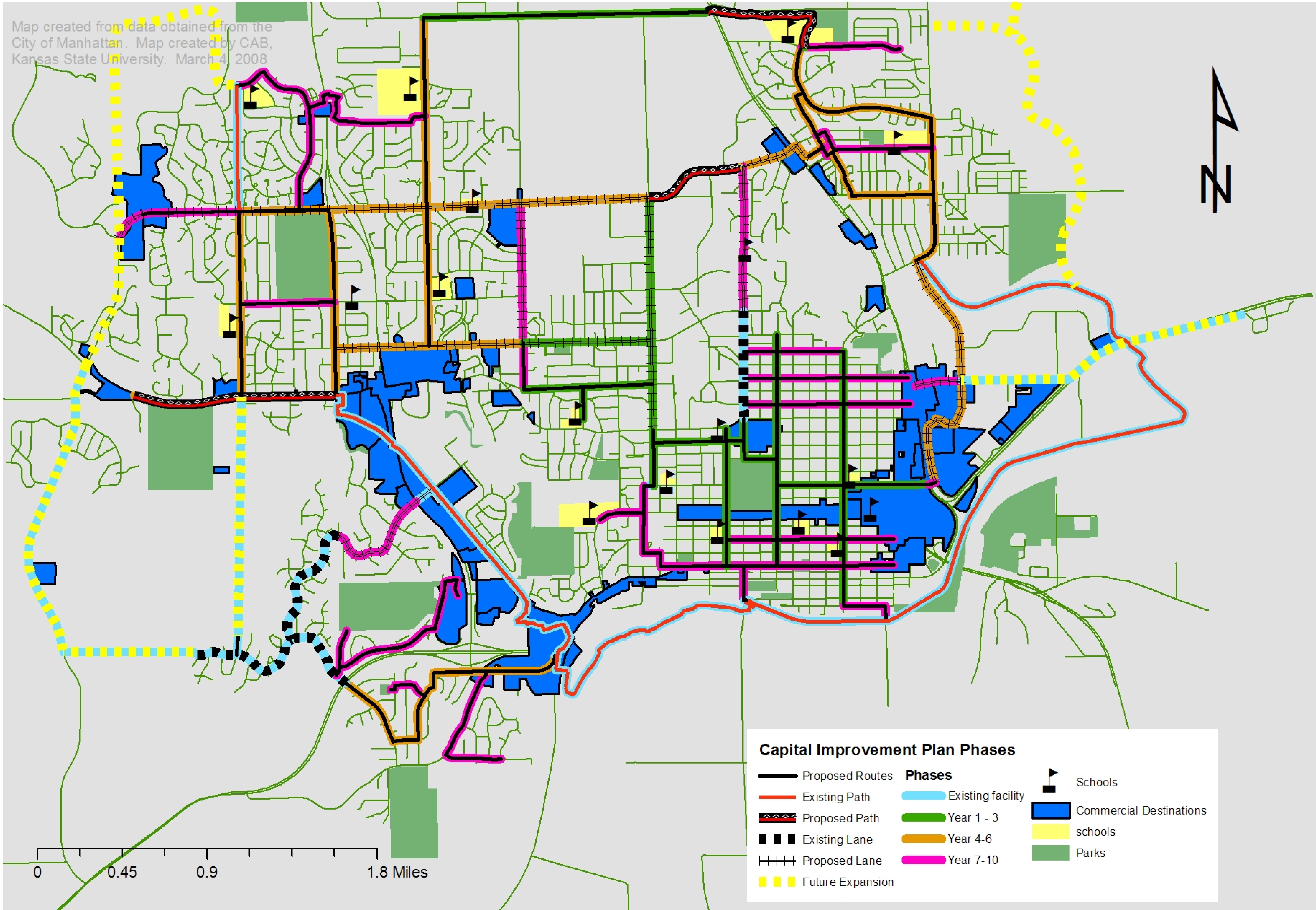


Figure 5.2: Manhattan Bicycle Master Plan Update
Proposed Bicycle Facilities

By calculating cost estimates, an Annual Capital Improvement Budget can be developed that helps determine the three (3) phases and the annual project priorities. Cost estimates can be found for each project by multiplying the length of a proposed bicycle facility improvement by a standardized cost per linear foot. The standardized costs are based on recently constructed bicycle, roadway and sidewalk improvements in the City of Manhattan. These estimates are not exact or specific to any recommended project in the plan, but rather an average of best and worst case construction scenarios. Exact costs will require detailed surveying and engineering design work. All dollars amounts shown are based on 2008 construction costs.

Cost Estimates for each Improvement Type

- **Bicycle Paths:** Bicycle path construction is estimated at $68 per foot for a ten (10) foot wide, six (6) inch thick concrete path. These estimates include limited earthwork and drainage, pavement and signage. It is assumed that all bicycle paths will be constructed in existing road right-of-way or on City-owned property. If land must be acquired, the cost per foot will increase considerable.

- **Bicycle Lanes:** Bicycle lanes are estimated to cost an average of $30 per foot. This estimate is a weighted average of the low and high end ranges of costs. At the low end it costs $2 per foot to strip a street with adequate curb width (14 feet). At the high end the cost to widen an existing street by eight (8) feet is $84 to install four (4) foot wide bicycle lanes on both sides of the street. The high end costs include lane widening, curb and gutter replacement, striping, marking and signs. Most planned bicycle facilities will not require road widening.

- **Bicycle Routes:** Bicycle routes are estimated to cost $2 per foot. No roadway improvements are required. The expense is associated with signage used to designate the road as a bicycle route. Signs typically cost $125 per sign. These signs are generally located at each intersection and at mid-block intervals.

Table 5.1 is the Capital Improvement Schedule that details the costs associated with each type of bicycle facility for each phase

.

Table 5.1 Capital Improvement Schedule

Phase	Length (Miles)	Cost per Unit of Distance	Total Cost	
Phase I				
Path	.73	$68/ft	$260,644	
Lane	1.94	$30/ft	$306,180	
Route	7.89	$2/ft	$83,330	
Bicycle Box	6	$4,000/unit	$24,000	
		Subtotal		$674,154
Phase II				
Path	1.08	$68/ft	$388,212	
Lane	5.66	$30/ft	$895,890	
Route	8.47	$2/ft	$89,460	
Bicycle Box	3	$4,000/unit	$12,000	
		Subtotal		$1,385,562
Phase III				
Lane	3.24	$30/ft	$473,280	
Route	11.98	$2/ft	$126,434	
Bicycle Box	6	$4,000/unit	$24,000	
		Subtotal		$623,714
Total	**40.99 Miles**		**$2,683,430**	

Successful implementation of this Plan will depend on the ability of the City to secure necessary financing. Besides the General Fund, the following sources of revenue are available to the City:

Millage, Assessments, and Bonds

- **Dedicated Millage:** Special millage can be used to generate revenues for a specific purpose. For example, the City of Manhattan residents could vote to establish a dedicated property tax millage to support the development of the bicycle and pedestrian way improvements.

- **Special Assessments:** Special assessments are compulsory contributions collected from the owners of property benefited by specific public improvements (paving, drainage improvements, etc.) to defray the costs of such improvements. Assessments may be useful in filling in the gaps of Manhattan's bicycle or trail system. Assessments can also be placed on property owners for the construction of bicycle facilities abutting their property.

- **Bond Programs:** Bonds are one of the principal sources of financing used by communities to pay for capital improvements. General obligation bonds are issued for specific community projects and are paid off by the general public with property tax revenues. Revenue bonds are issued for construction of projects that generate revenues.

Grants

- **Kansas Transportation Enhancement Projects:** In 2006, the Kansas Department of Transportation (KDOT) distributed more than $35 million to over forty (40) Kansas communities for a variety of transportation enhancement projects. This funding is provided by the Federal Government which requires each state to set aside ten (10) percent of their Surface Transportation Funds for Transportation Enhancement projects including bicycle and pedestrian facilities, transportation beautification projects, and historic preservation projects. Sixteen (16) communities and state agencies received grants for bicycle and pedestrian facility projects followed by eighteen (18) beautification projects and eight (8) historic preservation projects. KDOT received 67 applications from local Kansas communities. (KDOT Press Release, 2005).

- **Land and Water Conservation Fund (LWCF):** The LWCF is a federal program aimed at providing resources to maintain, develop and preserve outdoor recreational resources. This program provides up to fifty (50) percent reimbursement assistance. Local governments must be able to finance project costs up-front until reimbursement payments are made. Other federal and state grants may be used to help offset some of the local match requirement. The LWCF is authorized by the federal government to continue through 2015. (www.nps.gov/lwcf, 2008).

Private Sources

Corporations, non-profit organizations, and foundations should be considered to help finance bicycle related public improvement projects.

CHAPTER 6 - Future Research

As the 2008 Bicycle Master Plan Update is implemented, data and information should be collected to evaluate its effectiveness in increasing transportation mode shifts and decreasing bicycle/vehicle accidents.

The bicycle coordinator should collect and analyze police crash data for bicycle and bicycle/vehicle accidents. A historic base line should be collected to determine the frequency and severity of bicycle related crashes from the past ten (10) years. Information to gather and analyze include location, speeds, time of day, helmet use and age. Once the historic base line is established, the data can be continually updated to determine troubled spots in the network, assist in decision making for educational programs, bicycle facility design improvements and future capital improvement project.

User surveys and focus groups should also be a part the City’s future research in developing the best possible bicycle network. Using methodology from past research projects, the bicycle coordinator can use a variety of survey tools and focus groups to gauge the effectiveness of the new routes, evaluate user’s preferences and create approval ratings of the bicycle network to determine where bicycle riders needs are not being met. These surveys and focus groups will not only provide the community with valuable insight into future bicycle projects, but they can also validate the bicycle network project and give a meaningful voice to incorporate more bicycle facilities in the City.

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Appendix A - Windshield Survey

Neighborhood ____________________________ Proposed Route _________________

Vehicle Speed _______

Road Surface Quality 1 2 3 4 5 Traffic Volume 1 2 3 4 5

Perceived Road Width 1 2 3 4 5 Perceived Safety 1 2 3 4 5

Road slope 1 2 3 4 5

Any Vision Clearance Issues: Yes No

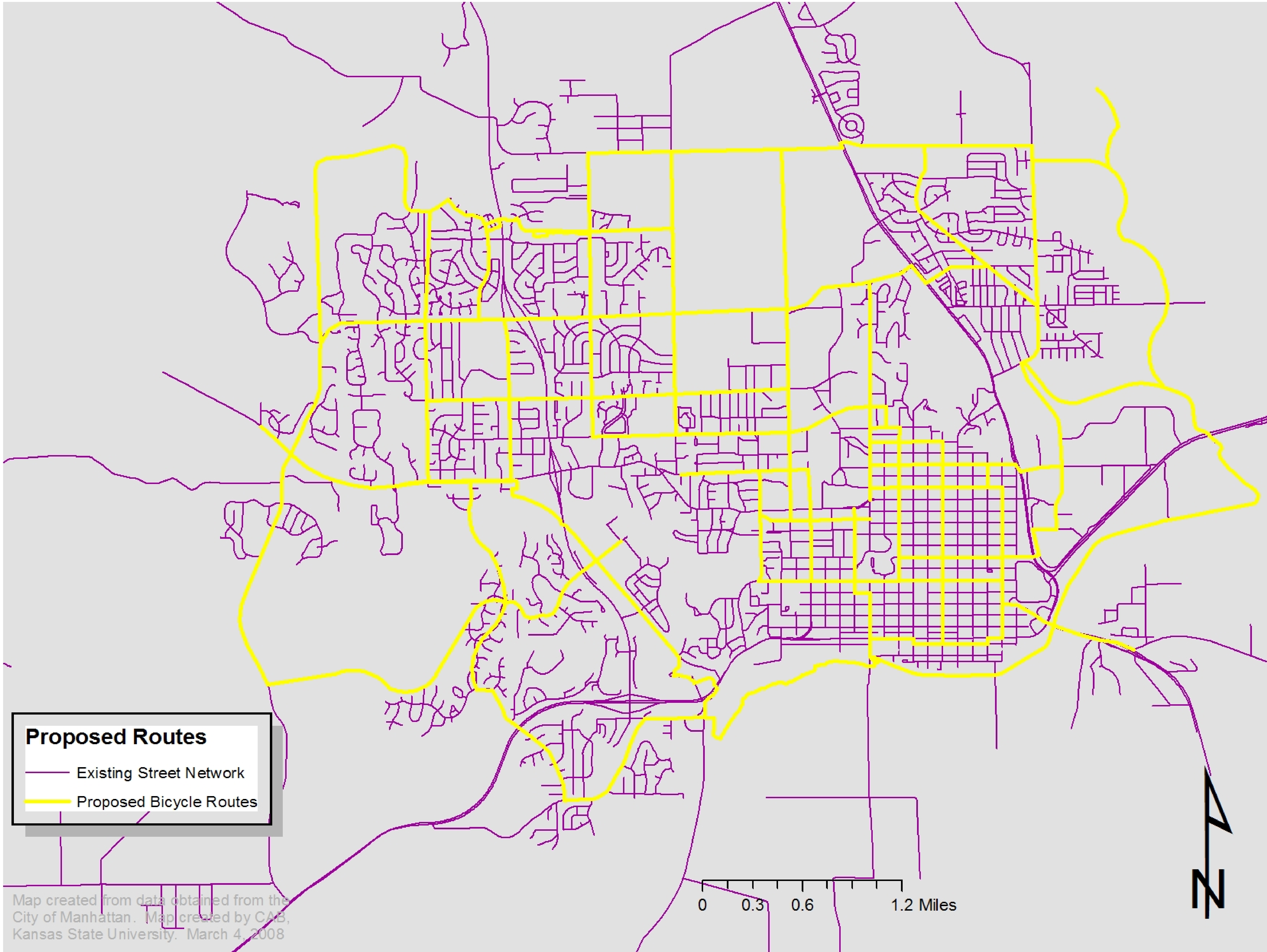
Vision Comments

Overall Comments

Appendix B - Neighborhood Bicycle Route Cost Estimate

Cluster	Proposed Facilities	Length (Miles)	Cost Per Unit of Distance)	Total Costs
Central Manhattan	Lane	0.25	$30/ft	39,600
	Route	2.55	$2/ft	26,928
	Bicycle Box	2	$4000/unit	8,000
		Subtotal		$74,528
East Campus	Lane	1.28	$30/ft	202,752
	Route	4.39	$2/ft	**46,358**
	Bicycle Box	3	$4000/unit	12,000
		Subtotal		$261,110
East Manhattan	Path	0.73	$68/ft	262,099
	Lane	1.86	$30/ft	294,624
	Route	4.25	$2/ft	44,880
	Bicycle Box	1	$4000/unit	4,000
		Subtotal		$605,603
Northwest Manhattan	Path	1.10	$68/ft	394,944
	Lane	1.50	$30/ft	237,600
	Route	3.80	$2/ft	40,128
		Subtotal		$672,672
Miller Ranch/	Lane	1.00	$30/ft	158,400
University Heights	Route	1.25	$2/ft	13,200
	Bicycle Box	2	$4000/unit	8,000
		Subtotal		$179,600
Southeast Manhattan	Route	6.60	$2/ft	**69,696**
	Bicycle Box	6	$4000/unit	24,000
		Subtotal		$93,696
West Campus	Path	0.37	$68/ft	132,845
	Lane	3.20	$30/ft	506,880
	Route	4.00	$2/ft	42,240
	Bicycle Box	1	$4000/unit	4,000
		Subtotal		$685,965
Woodland Hills	Route	2.86	$2/ft	30,202
		Subtotal		$30,202
Total		40.99		$2,683,430

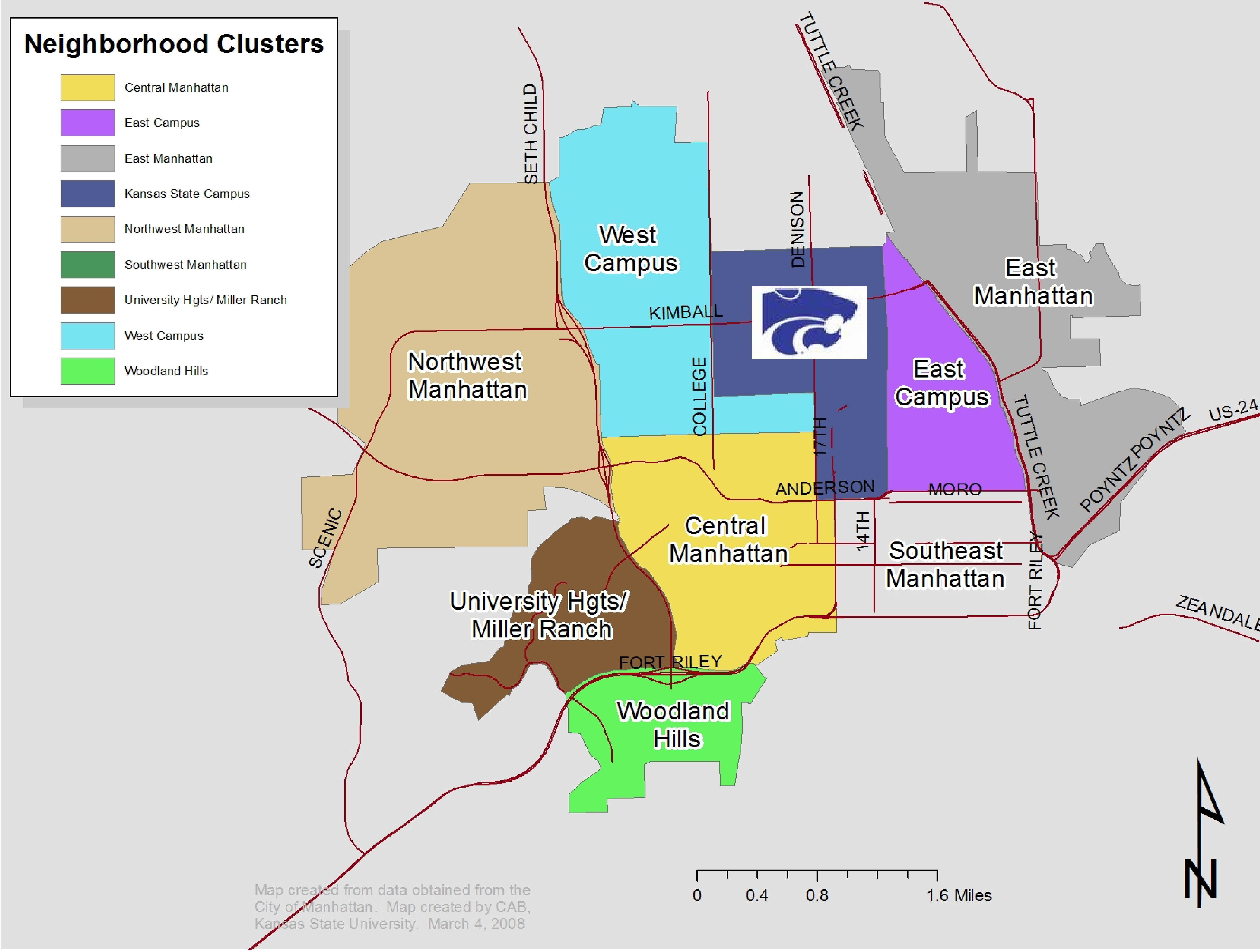
Appendix C - Maps



Map 1.1: 1998 Bicycle Master Plan
Proposed Bicycle Routes

Map 3.1: Manhattan Bicycle Master Plan Update
Proposed Bicycle Route Plan

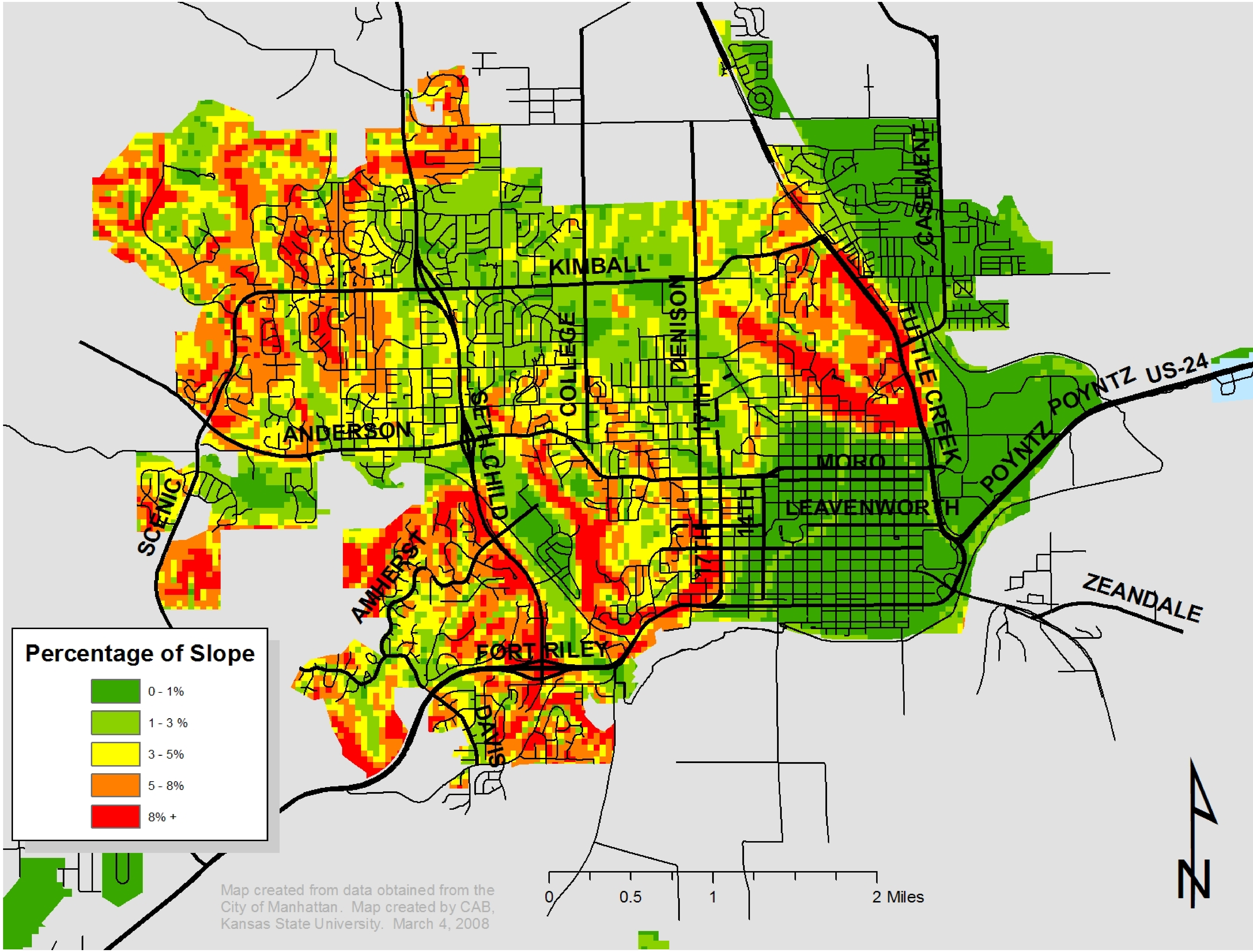
Neighborhood Clusters



Map 3.2: Manhattan Bicycle Master Plan Update

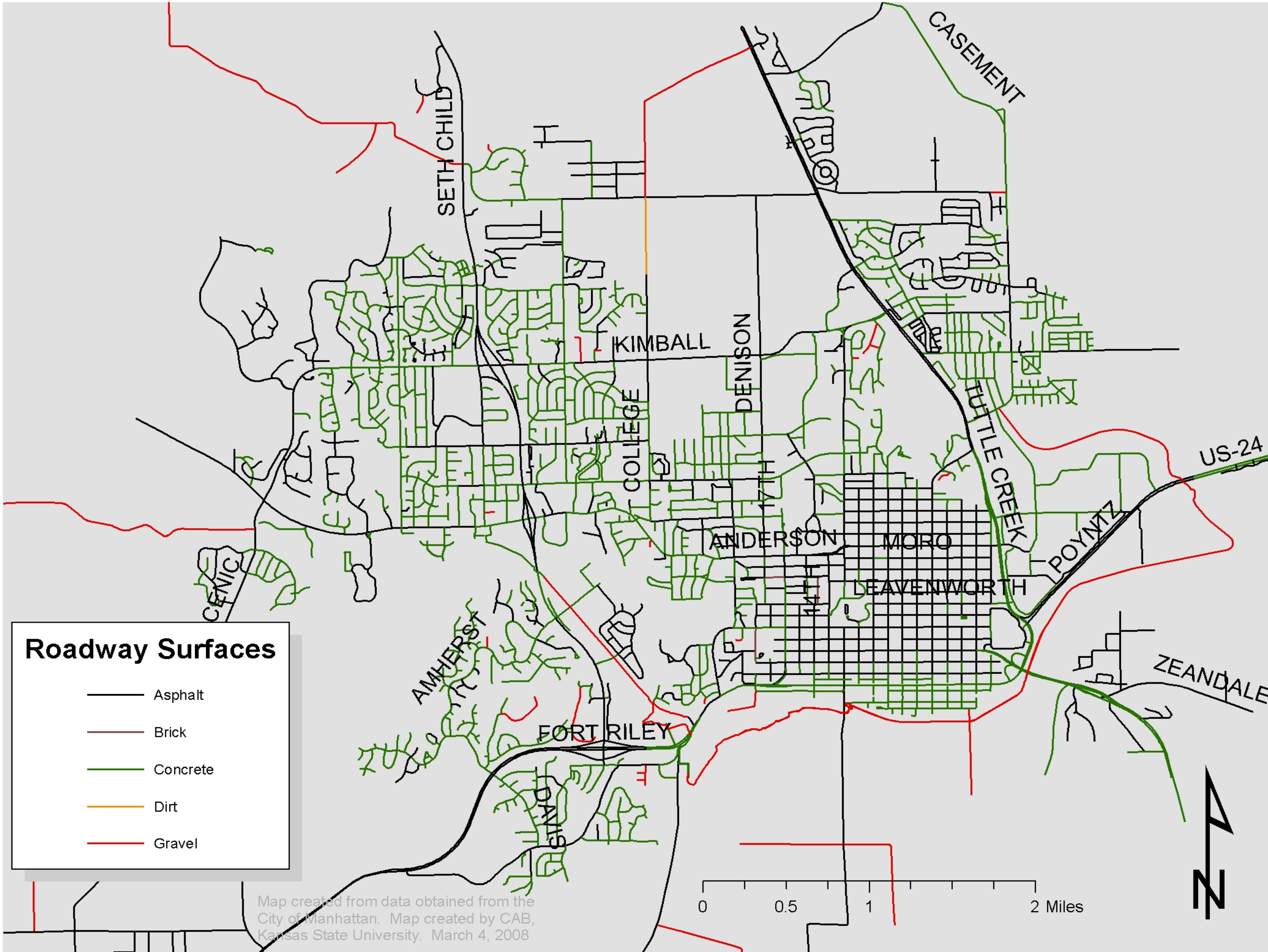
Bicycle Safety Index Factor

Percentage of Slope



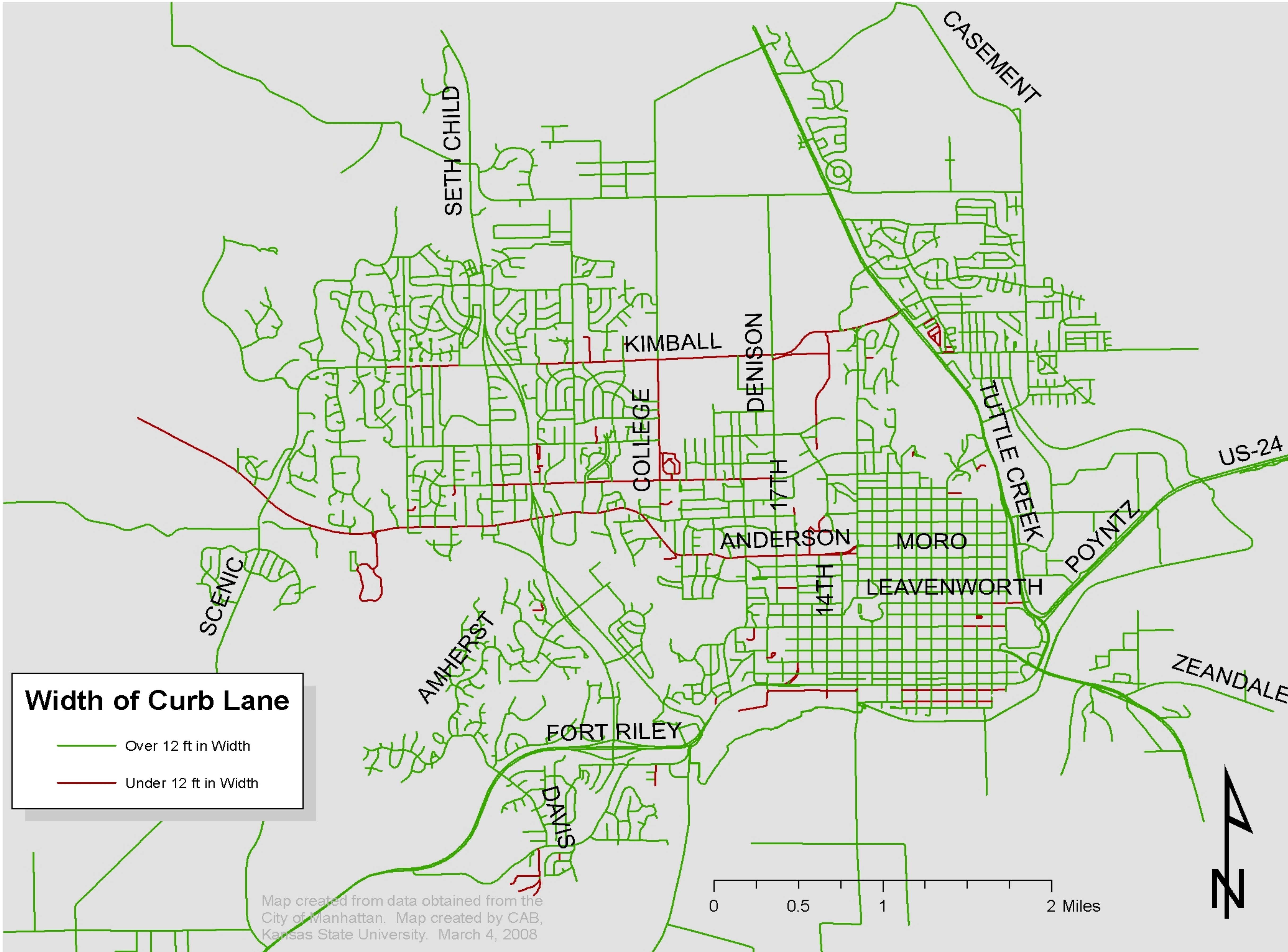
Map 3.3: Manhattan Bicycle Master Plan Update
Bicycle Safety Index Factor

Roadway Surfaces



Map 3.4: Manhattan Bicycle Master Plan Update
Bicycle Safety Index Factor

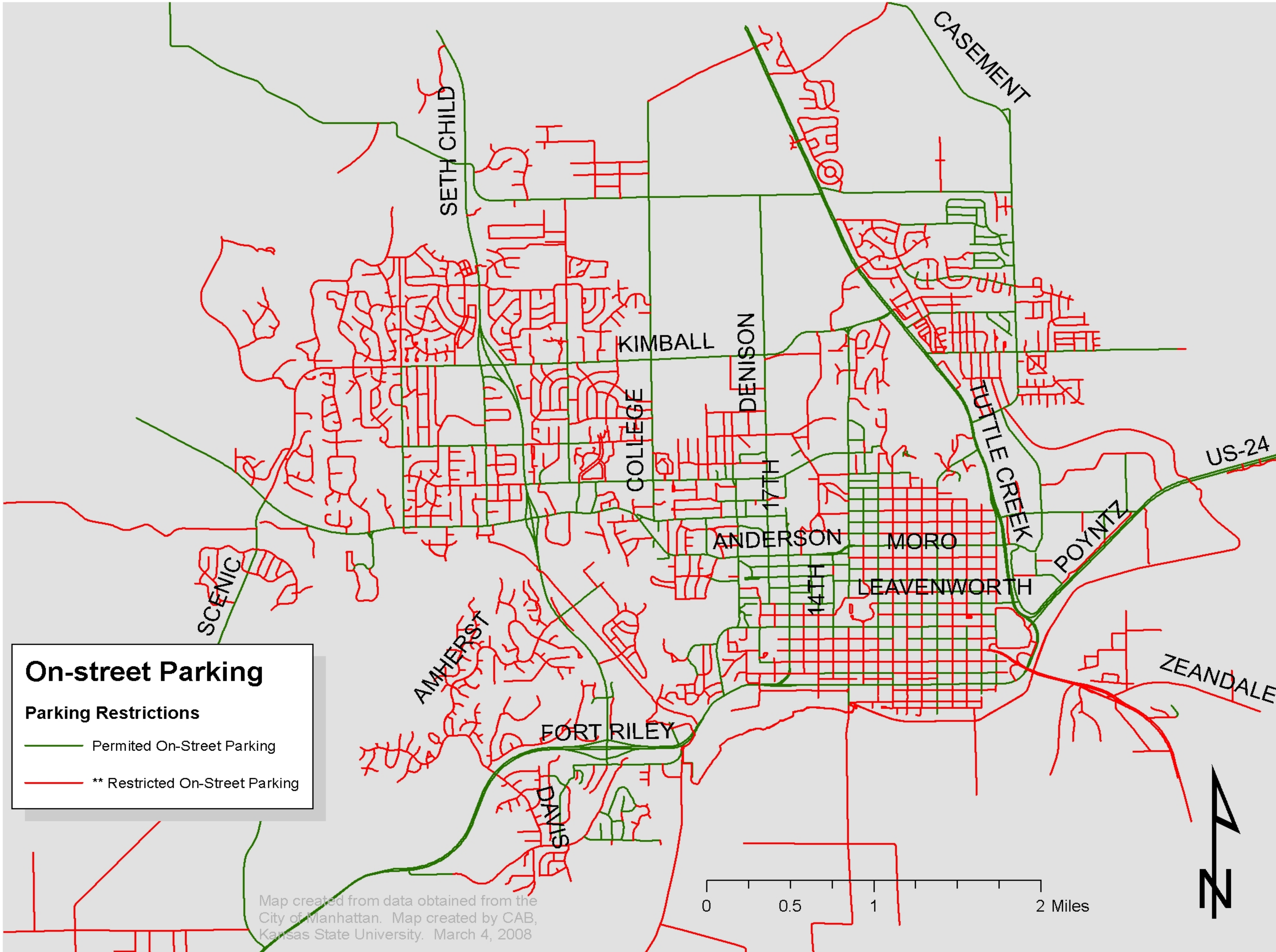
Estimated Width of Curb Lane



Map 3.5: Manhattan Bicycle Master Plan Update Bicycle Safety Index Factor

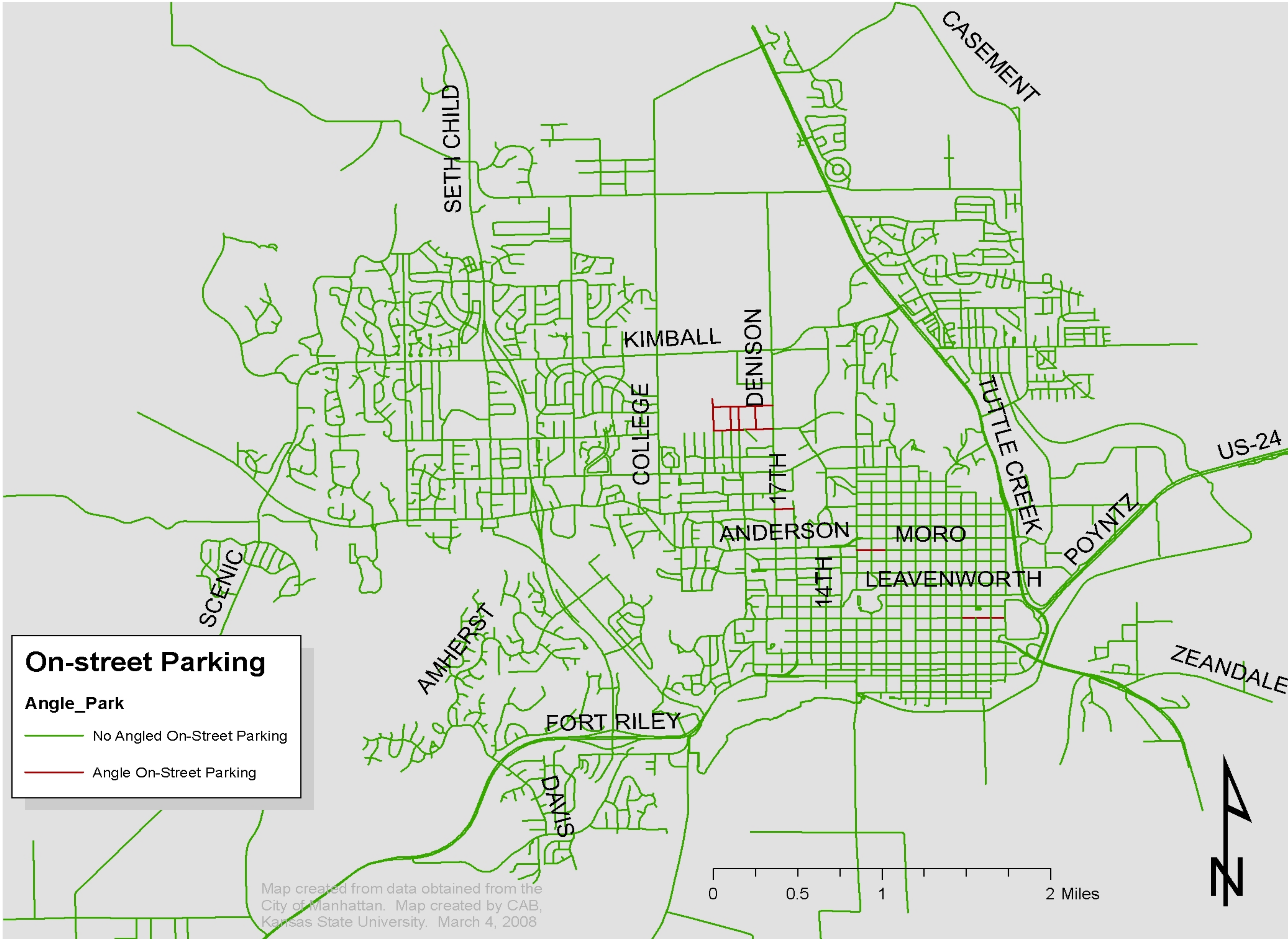
On-Street Parking Conditions

*** Restricted On-Street Parking on One or Both Side of the Street*



Map 3.6: Manhattan Bicycle Master Plan Update
Bicycle Safety Index Factor

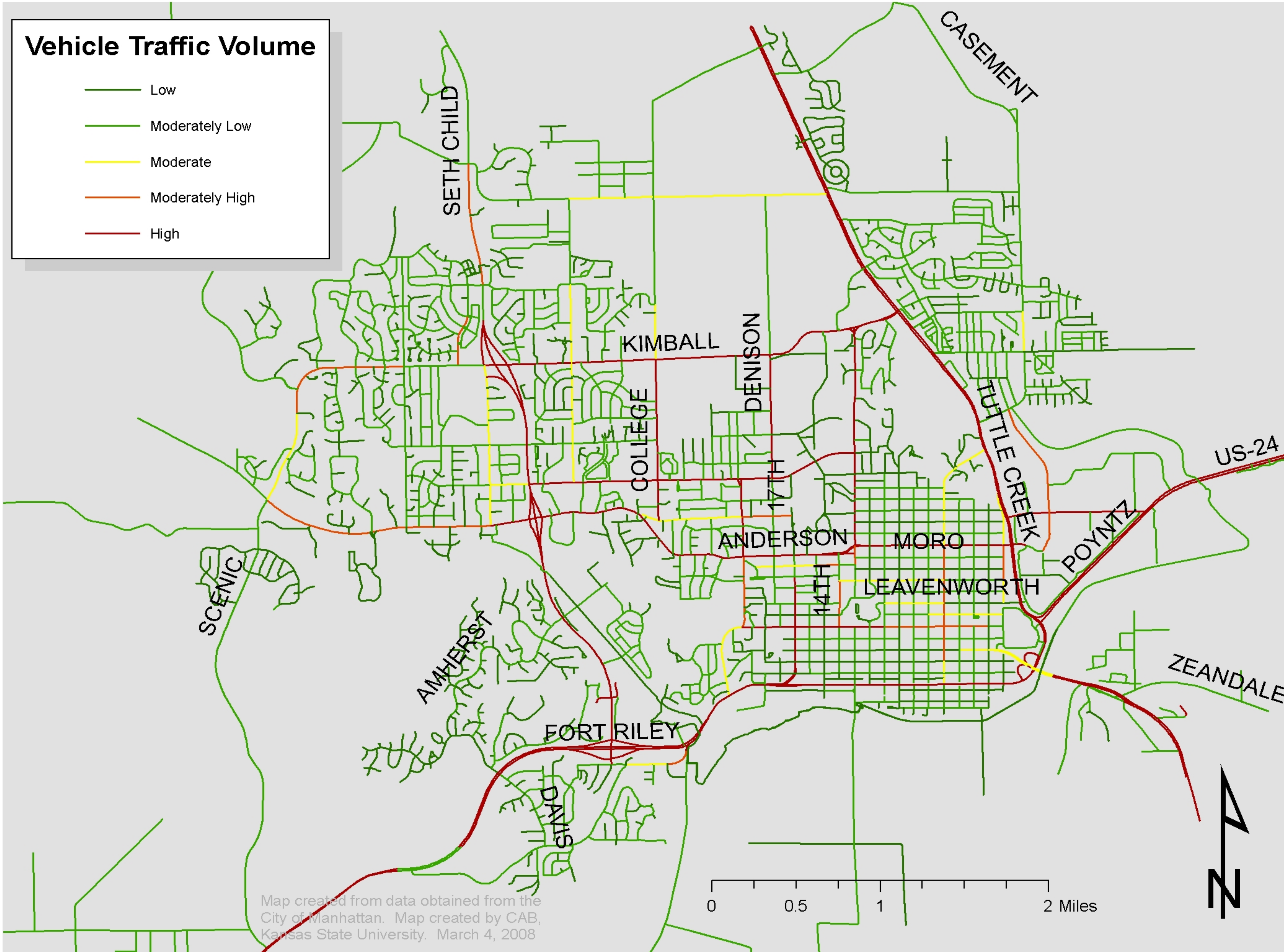
Presence of Angled On-Street Parking



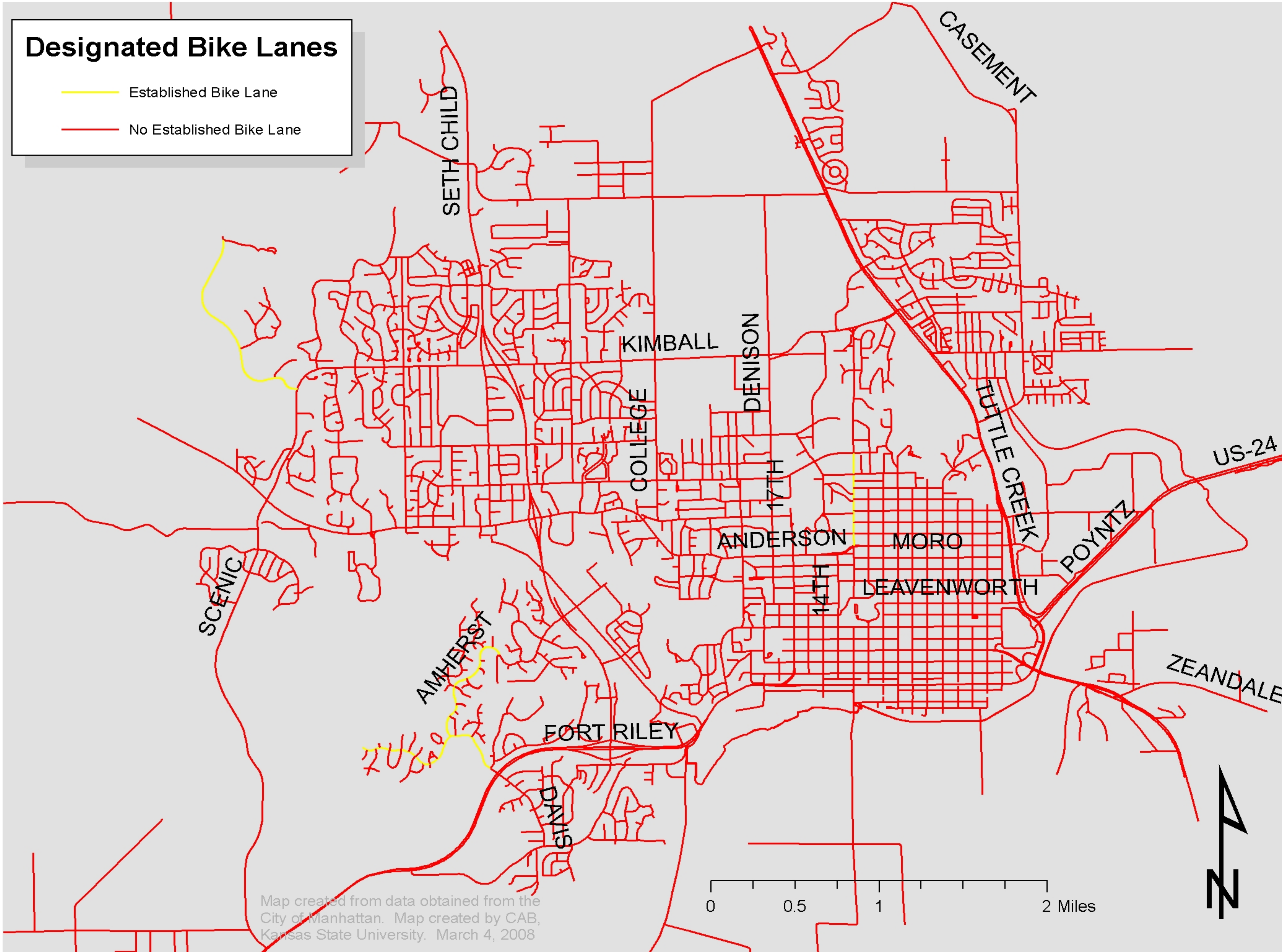
Map 3.7: Manhattan Bicycle Master Plan Update

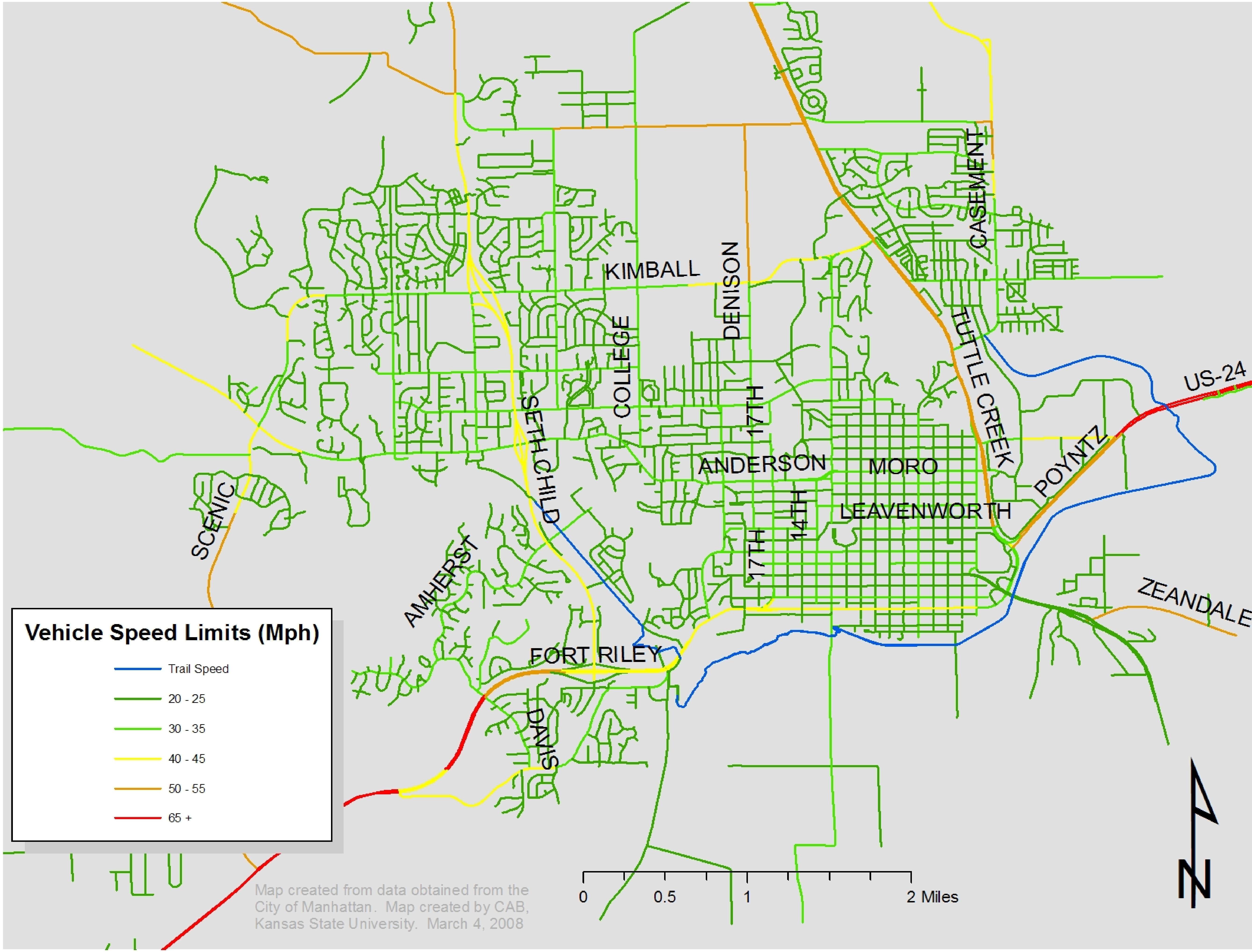
Bicycle Safety Index Factor

Estimated Vehicular Traffic Volume



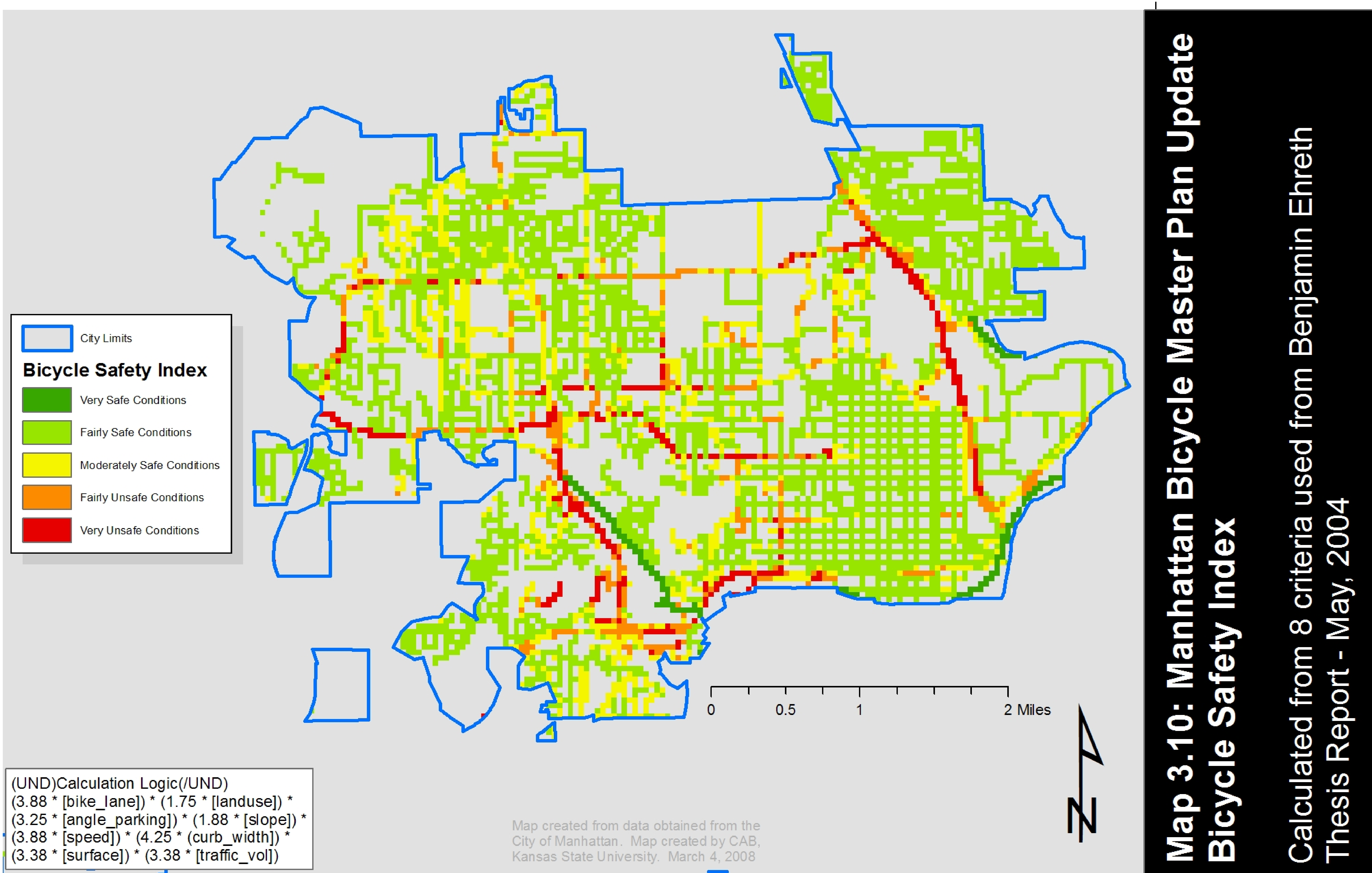
Map 3.8: Manhattan Bicycle Master Plan Update
Bicycle Safety Index Factor
Location of Designated Bicycle Lanes





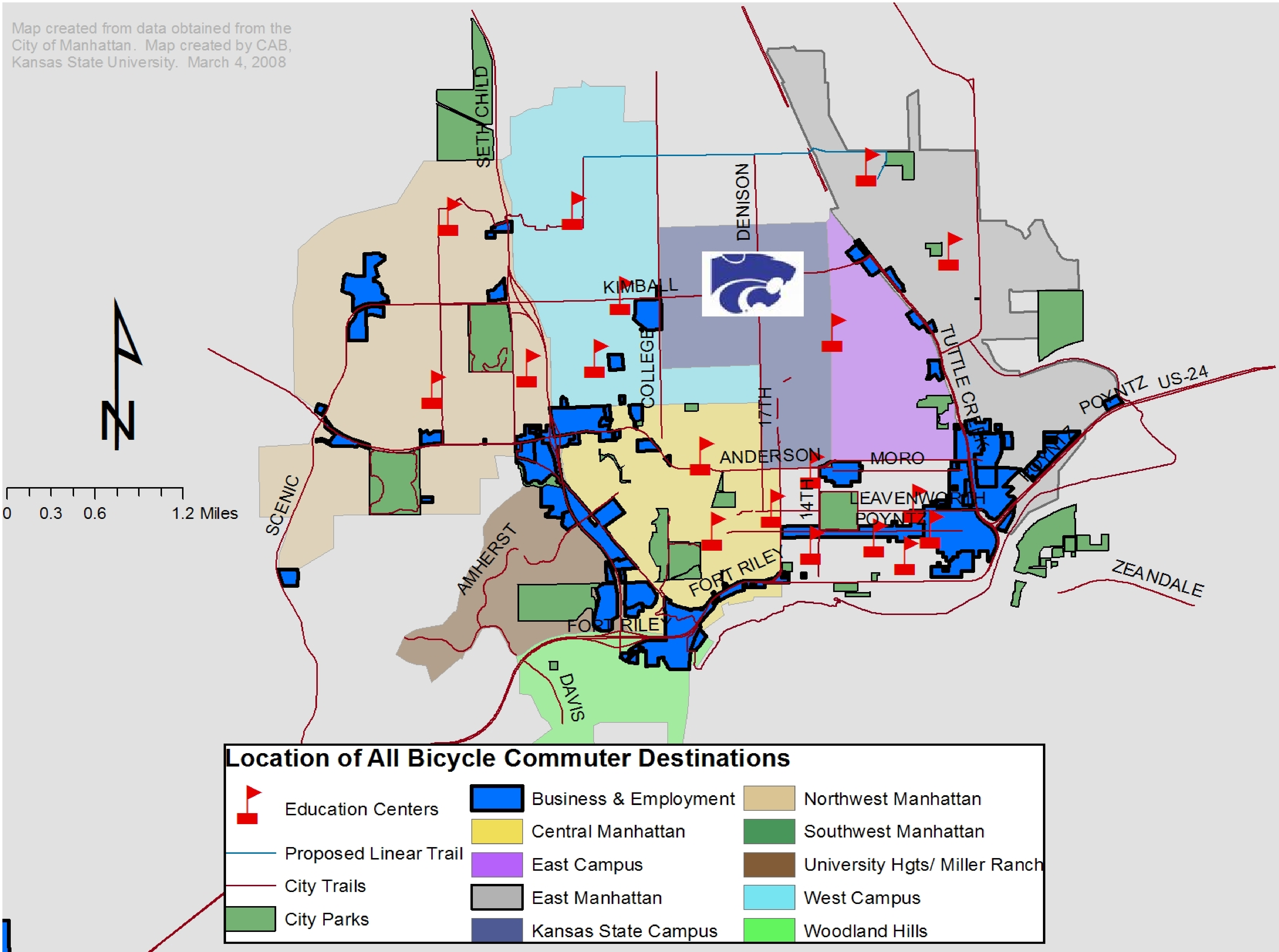
Map 3.9: Manhattan Bicycle Master Plan Update
Bicycle Safety Index Factor

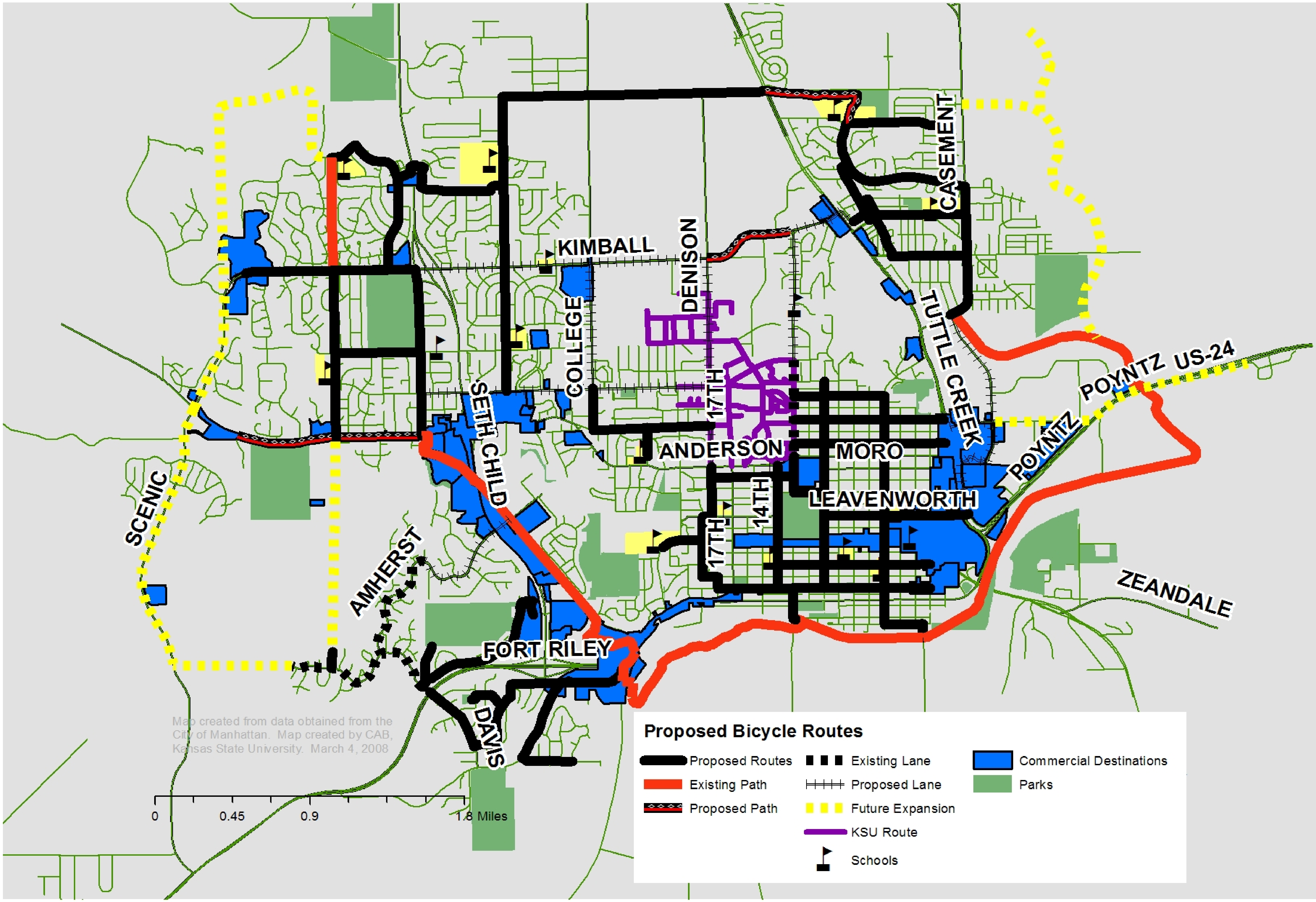
Posted Vehicle Speed Limits



Map 3.10: Manhattan Bicycle Master Plan Update
Bicycle Safety Index
Calculated from 8 criteria used from Benjamin Ehreth
Thesis Report - May, 2004
City Limits
Bicycle Safety Index
Very Safe Conditions
Fairly Safe Conditions
Moderately Safe Conditions
Fairly Unsafe Conditions
Very Unsafe Conditions
0
0.5
1
2 Miles
N
(UND)Calculation Logic(/UND)
(3.88 * [bike_lane]) * (1.75 * [landuse]) *
(3.25 * [angle_parking]) * (1.88 * [slope]) *
(3.88 * [speed]) * (4.25 * (curb_width]) *
(3.38 * [surface]) * (3.38 * [traffic_vol])
Map created from data obtained from the
City of Manhattan. Map created by CAB,
Kansas State University. March 4, 2008

Map 3.11: Manhattan Bicycle Master Plan Update
Proposed Bicycle Route Plan
Location of Destinations for Bicycle Commutuers





Map 5.1: Manhattan Bicycle Master Plan Update
Proposed Bicycle Facilities

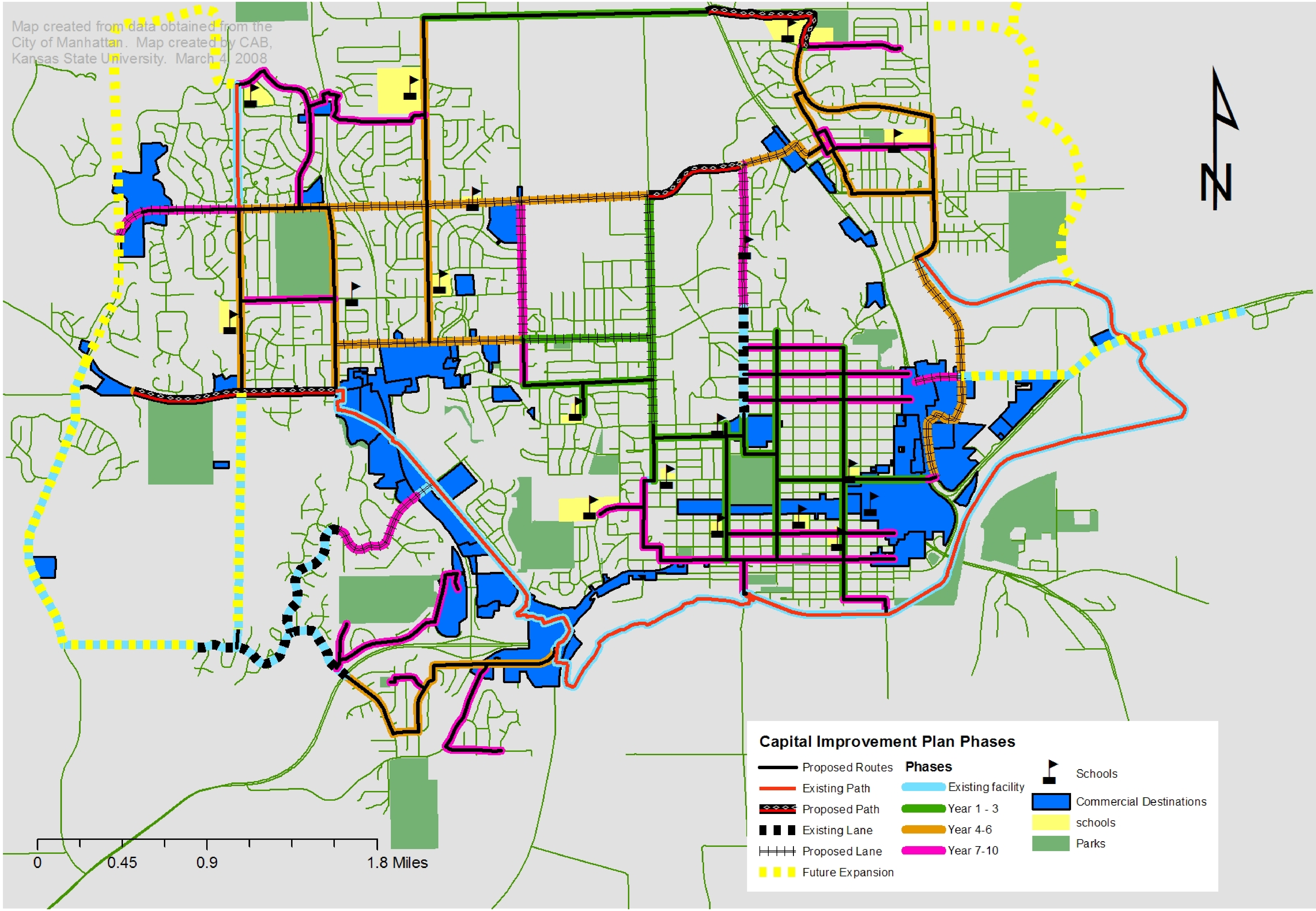


Figure 5.2: Manhattan Bicycle Master Plan Update Proposed Bicycle Facilities