POST-IMPLEMENTATION EVALUATION OF EMISSIONS BENEFITS OF CMAQ PROJECTS

Phase 2 Final Report

Submitted to
Chicago Metropolitan Agency for Planning

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Abstract

This study evaluates a random sample of eighteen bicycle and pedestrian facilities, sixteen of which were funded by the Congestion Mitigation and Air Quality (CMAQ) program in the Chicago metro area. Users of these facilities were surveyed in intercept mode during specific intervals of time starting in the summer of 2009 and ending in the spring of 2011, leading to 376 responses. Usage levels were also enumerated in all sites. The study showed varying levels of use at the different facilities and that motorized mode substitution (change from personal car use to bicycle and pedestrian modes) resulted after the facilities became available to users, potentially leading to improved air quality outcomes. There is also evidence of latent mode substitution, i.e., respondents self-reported that the current non-motorized trip could have been made by using motorized modes, but that they chose not to. The majority of users cited recreation and exercise to be the primary reason for using the facilities.

Site-level factors play an important role in the propensity to switch from being exclusively Single Occupant Vehicle (SOV) users to bicycle and pedestrian users, controlling for individual socio-demographic factors. Users of bicycle paths were less likely than pedestrians to have been SOV users for their trip purpose prior to starting use of the non-motorized facility. Bicyclists are more likely to self-report using public transportation or bicycles on alternative facilities prior to using the CMAQ-funded facility. Respondents surveyed in high density areas were also more likely to have been non-car users for the current trip prior to using the facility. Respondents surveyed in areas farther away from the center of the City of Chicago are more likely to have switched from SOV modes. Finally, respondents surveyed in areas with lower levels of car ownership are less likely to have used SOV modes for the current trip prior to using the facility.

The propensity to switch from being exclusively SOV users is positively correlated with the higher levels of Average Daily Traffic in highway links in surrounding census tracts and with the percent of population who speak limited or no English in surrounding areas. Finally, the ability to connect directly to a transit station is positively correlated while the recreational usage is negatively correlated with the propensity to switch from being previously exclusively SOV users for the trip purpose. Our analysis also found that depending on the location and overall sociodemographic, transportation and other characteristics of the surrounding areas, there are likely to be at least four groupings of CMAQ-funded projects that exhibit various combinations propensity to switch and overall use levels.

Although data on 4 randomly selected intersection improvement and 4 randomly selected signal interconnect projects ("roadway projects") were collected for the "before" period of a before-and-after evaluation of traffic outcomes, only two projects, both signal interconnect projects, were completed within the timeline of the project. The field observations reveal that there is a 7.15% and 10.68% improvement on the southbound and northbound direction respectively in one of the signal interconnect sites, which equates to a 2.8 mph and 3.2 mph increase in the southbound and northbound respectively. Field observations in the other location revealed that while there is a 5.81% improvement in speed (representing a 2mph increase) on the southbound direction, the northbound direction incurred a speed reduction of almost 11%, i.e., a 4.2 mph decrease in speed. Due to the extremely small sample size of completed before-and-after cases, we do not consider the results of the roadway project analysis to be conclusive or generalizable.

CHAPTER 1: INTRODUCTION AND SCOPE OF STUDY

1.1 BACKGROUND

The Congestion Mitigation and Air Quality (CMAQ) program was established by the Intermodal Surface Transportation Efficiency Act in 1991, following the passage of the Clean Air Act Amendments of 1990, which imposed strict new deadlines for meeting National Ambient Air Quality Standards (NAAQS) in nonattainment areas. The primary purpose of the CMAQ program is to fund transportation projects and programs that have a potential to reduce transportation related emissions. The initial focus of the CMAQ program was on areas designated as being in nonattainment for ozone and carbon monoxide, which were the pollutants of greatest concern when the CAAA and ISTEA were passed. Particulate matter became of concern later, when areas designated as being in nonattainment for particulate matter PM_{10}) became explicitly eligible to receive CMAQ funds under the Transportation Equity Act for the 21st Century (TEA-21). USEPA designations of nonattainment areas are based on violations of national air quality standards for carbon monoxide (CO), lead (Pb), ozone (O_3) (1-hour), particulate matter (PM_{10}), sulfur dioxide (SO_2) and previously, nitrogen dioxide (NO_2). Northeastern Illinois does not attain national ambient air quality standards for certain pollutants. It is classified as a moderate non-attainment area for the 8-hour ozone standard, and a non-attainment area for the annual fine particulate matter (PM2.5) standard. Currently, there are no nonattainment listings for nitrogen dioxide.

The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) program (2005-2009) authorized over $8.6 billion over the five-year authorization period, with annual authorization amounts increasing each year during this period (Federal Highway Administration, 2006). Under SAFETEA-LU, CMAQ funds may be invested in all 8-hour ozone, CO, and PM nonattainment and maintenance areas. It is also possible to expend funds in the few remaining1-hour ozone maintenance areas, since the 1-hour standard remains in effect for these areas. These counties also have Early Action Compacts in place (FHWA, 2006). Since 1991, the program has provided $22.7 billion in funding to states, Metropolitan Planning Organizations (MPOs) and transit agencies in US EPA designated non attainment and maintenance air quality areas to invest in projects that reduce criteria air pollutants emitted by transportation related sources. CMAQ funds have been used in the Chicago nonattainment area in Northeast Illinois (comprising of Cook, DuPage, Kane, Lake, McHenry, and Will counties, and part of Kendal and Grundy counties) to fund a variety of projects since 1992.

The overall goal of the project is to assess the effects of the CMAQ program as it pertains to selected non-motorized and roadway projects and as implemented in Northeastern Illinois, on the basis of primary (measured) and not modeled data on outputs and outcomes. The purpose of this report is to present the results of this study. The scope of the evaluation project is restricted to the evaluation of: (A) non-motorized: bicycle and pedestrian facilities that have been constructed using program funds and (B) roadway: intersection improvements and traffic signal improvement projects.

1.2 Objectives of the Study

The project has two major objectives:
1) *Determine the outcomes of investments on non-motorized facilities*: The outcome of interest with non-motorized projects is changes in trip-making behavior, specifically the diversion of trips from motorized to non-motorized modes such as biking or walking, due to program-funded non-motorized facilities.
2) *Determine the outputs of investments in roadway projects*: The primary output in the case of the roadway projects are changes in speeds of motorized traffic using road segments in which intersection improvement and traffic signal interconnect projects were implemented.

Description of the sampling design used to select sites for analysis, along with the data collection methods, is given in an earlier report titled "Post-Implementation Evaluation of Emissions Benefits of CMAQ Projects: Phase 1 Final Report" (Thakuriah, et al. 2010), and will not be reproduced here in detail. Very briefly, projects were randomly selected from the universe of CMAQ projects funded in each of the two project categories. A 16-item survey questionnaire was used to query bicycle and pedestrian users of the selected CMAQ non-motorized projects about a variety of factors relating to their sociodemographics, facility use patterns and their travel behavior prior to using the CMAQ-funded non-motorized facility including the mode of transportation for the trip purposes for which the respondent currently uses the facility, frequency of use and travel time spent for the same trip purposes. This enabled us to implement a "recall-after" approach to a "before-and-after" evaluation design, wherein a baseline or control was established by means of respondent's recall of their travel behavior "before" their use of the facility. Due to potential memory decay and recall problems, only recent projects funded by the program were considered for selection into the study sample. In the case of the roadway projects, traffic conditions such as speeds were measured at two different points in time – before the CMAQ-funded project was implemented and after. This allows us to compare changes in outcomes of interest such as speeds that can be attributed to the CMAQ-funded roadway project.

The study consisted of two phases:

a) Phase 1: This phase was completed in June 2009. We collected data from 10 bicycle and pedestrian projects and the "before" period data from 10 signal interconnect and intersection improvement projects. The report titled "Post-Implementation Evaluation of Emissions Benefits of CMAQ Projects: Phase 1 Final Report" (Thakuriah, et al. 2010) provides extensive details on the overall study methodology for the entire study (including Phase 1 and Phase 2), as well as the results of the Phase 1 data collection effort.

b) Phase 2: This phase was completed in June, 2011. Data were collected from an additional 8 non-motorized projects and the "after" period of 2 of the 10 roadway projects that were constructed within the overall project timeframe.

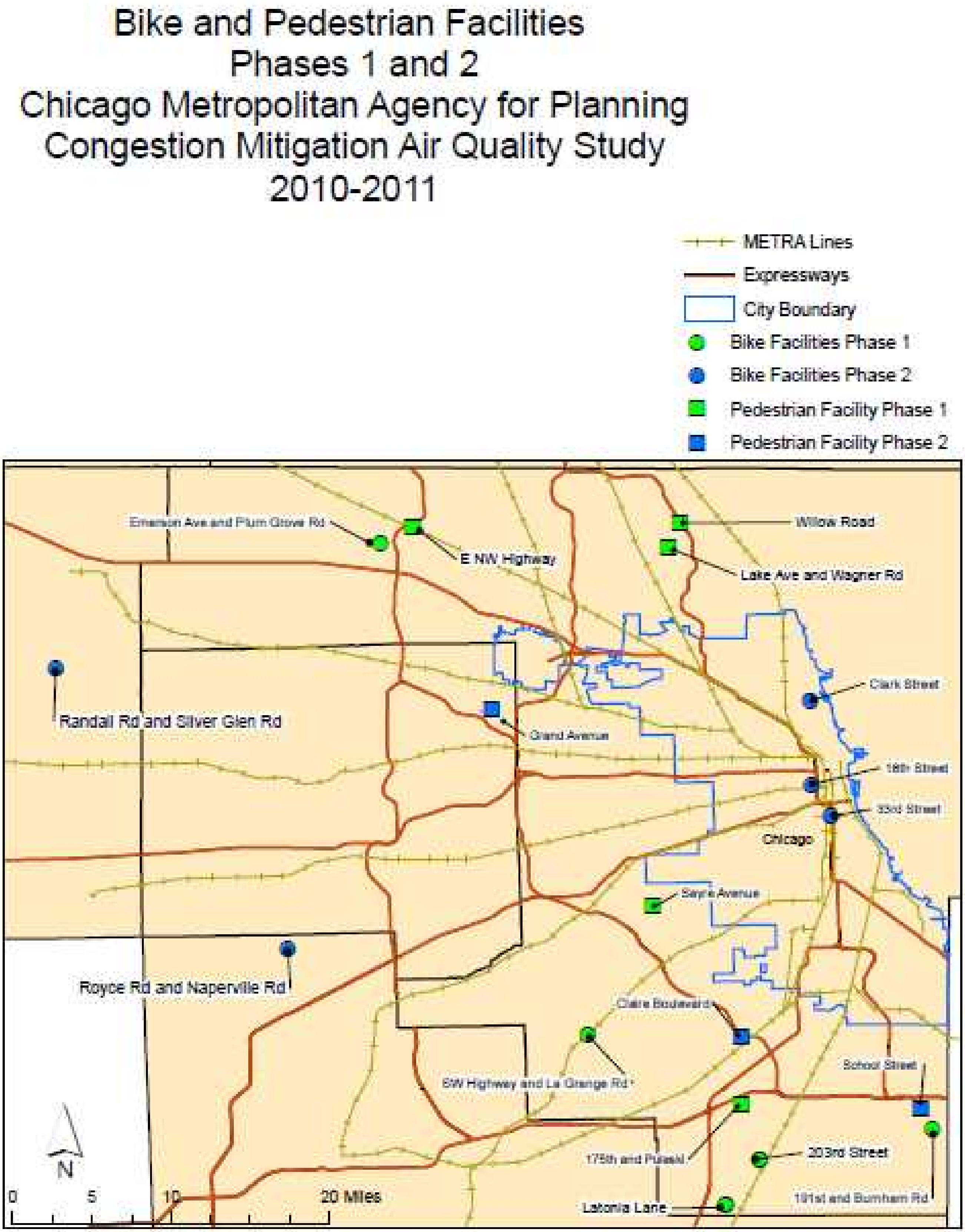
The results of the data collection effort, over these two phases, are as follows:

a) Non-motorized projects: In total, we surveyed users of eighteen bicycle and pedestrian facilities between the summer of 2009 and the spring of 2011, sixteen of which were funded by the CMAQ program and two projects that are very similar to the CMAQ projects but which were funded by other state and local programs. The locations of the non-motorized projects studied are given in Figure 1.1. Valid responses were obtained from 376 users.

b) Roadway projects: We also collected "before" data from eight roadway projects, 4 of which were signal interconnect and 4 were intersection improvement that were at the letting stage, before these were constructed or improved by means of CMAQ funds. However, by the time our project ended, construction/improvement in only two of the 8 projects for which before data had been collected had been completed. Hence, our sample of roadway projects for the completed before-and-after analysis consists of two projects.

The report is organized as follows: in Chapter 2, we present the results of the non-motorized project evaluation and in Chapter 3, we discuss the main findings from our evaluation of the roadway projects. Conclusions from the study are given in Chapter 4. A series of technical appendices present the details of various methodological aspects of the study.

Figure 1.1: Location of Bicycle and Pedestrian CMAQ projects in study sample



CHAPTER 2: ANALYSIS OF NON-MOTORIZED FACILITIES

2.1 BACKGROUND

The bicycle and pedestrian facilities considered in this study were randomly selected from a master list of non-motorized CMAQ projects that were completed upto two years prior to the survey date for each site. A preliminary list was created from a longer list of randomly sampled projects. We attempted to obtain more information about each site with the help of CMAP staff and from program managers and by means of site visits. Each site was visited and assessed to see what the current status of the project was and also to take photographs and to develop written descriptions of the facility. After this was completed, we were able to choose exactly which projects were going to be fully researched and surveyed. The final list included eighteen sites. Two of the listed pedestrian facilities, located in Lansing and Midlothian, were partially funded by the Safe Routes to School program. Two of the selected bicycle projects – one in Lansing (Lansing Greenway) and the other in Orland Park (US 45-IL7) – were not CMAQ-funded, but similar in scope and scale as the CMAQ projects. At each site, users were randomly selected for surveying, as described in Section 2.4. Refusals were recorded and every passing person was counted using specially-developed enumeration forms to obtain information on facility usage levels.

2.2 PHASE 2 FACILITIES

In this section, we describe the Phase 2 bicycle and pedestrian facilities in detail. The projects which were surveyed in Phase 1 are described in detail in the Phase 1 report, but for the sake of completeness, briefly included here, in Section 2.3.

2.1.1 PHASE 2 BICYCLE FACILITIES

(1) Clark Street from Diversey to Addison, City of Chicago

The first bicycle facility is located along Clark Street in the City of Chicago, between Addison Street to Diversey Parkway, and is a designated striped lane along both sides of the street. The facility is approximately 1.2 miles long. The facility is mainly used to access downtown Chicago and is heavily used during the rush hour. Land use around the facility tends to be a mix of commercial and residential. The facility passes through several neighborhoods and there are different land uses along the way. This site was surveyed twice during our survey period, once from 7:00AM to 10:00AM to record morning rush and once from 3:00PM to 6:00PM during the afternoon rush.

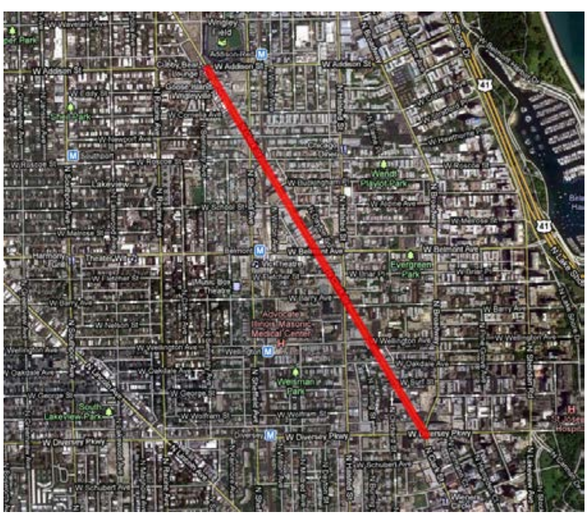


Figure 2.1 Bicycle lane on Clark Street, City of Chicago

(2) 18th Street, City of Chicago

The study also surveyed users of the bicycle lanes in a 1-mile long section along 18th Street from Loomis Street to Halsted Street, where 18th Street ends in a T-intersection. The lanes begin again half a block south of the T-intersection and eventually end at Clinton Street. As with Clark Street, the facility included a designated striped lane on both sides of the street and marking identifiers. We surveyed this site twice as well, once in the morning and once at night.

(3) 33rd Street from Halsted to Martin Luther King Drive , City of Chicago

The last bicycle facility that was surveyed in the City of Chicago is a bike lane along 33rd Street that passes through the Illinois Institute of Technology campus. The path is located from Halsted Street to Martin Luther King Drive, spanning 1.5 miles. Unlike the two other city sites (on Clark Street and 18th Street), 33rd Street does not have a designated lane, but has marked identifiers along the roadway thus allowing bicyclists to share the roadway with motorists. The site was surveyed once during the morning rush hour and once during the afternoon rush.

Figure 2.3: 33rd Street shared lane identifier

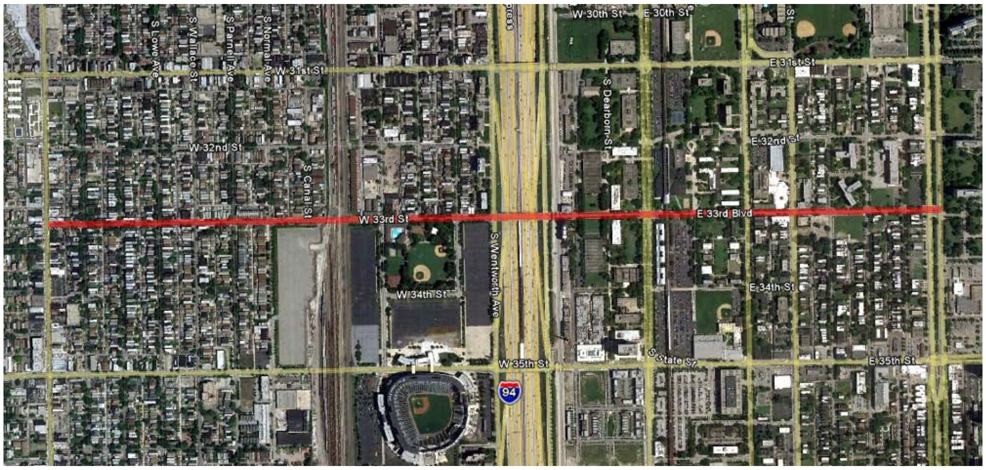


Figure 2.4: Location of shared lane facility along 33rd Street.

2.2.2 Phase 2 Mixed Facilities

Two of the suburban facilities surveyed in Phase 2 were considered to be mixed facilities allowing pedestrians and bicyclists to use the facility. At these locations, respondents who were biking or walking were asked to complete the survey. These locations were typically identified as trails and were located near parks and recreational facilities.

<u>(4) DuPage River Trail, Naperville</u>
The DuPage River Trail is a winding, mixed use pathway that is approximately 2.5 miles long and is located along or near the DuPage River through Kane and Will Counties. The CMAQ grant was used to fund an extension of the project in Will County in the southern parts of the City of Naperville.

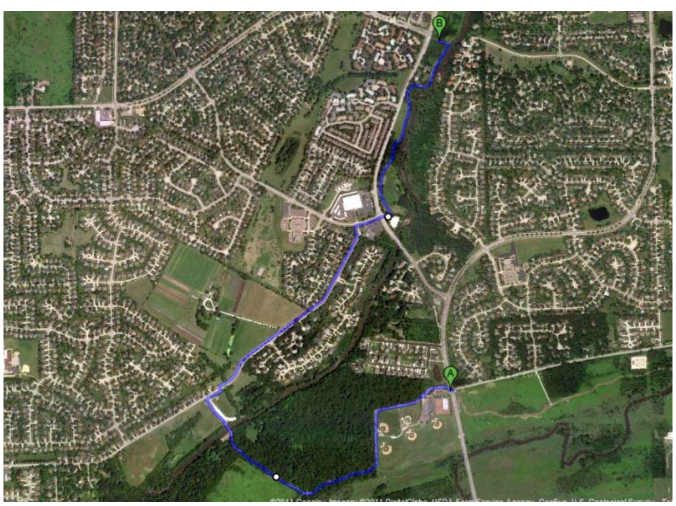


Figure 2.5: Segment of the DuPage River Trail surveyed in Naperville

(5) Randall Road Pedestrian Bridge, St. Charles
The second mixed use facility is located in St. Charles, Illinois, directly south of Elgin in Kane County. The facility is comprised of a large pedestrian/bicycle bridge that spans over the intersection of Randall Road and Silver Glen Road. The facility is a part of the larger River Bend Bike Trail that goes through the Blackhawk County Forest Preserve and eventually connects to the Fox River Trail which runs adjacent to the Fox River. The bridge was built in 2007 to provide better access to those using the trial. The bridge was constructed to provide bicyclists and pedestrians with a safe way to cross the busy Randall Road.

Figure 2.6: Pedestrian bridge over Randall Road, St. Charles

2.2.3 Phase 2 Pedestrian Facilities

The pedestrian sites that were surveyed in Phase 2 were located in the suburban areas of Chicago. The projects considered were either newly constructed sidewalks, extensions of existing sidewalks or the addition of traffic signals to facilitate street crossing. Two of the projects (Claire Boulevard sidewalk and the traffic signal installation at Ridge and School Streets) were part of the Safe Routes to School program as well as CMAQ. These projects were located close to schools and provided better access for students walking to and from school.

(6) Grand Ave Sidewalk from York Road to Church Road, Bensenville
The Grand Avenue sidewalk project is located on Grand Avenue in the Village of Bensenville, between York Road and Church Road. The sidewalk approximately 0.7 miles long . The sidewalk is located only on the north side of the street. The area is primarily commercial with several auto dealerships and commercial centers along Grand Avenue.

Figure 2.7: Grand Avenue sidewalk location

<u>(7) Claire Blvd, Midlothian</u>

The last two pedestrian facilities were co-funded by Safe Routes to School program. The first is a sidewalk along Claire Boulevard in Midlothian that connects neighboring communities to Springfield Elementary School. The sidewalk is approximately 0.2 miles long and extends from the Tri-State Tollway (I-294) to Springfield Street. The facility surveyed is located on the south side of the street.

Figure 2.8: Claire Boulevard sidewalk

(8) Ridge and School Streets, Lansing

The final facility surveyed in Phase 2 is located in Lansing and is a traffic signal construction project at the intersection of School Street and Ridge Road. The intersection is located very close to Lansing Memorial Junior High School and traffic signal project facilitates easier crossing by the many school children who walk everyday to and from the school.

Figure 2.9: Intersection of School Street and Ridge Road, Lansing

2.3 PHASE 1 FACILITIES

The CMAQ-funded facilities that were surveyed in Phase 1 are described in detail in the Phase 1 report. For the sake of completeness, we describe them here very briefly.

2.3.1 PHASE 1 BICYCLE FACILITIES

The first bicycle facility, in Rolling Meadows, was completed in 2006. It is a picturesque route about ½ a mile long through mostly wooded park and open space areas (Figure 2.10). The second bicycle facility, in Olympia Fields, is 1,260 feet long and was completed in 2007 (Figure 2.11). The third bicycle facility, in Richton Park, is 7,197 feet and was completed in 2007 (Figure 2.12). The fourth bicycle facility, in Orland Park, was completed also in 2007 (Figure 2.13). Finally, the fifth bicycle facility, in Lansing, is approximately 1.5 miles long and was completed in 2008 (Figure 2.14).

Figure 2.10: Bike path area in Rolling Meadows

Figure 2.11: Bike Path in Olympia Fields

Figure 2.12: Bike path in Richton Park

Figure 2.13: Bike path area in Orland Park

Figure 2.14: Bike path in Lansing

2.3.2 Phase 1 Pedestrian Facilities

All five pedestrian facilities surveyed in Phase 1 are sidewalks. The first sidewalk is located in Bedford Park and is approximately 2,550 ft long. The facility was completed in 2006. It is on the east side of Sayre Avenue from 75th St. to 79th St. (Figure 2.15). The second sidewalk, in Palatine, was completed in 2007 to improve access to the train station near Arlington Park racetrack (Figure 2.16). The third, in Northfield, was completed in 2008 to link the high school to downtown (Figure 2.17). The fourth sidewalk, in Country Club Hills, is about 0.5 miles long and was completed in

2007 to help with high school student access to and from school. Finally, the fifth sidewalk, in Glenview, is about a mile long and was completed in 2008 .

Figure 2.15: Pedestrian facility (sidewalk) in Bedford Park

Figure 2.16: Pedestrian facility (sidewalk) in Palatine

Figure 2.17: Pedestrian facility (sidewalk) in Northfield

2.4 SURVEY DESIGN

In order to properly analyze and understand the use of each facility, a 16-item survey instrument was created. The survey asked questions regarding the respondent's socio-demographics, reasons for use of the path, variations in seasonal trip making and time spent on the path. The survey also established the respondent's travel conditions prior to starting use of the facility. The resultant data allowed us to develop an understanding of each respondent's reason for taking the path and their daily trip patterns to assess the overall use of the facility. The survey instrument is given in Appendix A.

The questionnaire is a pen-and-paper instrument (PAPI) to implement the before-after study design based on the subjects' recall of their travel and transportation conditions before they started to use the facilities , and after. The details regarding questionnaire development are given in the Phase 1 report. The purpose of the questionnaire was to gather data on the research questions of interest and the design was specifically driven in order to implement the research design adopted. The broad topics covered in the instrument include the following:

- History of facility use including the time period at which the respondent first started to use the facility;
- Current facility use patterns including trip purposes, reasons for not using the facility for all trips for the stated purpose, access and egress points and connectivity to their final destination or intermediate transfer points such as parking lots and transit stations and bus stops, trip frequency;
- Facility use patterns over a whole year (asked for the summer, winter and fall/spring months);
- Transportation behavior prior to the facility use including the mode of transportation for the trip purposes for which the respondent currently uses the facility, frequency of use and travel time spent for the same trip purposes;
- Sociodemographics and other background characteristics, including facility access and egress points and the nearest intersection to the respondent's home location as well as the nearest intersection of their final destination.

2.5 Data Collection

In Phase 1, each site was visited two times for a full day shift. Each site was visited two times between the hours of 6:00 A.M. and 7:00 P.M. Days were divided into two shifts with teams of two reporting between 6:00 A.M. and 12:30 P.M. and between 12:30 P.M. and 7:00 P.M. The13-hour day was divided into 20-minute intervals, and during each interval, only one interview was completed. This was done to randomize among passers-by and to break up clustering patterns, including avoiding members of the same family. We received a total of 297 completed surveys from Phase 1. The breakdown, in terms of total enumerated, refusals, number completed and the response rates for Phase 1 projects are shown in Table 2.1.

Table 2.1: Facility list showing number of completed surveys, the number of refusals reported and the total population of reported during the survey periods – Phase 1 facility list

Project Name	Facility Type	City	Completes		Refusals	Enumerated (over 26 hours)
			Number	Percent		
Plum Grove Rd.	Bicycle	Rolling Meadows	36	12.1%	32	289
Palatine Sidewalk	Pedestrian	Palatine	42	14.1%	3	202
Happ Sidewalk	Pedestrian	Northfield	34	11.4%	28	219
Wagner Rd. Sidewalk	Pedestrian	Glenview	16	5.4%	15	168
Sayre Ped	Pedestrian	Bedford Park	42	14.1%	40	205
Forest Preserve	Bicycle	Olympia Fields	30	10.1%	6	111
175th. St. Sidewalk	Pedestrian	County Club Hills	23	7.7%	2	255
Latonia-Imperial	Bicycle	Richton Park	5	1.7%	6	38
Lansing Greenway*	Bicycle	Lansing	36	12.1%	15	300
US 45-IL7 Bike*	Bicycle	Orland Park	33	11.1%	11	258
Total			297		158	2045

* Not funded by the CMAQ program.

In Phase 2, three surveyors were usually present at each site. One surveyor oversaw the collection process. Another surveyor approached the bicyclists or pedestrians to request them to complete survey. The last surveyor enumerated every bicyclist or pedestrian using the facility during the allotted time, using the Enumeration Form given in Appendix B. Bottles of water and snacks were given to each respondent who chose to take the survey to thank them for their participation.

As mentioned, enumeration was done to determine the overall use of the facility during the rush hour times. The form also allowed us to note information concerning demographics and use of the path. This included race, the approximate age of the user and which direction they were travelling. The outcome of our respondent recruiting effort was also noted on the form. If a surveyor approached a user and asked them if they would fill out the survey and the user declined, it was noted as a refusal. The refusal form is given in Appendix C. If the user completed the survey on site, it was noted as complete. In some circumstances, users were not able to fill out the survey on site, but would take it with them and mail back the completed survey. They were noted as “mail backs.” For those that were not asked (usually due to them travelling on the other side of the street or if someone seemed to be a minor) they were coded as “NA” or not asked.

In some of the sites for Phase 2, however, due to the low number of users, we noticed that waiting for 20 minutes to approach someone drastically limited our expected completion rates. For example, if we approached someone during each interval and they refused we would have to wait another 20 minutes to ask someone again. This method was replaced by asking anyone who passed at anytime to take the survey. In the end we were able to receive many more surveys by this method.

Additionally, in Phase 2, sites were surveyed a variable number of times. The Grand Avenue sidewalk, the intersection of School and Ridge Streets and the Claire Boulevard sidewalk projects were only surveyed once during the survey period. For the most part, this was due to weather conditions during that time. Also, some of these sites represented some of the lowest levels of use compared to other projects. The pedestrian bridge over Randall Road in St. Charles was visited three times during the survey period. The first two times were done during rush hour periods from 7:00AM to 10:00AM and from 3:00PM to 6:00PM. The results from these two site visits yielded a very small number of enumerated persons using the facility. Also, no surveys were completed during both site visits. It was noted by those at CMAP that the site was probably used more frequently during the weekend for recreational purposes. On Saturday, June 4, 2011, the site was surveyed for a third time from 11:30AM to 2:30PM to determine its overall use on weekends. 37 persons were enumerated and we received 7 surveys.

In the end, we received 79 completed surveys from the Phase 2 projects. This includes surveys completed by respondents on site and also those mailed back. The highest response rate was for the DuPage River Trail in Naperville. The lowest was from the intersection improvement at Ridge and School Streets where no persons were surveyed because although usage levels was quite high, all users appeared to be under 18 years of age and we were not allowed, by our Institutional Review Board (IRB) requirements, to survey persons less than 18 years of age. Table 2.2 shows the Phase 2 results.

Table 2.2: Facility list showing number of completed surveys, the number of refusals reported and the total population of reported during the survey periods – Phase 2

Project Name	Phase	Facility Type	City	Completes		Refusals	Enumerated (over 6 hours)
				Number	Response rate		
Clark Street	2	Bicycle	Chicago	23	5.4%	146	275
Randall Rd. Pedestrian Bridge**	2	Mixed	St. Charles	7	29.2%	17	37
DuPage River Trail	2	Mixed	Naperville	7	63.6%	4	14
Grand Avenue*	2	Pedestrian	Bensenville	0	0.0%	8	14
Claire Blvd*	2	Pedestrian	Midlothian	1	50.0%	2	6
33rd St.	2	Bicycle	Chicago	14	37.9%	23	63
18th St.	2	Bicycle	Chicago	27	34.8%	52	162
Ridge and School Sts.*	2	Pedestrian	Lansing	0	0.0%	0	145
TOTAL				79		252	716

**Site was surveyed three times
*Site was surveyed once

2. 6TRENDS IN BICYCLE AND PEDESTRIAN FACILITY USE

This section presents the findings from the bicycle and pedestrian use data acquired from the intercept survey during Phases 1 and 2 of the project. Phase 1 surveying was done during 2009 while most of Phase 2 surveying was done in 2010, although a few sites were surveyed during the spring of 2011. Although we surveyed at different times of the year, the data is still consistent for each site. Many questions ask the respondent to check all values that apply. Thus on many of the following graphs, the percentage values do not add up to 100%.

2.6.1 USAGE LEVELS

Table 2.3 shows the usage of each site from Phases 1 and 2. For Phase 1 projects, in total 26 hours was spent at each site to collect data and enumerate. For Phase 2, only rush hour periods were surveyed which represented 6 hours of complete surveying. Many of the new sites that were surveyed (Clark Street through DuPage River Trail) in Table 2.3, show low usage during the morning and afternoon rush hours. The Grand Avenue sidewalk only average .67 persons per hour during our site visits which represented the lowest amount on any site. The sidewalk in Midlothian was also sparsely used by persons in the community and only averaged 2 users per hour.

Table 2.3: Usage levels per site (estimated hourly volume)

Location of project	Mode	Type of project	Estimated average hourly volume
Rolling Meadows	bicycle	Bike Path	11.12
Olympia Fields	bicycle	Bike Path	4.27
Richton Park	bicycle	Bike Lane	1.46
Orland Park	bicycle	Commuter and Bicycle Bridge	9.92
Lansing	bicycle	Bike Path	11.54
Bedford Park	ped	Sidewalk	7.88
Palatine	ped	Sidewalk	7.77
Northfield	ped	Sidewalk	8.42
Country Club Hills	ped	Sidewalk	9.81
Glenview	ped	Sidewalk	6.46
Clark Street	bicycle	Bike lane	45.67
33rd Street	bicycle	Bike lane	5.16
18th Street	bicycle	Bike lane	27.00
Grand Avenue	ped	Sidewalk	0.67
Randall Road	mixed	Bicycle/pedestrian bridge	7.83
Lansing	ped	Sidewalk	48.00
Midlothian	ped	Sidewalk	2.00
DuPage River Trail	mixed	Bike Path	4.00

The sites with the highest usage were typically bike lanes along major streets in the City of Chicago. For example, Clark Street averaged 45.67 users per hour during the peak periods of the day. The Ridge and School Street pedestrian project in Lansing site also saw a large number of users during rush hour periods. This was due to its proximity to a local school that many children in the area walk to and attend. It needs to be noted that although counts were high, we could not survey the school children because of their age due to restrictions put by our institution's Institutional Review Board (we did not approach any person who looked to be less than 18 years of age); hence the number of survey responses from this site is 0.

2.6.2 Trip Purposes and Reasons for Using Non-Motorized Facility

Figure 2.18 shows that, in general, most respondents (68.0%) use the path for recreational purposes, with many using the paths for exercise. Errands/ personal business were reported by 30% of those surveyed and commuting as a trip purpose was reported by 37.7%. Close to 3% of the trips were categorized as other. In this question, respondents were given the option to choose multiple answers.

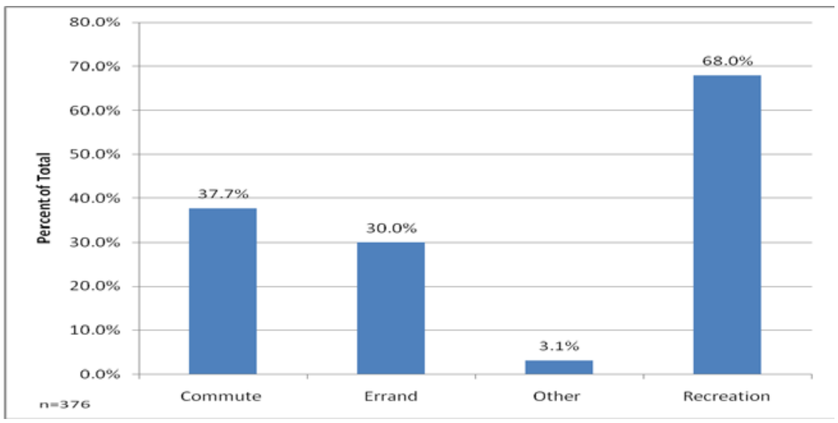


Figure 2.18: What are the reasons for which you use this path?
(Respondents could "CHECK ALL THAT APPLY")

Figure 2.19 shows that recreation was the most cited reason as to why the respondent chose to use the path (57.9%) on the survey day. Convenience was also noted as being important to the choice of path with 52.3% indicating that it was convenient to use the facility on the survey day. Close to 20% self-reported the environment as being a factor along with 10.9% stating that biking or walking was a less costly alternative. 18.3% responded that there was no other way to make the trip and 6.3% stated other reasons.

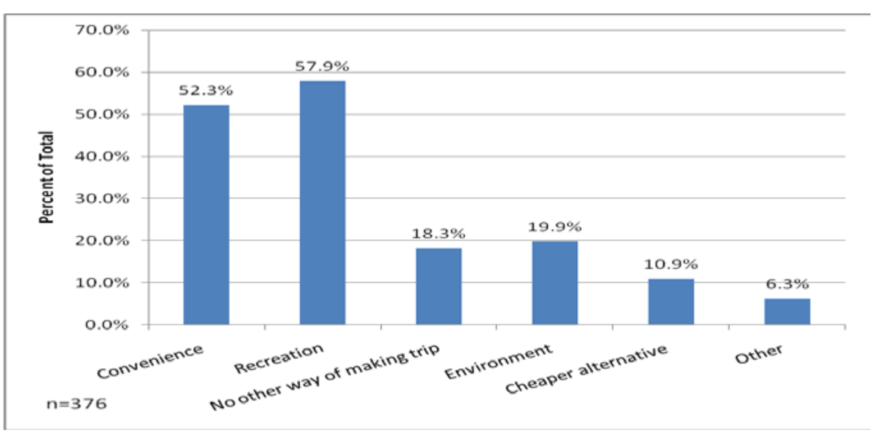


Figure 2.19: Why did you choose to use this path today?
(Respondents could "CHECK ALL THAT APPLY")

Figure 2.20 shows that 76% of those surveyed answered that they always use the path for the trip purposes stated in the first graph. 24% responded that the path did not always use the path for that reason.

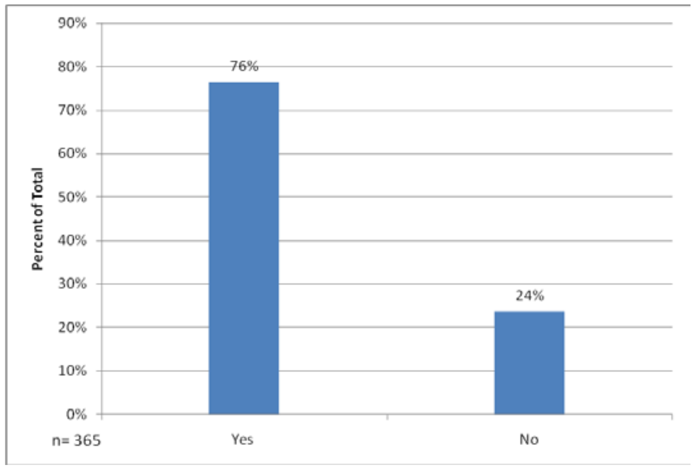


Figure 2.20: Do you always use this path for your trips for the purpose indicated above?

2.6.3 *ALTERNATIVE TRANSPORTATION*

Figure 2.21 shows that the majority of respondents stated that if the path was available, they would have biked or walked elsewhere (54.4%). About 19% responded that public transit would also be an option. Private car was seen as an alternative option by 29.3% of those surveyed along with 14.9% stating that shared ride was available. Only 12.5% would not have made the trip if the path was not present and 4.2% responded with other reasons.

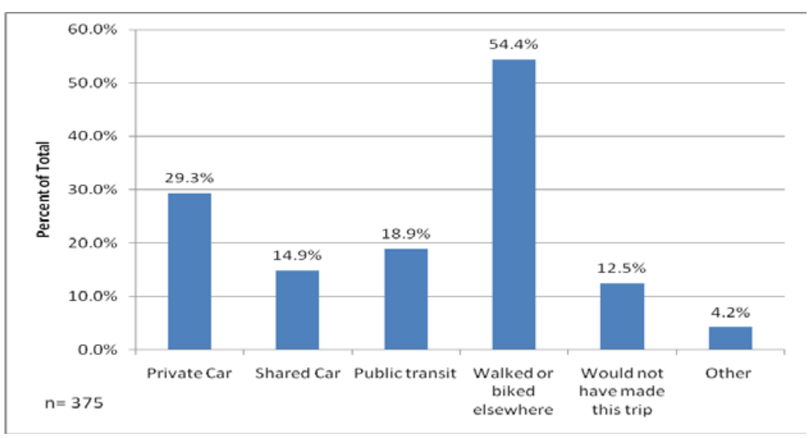


Figure 2.21: How else could you have made this trip?
(Respondents could "CHECK ALL THAT APPLY")

2.6.4 *Seasonal Trends*

The results of the survey showed that respondents use the facilities in greater frequency during the summer months compared to other seasons. The average weekly trip number for summer was 7.9 trips and the spring and fall season averaged 7.9 trips per week. A sharp decline was seen for trips during the winter season. Respondents only averaged 4.9 trips per week. Figure 2.22 shows the results.

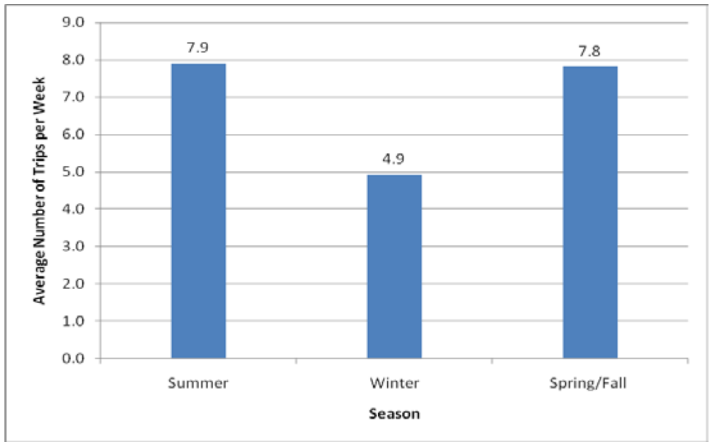


Figure 2.22: How many times per week do you typically use this path during the summer, winter and the fall and spring months?

2.6.5 *Trip purposes*

We asked those who responded that they did not always use this particular path to reach their final destination for their reasons behind that choice. The majority (40.1%) responded with other reasons not listed, for example, 9.8% responded that weather conditions played an important factor in them not using the facility. 21.2% responded that a car was needed for that trip at certain times along with their own personal safety cited as a reason by 21.9% of the respondents in this category. Family reasons were seen as a factor for 9.2% of the respondents. This included dropping off or picking up a family member as well as the transportation of children. These trends are shown in Figure 2.23.

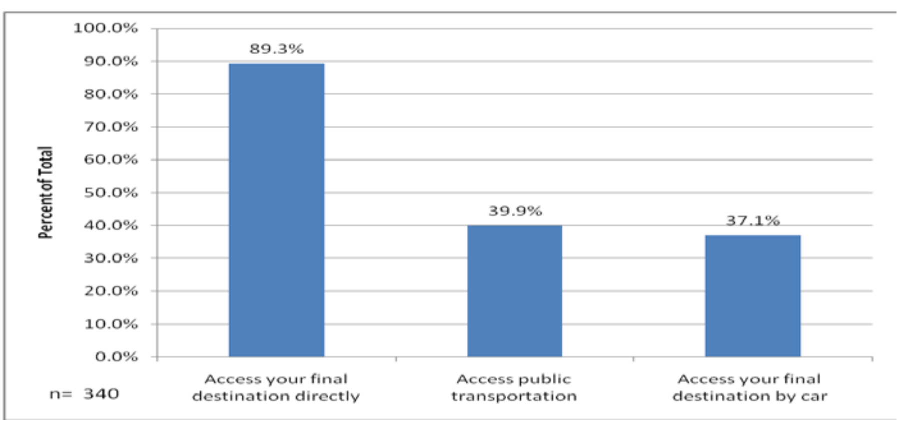


Figure 2.23: What are the reasons for not using this path for all of your trips for the purpose indicated above? CHECK ALL THAT APPLY

Figure 2.24 depicts responses for the question that dealt with how well the path gives access to the respondent's final destination. Close to 89% responded that the path allowed direct access to their final destination. Only 39.9% said that the path would eventually lead them to public transit (either a bus or train station) that they would then take to their final destination. 37.1% cited that they could use the path to then get access to a vehicle that they could then drive to their final destination.

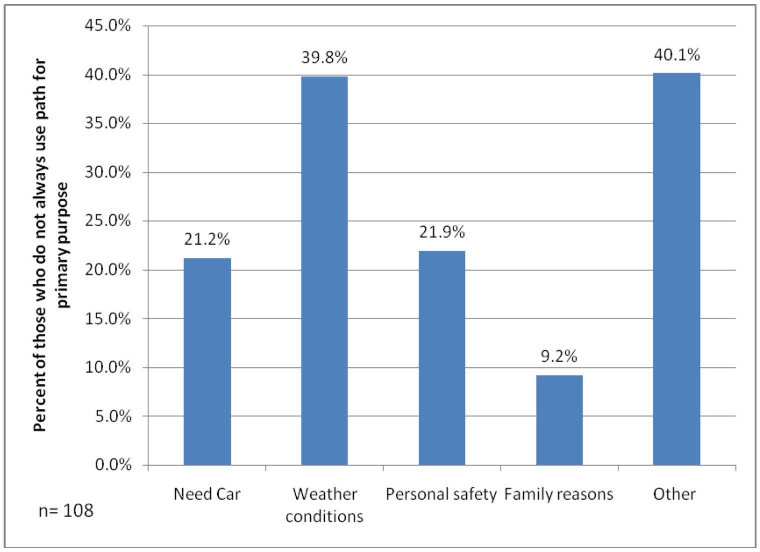


Figure 2.24: Accessibility reasons for using facility. CHECK ALL THAT APPLY

2.6.6 Duration of Facility Use and Travel Times

As shown in Figure 2.25, about 37% typically spend less than 10 minutes on the path. 23.8% responded that it takes them 11 to 20 minutes on the path to reach their destination, while 16.6% spend between. 21 to 30 minutes. The remaining respondents spend more than 30 minutes on the path.

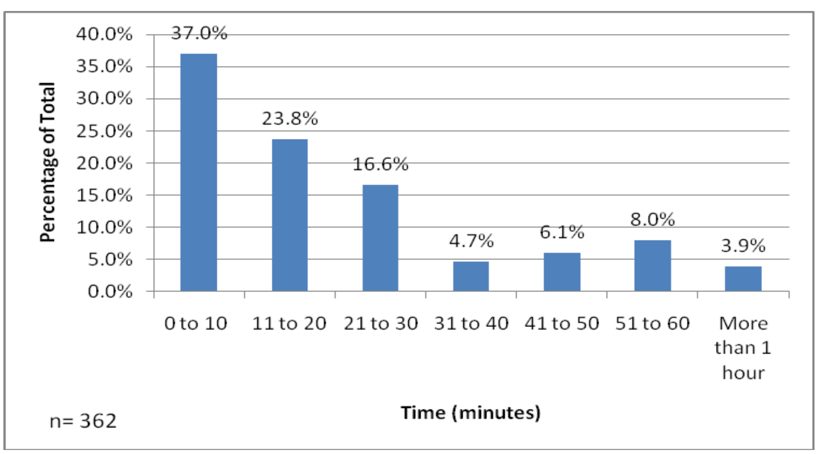


Figure 2.25: How much time do you typically spend on this path for this trip?

Figure 2.26 graphically depicts responses to the question on total door-to-door travel times (including the time spent on the path and additional time for access and egress to and from their trip origins and destinations). The majority of those asked said the total amount of time was between 21 and 30 minutes. Close to 16% said the overall time took on average 11 to 20 minutes.

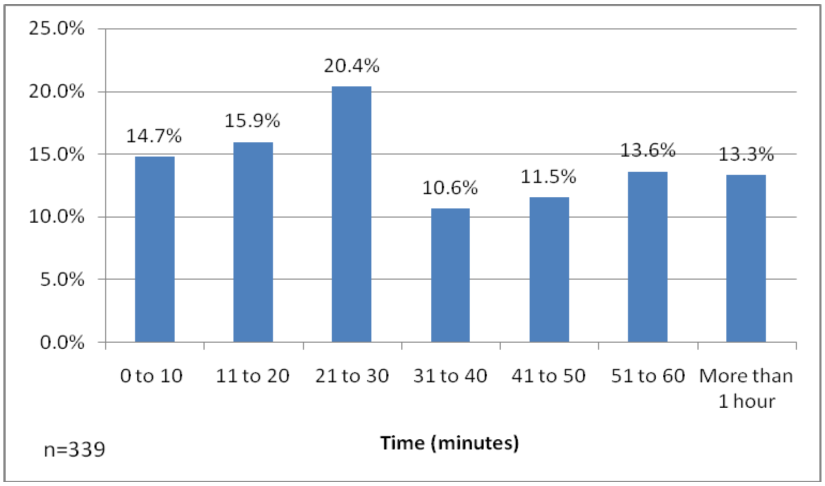


Figure 2.26: How long is your overall (door-to-door) trip? This will include time off the path.

Figure 2.27 gives the distribution of responses for a major policy question in the current analysis – the percent of respondents who indicated that they changed to the current non-motorized path use from car or shared-car (motorized) modes for their current trip purpose. This question indicates the extent to which air quality gains may have accrued as a result of the facility.

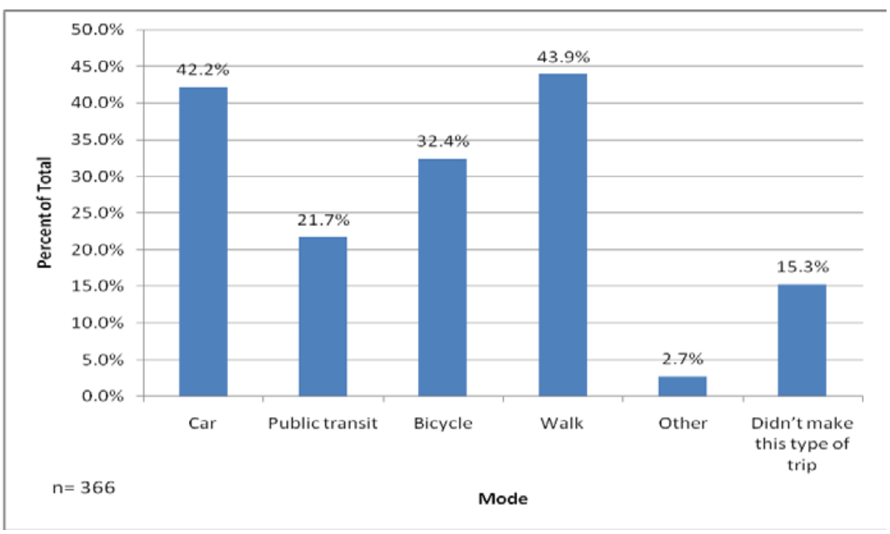


Figure 2.27: Before you began using this path for this type of trip, what type of transportation did you use? CHECK ALL THAT APPLY

Public transit was noted by 21.7% to be the previous mode used to reach their destination, before starting use of the path. Close to 32% responded that previously they would still ride a bicycle on alternative paths to arrive at their final destination, even though the CMAQ-funded path was not available at that time. Walking was noted by 43.9% of those asked as a previous mode. About 42% responded that they previously used a car before the path was available. Of these respondents, 16% reported being exclusively car users for the trip purpose prior to using the service.

Figure 2.28 gives site-level estimates of the percent of respondents whose only other travel alternative is a car and those who reported being exclusively car users for the trip purpose prior to starting to use the CMAQ-funded non-motorized facility. Blue represents the percent of those who exclusively switch from private car to bike or pedestrian, ie, they were previously, prior to the availability of the path, exclusively car users for the trip purpose that was being undertaken at the time of the survey. The red bars represent the percent for whom the only other alternative mode of travel for the current trip is private car, ie, they represent the percent of respondents, who, if the path was not available on the day of the survey, would have to use a private automobile.

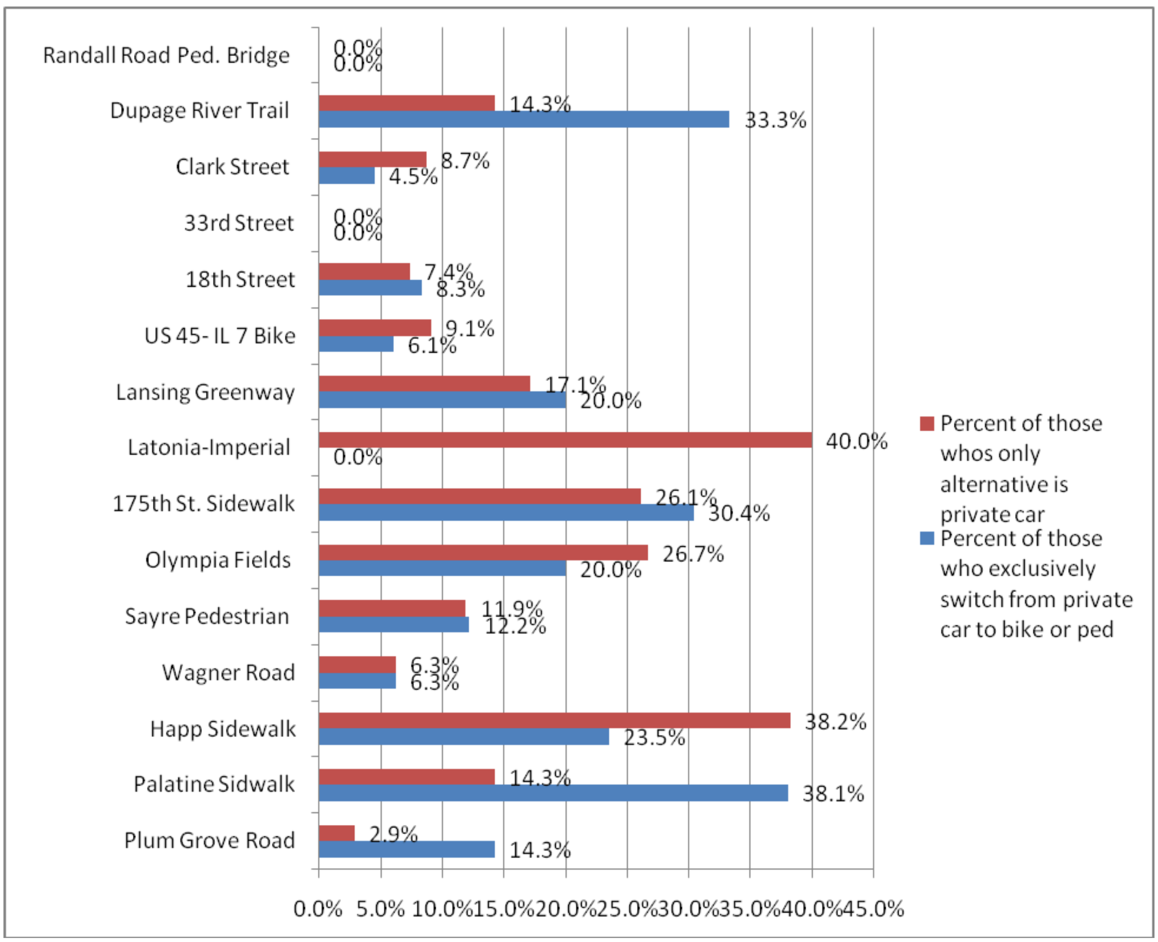


Figure 2.28: Site-by-site comparison of (A) percent for whom a private car is the only other mode of transportation available for the current non-motorized trip and (B) percent who were exclusively private car users for the trip purpose prior to the availability of the path

2.7 Analysis of Results

Since CMAQ funds projects to improve air quality and to relieve congestion, and since the potential of a facility to provide non-motorized alternatives to the Single Occupant Vehicle (SOV) is a major factor in funding allocation decisions, we consider a policy variable *D_CarChange,* which is a binary variable that takes a value of 1 if the respondent indicated that they were exclusively solo car drivers (excluding shared rides) for the particular trip purpose (e.g., shopping, work, etc) prior to using the facility, and 0 otherwise. Overall, 16% of all respondents surveyed indicated that they drove a car exclusively for the trip type prior to the availability of the path, with the remaining respondents indicating that they previously walked, biked, used public transportation or shared rides for their current trip purpose. Figure 2.29(A) shows the percent who switched from being exclusive car users for the trip type at each site, against estimated hourly volumes. A slightly decreasing relationship appears to be observed.

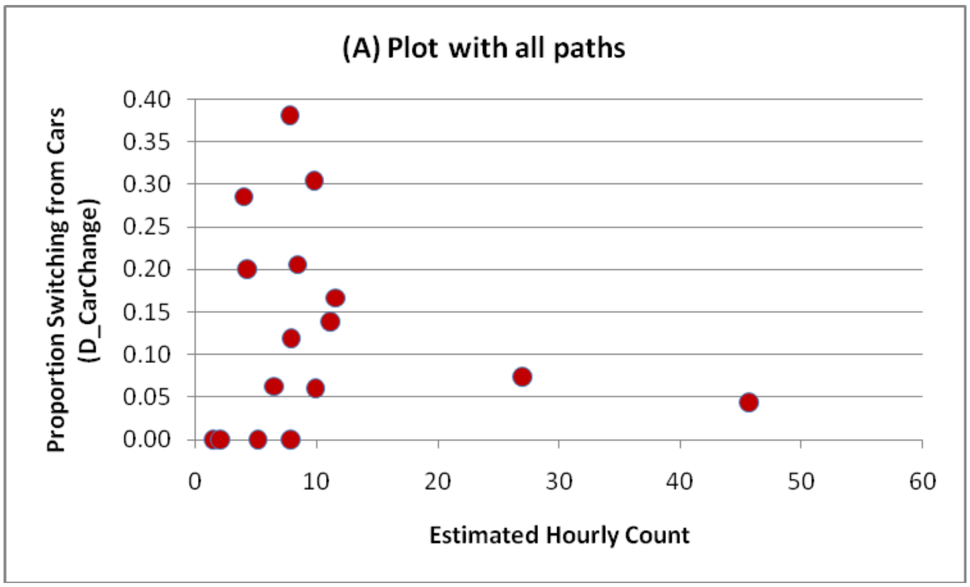


Figure 2.29(A): Percent who switched from being exclusive car users for the trip type at each site, against estimated hourly volumes

However, if the sites with very high counts per hour are removed, as in Figure 2.29(B), the percent who switched from being exclusive car users appear to increase linearly with hourly counts, although there is a great deal of site-to-site variability.

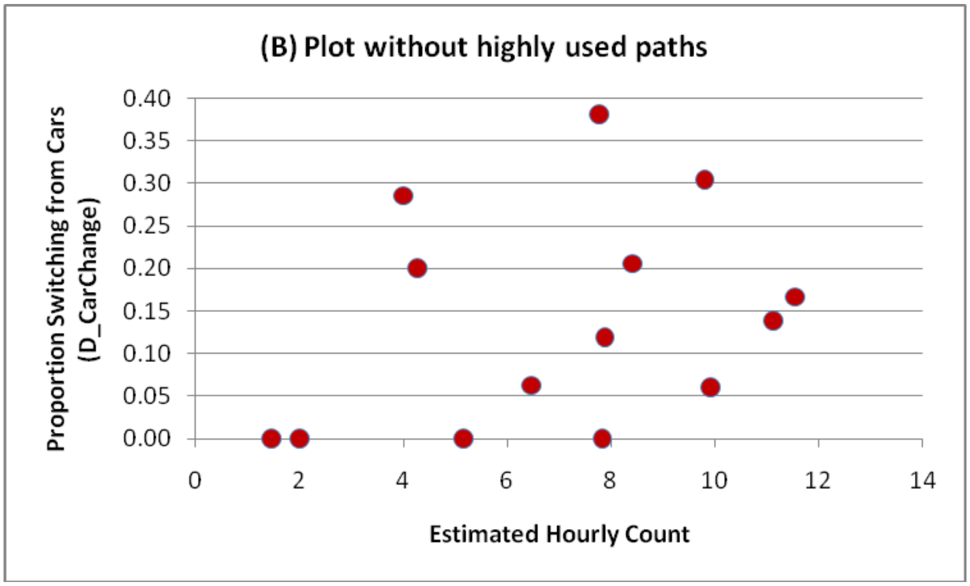


Figure 2.29(B): Percent who switched from being exclusive car users for the trip type at each site against estimated hourly volumes, with high usage sites removed

Emphasis is given in the Chicago area project selection process on both bicycle and pedestrian facilities that reduce automobile travel (Chicago Metropolitan Agency for Planning, 2011). Proposals for bicycle and pedestrian projects for the FY 2012-2016 grant cycle solicits information on the miles of existing bicycle/pedestrian facilities intersecting the proposed facility, trip attractors (work centers, transit facilities, schools and shopping centers) linked directly to the proposed facility, and for off-street bicycle facilities, the traffic volumes, speeds and percent trucks on adjacent roadway.

In addition, proposers are required to show any major land uses connected by the proposed facility, e.g., schools, shopping centers, office centers, recreation sites, and residential neighborhoods. Information on outreach and marketing of the facility is also required. Weights are applied to a selection of these factors and to internally derived factors such as the population of the surrounding area (a mile for bike projects and a half-mile buffer, for pedestrian projects); these weighted factors, along with fixed SOV diversion rates of 0.43 for all proposed bike projects and all 0.5 for pedestrian proposals, are used to estimate reduction in daily Vehicle Miles Traveled (VMT), and ultimately to air quality impacts. Projects are prioritized on the basis of technically derived expected air quality benefit estimates; however, availability of matching funds and several additional considerations enter into final project selection, including "regional equity, project readiness and project mix" (CMAP, 2011).

Our objective here is to understand the types of factors that contribute to the propensity of users to switch from cars. The major variables used in this part of the analysis are given in Table 2.4. Part I of the table give variables on the respondent's socio-demographics and use factors (person-level factors), Part II gives site-level descriptors and usage levels and Part III gives site-level variables from secondary sources including the Census 2000 and a Spatial Decision Support Systems (SDSS) created by the authors.

Table 2.4: Major variables used in the analysis (see footnote for explanation of significance of correlation coefficient)

Variable	Description	Means	Correlation Coefficient with D_CarChange
D_CarChange	1 if the respondent was exclusively solo car driver (excluding shared rides) for the particular trip purpose prior to using the facility, and 0 otherwise	0.16	1
Part I: Person-Level Factors			
gender	gender of interviewee; 1 if male; 0 if female	0.60	-0.00339
age	age of respondent	43.41	0.04765
finaldestconnect	1 if path connects respondent to final destination; 0 otherwise	0.89	-0.04497
finaldesttransit	1 if path connects respondent to transit; 0 otherwise	0.40	0.10248
pathchoose_recex	1 if trip purpose is recreation; 0 otherwise	0.68	-0.15348
pathchoose_errand	1 if trip purpose is to run errands; 0 otherwise	0.30	0.06285
propttime	proportion of total travel time spent on facility	0.81	-0.05918
Part II: Site-Level Descriptors and Usage Levels			
facility_type	facility type where interview took place; 1 if bicycle path; 0 if pedestrian path	0.54	***-0.15384***
bike	mode of transportation of respondent; 1 if bike, 0 if pedestrian	0.38	-0.05305
Hourly_count	Estimated hourly volume	17.63	-0.13
			0
Pop00_Density	Population /square mile in census tract	6,049.66	***-0.14205***
Transit Availability Index	Composite index giving the extent to which residents have access to transit (bus and rail); based on three input measures – frequency (person-minutes served), hours of service (number of hours) and service coverage (percentage of census tract area covered	0.57	0.01957
Pedestrian Environment Factor	Composite index ranking tract suitability for pedestrian travel; based on input values of population, income, number of households, amount of commercial and residential land uses as a percentage of census tracts, weighted trip origins and destinations	26.88	0.08192
Dist_citycenter	Distance (miles) to CBD	27.09	***0.14935***
Sum_AADT	Total annual average daily traffic on links of all highway functional classes within census tract; output from regional traffic assignment model and GIS	570,862.62	**0.10629**
PercentLowEng	Percentage of persons who speak no English or limited English (Census 2000 data)	0.29	**-0.10408**
PercentChildren	Percentage of population under the age of 16 (Census 2000 data)	0.27	-0.07373
PercentNoCars	Percentage of population without access to a vehicle (Census 2000 data)	0.09	***-0.15283***

Italicized and bold: Significant at .01 level
Bold: Significant at .05 level
Underlined: Significant at .10 level

Table 2.4 shows that the following variables have a highly significant correlation with *D_CarChange* (at $p < .01$):

1) *Facility type*, with bicycle facilities having a negative correlation with *D_CarChange*, indicating that the respondents surveyed in bicycle facilities were more likely to have been using other non-car modes for the current trip prior to using the facility;
2) *Population density of surrounding census tracts*, also having a negative correlation with *D_CarChange*, indicating that the respondents surveyed in high density areas were more likely to have been using other non-car modes for the current trip prior to using the facility;
3) *Distance from City Center* (State and Madison Streets) is positively correlated with *D_CarChange*, indicating that the respondents surveyed in areas farther away from the center of the City of Chicago are more likely to have switched from SOV modes for the current trip after to using the facility;
4) *Percent of population with no cars in surrounding census tracts* has a negative correlation with *D_CarChange*, indicating that the respondents surveyed in areas with lower levels of car ownership are less likely to have been using SOV modes for the current trip prior to using the facility.

Table 2.4 also shows that the following variables have a significant correlation with *D_CarChange* (at $p < .05$):

1) *Average Daily Traffic in highway links in surrounding census tracts* is positively with *D_CarChange*, indicating that the respondents surveyed in areas with heavier levels of motorized traffic are more likely to have switched from SOV modes for the current trip after to using the facility;
2) *Percent of population who speak limited or no English in surrounding census tracts* is negatively correlated with *D_CarChange*, indicating that respondents surveyed in such areas are more likely to have already been using non-motorized modes for the current trip prior to using the CMAQ-funded facility.

Finally, Table 2.4 also shows that the following variables have a statistically weak correlation with *D_CarChange* (at $p < .10$):

1) *Ability to connect directly to a transit station* is weakly but positively correlated with *D_CarChange*, as these individuals are potentially able to use non-motorized modes to access transit stops to reach their final destinations due to the CMAQ-funded facility, thereby enabling them to switch from private cars to access transit;
2) *Recreational usage* is weakly and negatively correlated with *D_CarChange*, as these individuals are probably already using other forms of non-motorized modes or in other locations for recreational purposes.

The variables discussed above may interact in different ways to create groupings of CMAQ-funded sites, in terms of how *D_CarChange* changes with different combinations of variables. To test this idea, we conducted a cluster analysis using *D_CarChangeE*, *Hrly_Count*, *Pop00_Density*, *Dist_CityCenter* and *PercentNoCars* as clustering variables (we tried different various combinations of variables and these variables gave the best fit). The cluster analysis results are shown in Table 2.5. There are four clusters of facilities, with unequal sample size in each cluster.

Table 2.5: Results of Cluster Analysis

	Clusters			
Variable	**A**	**B**	**C**	**D**
D_CarChange	0.18	0.17	0.04	0.04
Hourly_count	6.56	10.28	91.67	37.50
Proportion Less than 25 Years	0.29	0.41	0.17	0.54
Pop00_density	1,691.06	4,058.07	29,418.00	20,920.98
finaldestransit	0.32	0.29	0.50	0.83
finaldestconnect	0.92	0.83	0.95	0.94
Peestraian Environment Factor	29.60	24.17	9.01	25.82
Sum_AADT	686,640.63	330,258.33	54,750.00	282,961.11
PercentLowEng	0.21	0.17	0.17	0.79
Dist_CityCenter	27.58	26.77	4.16	2.75
Pathchoose_commute	0.32	0.14	0.87	0.71
Pathchoose_Errand	0.26	0.19	0.65	0.65
Pathchoose_Recreational	0.72	0.79	0.57	0.62
PercentNoCars	0.05	0.04	0.30	0.28
PercentChildren	0.28	0.32	0.16	0.30
Ratio of time on facility to total travel time	0.78	1.03	0.49	0.56

Cluster A: Long-Distance Transit-Based Commuting Facilities: *Facilities that lead to the highest levels of switching in the sample from solo car use (18%) on the average and with greatly lower levels of usage on an hourly volume basis (an average of only 7 users per hour)*. These facilities are located in extremely low-density areas and are the farthest away from the center of the City of Chicago, but connect a larger share of users to public transportation than Cluster 1 facilities, thereby increasing the ability of users to use the facility for part of their commuting trip. Reflecting the commuting nature of the facility use, average ages of users are higher (only 29% are less than 25 years of age). The walkability levels in the surrounding neighborhoods are the lowest of all clusters and highway network links in the surrounding areas have the highest levels of Average Annual Daily Traffic. Cluster 3 users tend to spend the longest proportion of time on the facility out of their total travel time (78% of their total time spent in travel is on the facility). The facilities in Palatine, Northfield, Glenview, Bedford Park, Olympia Fields, Richton Park, Lansing and the DuPage River Trail are in this cluster.

Cluster B: Recreational Facilities for Discretionary Usage: *Facilities that lead to high levels of switching from solo car use (17%) for the trip purpose for which the respondent was traveling at the time they were surveyed, but with fairly low levels of total usage, on an estimated hourly volume basis (about 10 users per hour)*. These facilities tend to be located far away from the city center and have high levels of Annual Average Daily Traffic. Users are young, with more than 40% less than 25 years of age. The vast majority of travelers use the facilities for recreational purposes (79%), with low levels of commuting trip purposes. These facilities tend to be in areas with a large proportion of young children (in our sample, 32% are children less than 16 years of age). The overall walkability characteristics of surrounding areas is low, and the vast majority of users reported being able to reach their final destination from the facility (presumably home, after their recreational trip) and only a small proportion of individuals are able to reach a transit stop from the facility that connects them to their final destination. The facilities in Rolling Meadows, Country Club Hills and Orland Park are in Cluster B.

Cluster C: Non-motorized Commuting Facilities in Extremely High Density Areas: *Facilities with high volumes of non-motorized usage for commuting purposes: Low proportion of users who switched from motorized modes prior to using the CMAQ-funded facility (4%), but with highest levels of hourly volumes of non-motorized usage on the facility (an average of 92 users per hour).* These facilities lead to high levels of non-motorized usage but are drawing users who were already non-motorized or public transportation users prior to using the CMAQ-funded facilities. Such facilities have high levels of commuting trips, with a large proportion of users of all ages being able to reach their final destination, such as work, directly from the facility or via additional facilities to which the facility connects to. The areas surrounding such facilities have the highest levels of population density, high levels of walkability and the lowest levels of Annual Average Daily Traffic.The surrounding areas have low levels of residents who speak little or no English and, overall, low levels of car ownership (30% of households in surrounding areas do not have a car). They are located close to the center of the city. In our sample, only the Clark Street bike facility is in this cluster.

Cluster D: Non-motorized Commuting and Mixed Use Facilities in High Density Areas: *The lowest proportion of users who switched from motorized modes prior to using the CMAQ-funded facility (3%), but with relatively higher levels of hourly volumes of non-motorized usage on the facility (an average of 38 users per hour).* These facilities draw the greatest share of young users (with 54% less than 25 years of age), who tend to use the facilities for a wide variety of purposes including commuting, running errands and for recreational purposes. They are located close to the City of Chicago's downtown area, have high levels of carlessness in surrounding areas (27% of households in surrounding areas without cars) and very large numbers of residents who speak little or no English (79%). Large shares of the population in surrounding areas are children less than 16 years (close to 30%). The 18th Street and 33rd Street locations are in Cluster D.

The analysis above identified the variables which have a significant correlation with D_CarChange. However, many of those variables are themselves correlated with each other. In order to find out which combination of variables explain the propensity to switch from cars to the current non-motorized mode, we utilize a binary logit model of $p_{ij} = \Pr(D\_CarChange_{ij} = 1)$

The results are shown in Table 2.6.

Table 2.6: Parameter Estimates and Odds Ratio of Binary Logit Model of P(D_CARCHANGE=1)

Variable	Estimate	p	Odds
Intercept	-4.07	0.01	0.02
Age	0.01	0.59	1.01
Gender	-0.52	0.23	0.59
Hourly Count	0.03	0.53	1.03
Access to Public Transportation	**0.86**	0.04	2.37
time_prop	-0.68	0.16	0.51
Transit Availability Index	0.33	0.83	1.40
Pedestrian Environment Factor	-0.01	0.65	0.99
Facility Type	-0.89	0.07	0.41
Distance from City Center	***0.10***	0.01	1.10

Underlined***:*** Significant at .10 level; **Bold:** Significant at .05 level; ***Bold and Italicized***: Significant at .01 level

McKelvey-Zavoina R^2	0.67
AIC	200.31
N	242
Log-Likelihood	-90
Likelihood Ratio	23.50

The model results show that because *Dist_CityCenter* is strongly correlated with a number of other variables, including *Pop00_Density*, *SUM_AADT* and other variables that were found earlier to be important in explaining *D_CarChange*, we can simply use it as a proxy for these other variables. It is significantly related to *D_CarChange* at the .01 level, an increase in which increases the odds of switching from cars to bicycle or pedestrian use in the CMAQ-funded facilities by 1.10. Controlling for other variables, access to public transit from the facility increases the odds of *D_CarChange* by a factor of 2.37. As noted earlier, bicycle facilities are less likely to significantly lead to a switch from cars, since many bicycle users are likely to have been users of other (non-motorized or public transport modes) prior to using the CMAQ facilities.

CHAPTER 3: ASSESSMENT OF SIGNAL INTERCONNECT AND INTERSECTION IMPROVEMENT PROJECTS

3.1 BACKGROUND

In assessing CMAQ investments on signal interconnect and intersection improvement projects, CMAP was interested in using field data on travel behavior before and after the investments in both types of projects, with the goal of assessing their effects on reducing emissions. As mentioned previously, a before-after study design was adopted for this purpose. The primary travel behavior measure used in both signal interconnect and intersection improvement projects is travel speed. The general premise is that improving travel speed will reduce traffic related emissions. Travel speed is impacted by several traffic parameters such as traffic volume, signal plan, pedestrian volume and roadway geometry. Therefore, data must be collected on those factors along with travel speed, which will be discussed in the data collection subsection.

In the rest of the chapter, we describe our research approach to assessing the effects of the two categories of traffic improvement projects. First, we describe the before-after study design and the advantages and limitations of this design, as it relates to traffic improvement projects. Then we present the project site selection procedure for field data collection and analysis. Next, we discuss the data collection requirements to assure data quality and validity of the research findings. Lastly, we describe methods for data analysis once the before and after data are collected and processed.

3.2 BEFORE-AFTER STUDY DESIGN

To assess the potential benefits of the traffic improvement projects, we implemented a before-after study design, in which the pre-defined travel behavior metrics (e.g., travel speed, traffic volume) were measured in the field both before a project (i.e., signal interconnect or intersection improvement) is implemented and after. The difference between the before and after measurements is the estimated impact of the investment and the “before” measurements serves as a baseline or the control measurements.

3.2.1 DESIGN ISSUES

In this study, the study population is defined as the CMAQ-funded signal interconnect and intersection improvement projects that were funded in the six-county NE Illinois region. Random samples of projects were drawn from the study population by randomly selecting a weekday (Tuesday, Wednesday, or Thursday) on which to collect data. Ideally, measurements should be taken repeatedly from the same sample over time to account for the changes over time due not only to changes as a direct outcome of the investment and “natural change” that would have happened anyway regardless of the investment, but also to other changes such as shift in demographics and land uses in the surrounding areas. There are also possibly time lags during when drivers learn about the improvement and time-lapses in recovery and adjustment in driver behavior after the implementation.

In this study, measurements are taken only once in time before and once after the implementation. The underlying assumption for doing so is that the eligible population of users is reasonably constant over time. In addition, the selection of the "after" data collection time point becomes somewhat a delicate exercise for the reasons explained above. Of course, the study can be considerably strengthened if measurements are taken at multiple points in time both before and after such that the effects of other changes are better controlled and accounted for. In particular, we recommend, if resources permit, a longer-term, repeated (time series) data collection to facilitate more powerful and useful evaluation.

3.2.2 Strengths and Weaknesses of Before-after Study

The key strength of the before-after study is that it is relatively easy and simple to implement. However, the design has considerable weaknesses that must be recognized when one interprets the study findings.

The main weakness of the design, as mentioned earlier, is that the "after" measurements do not separate out the changes due to different causes. This is particularly problematic if the improvement is expected to have a relatively small impact, compared to even the "natural change" that happens anyway over time due to other changes that may take place during the study period.

The design can be strengthened by collecting the time series data over a longer time period extended before and after the implementation of the project. With the time series data, it is then possible to more accurately identify the time point at which the change or effect takes place after the project is implemented. On the other hand, this requires much more data collection effort.

3.3 Site Selection Procedure

Both "before" and "after" traffic data must be collected for the CMAQ funded signal interconnect and intersection improvement projects in order to evaluate each individual project. The project scope led us to collect the "before" data in Phase 1 and the "after" data in Phase 2.

Before the field data collection, a list of project must be determined. As described there are a total of 770 funded CMAQ projects in the Great Chicago metropolitan region. This includes 202 signal interconnect projects and 74 intersection improvement projects.

As per the before-after study design we have adopted, projects that are already completed are obviously no longer eligible for the study. Therefore, the candidate projects must be those (1) that are labeled "incomplete" in the database during Phase I of the study; and (2) that are expected to be completed within 12 to 18 months after Phase I study and before the "after" data collection in Phase II. Based on those criteria, there were 42 intersection improvement projects and 58 signal interconnect projects that were incomplete and had estimated completion years between 2007 and 2011.

We then compiled a short list of candidate projects using random sampling from the above list and randomly selected 10 projects in each category. In the next step, phone calls were made to the project contacts to confirm the incomplete status of the projects. If the project was already completed but its status was not updated in the database, it was dropped from the list.

Next, the expected completion dates of the candidate projects were confirmed with the Illinois Department of Transportation (IDOT). Due to many practical factors involved in the completion of a project, the expected completion dates are subject to frequent changes. After communicating with the CMAP staff, it was determined that the best available information to be based on to estimate the completion dates was the estimated letting date information posted by IDOT. Because CMAQ funding comes from the federal government, plan sets require IDOT's approval before the project can move forward to a public bid (let) and then to the construction stage The IDOT oversees the public bid process for the majority of the projects, although there are some agencies that have approval to do the bid process themselves.

Previously in Phase 1, there were only 10 intersection improvement projects the IDOT letting list included with geographical locations shown in Figure 3.1.

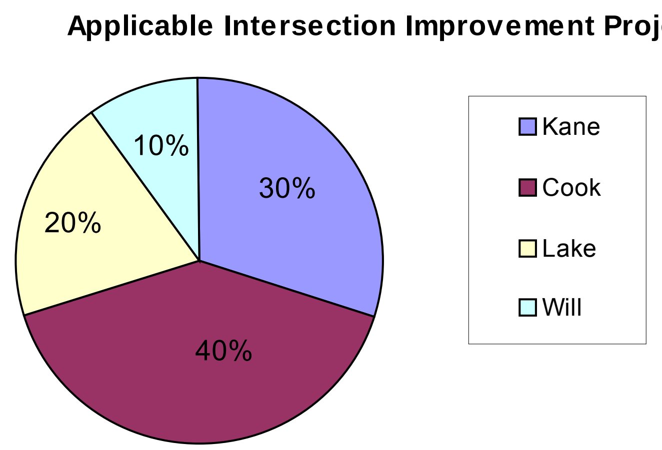


Figure 3.1: Applicable Intersection Improvement Projects

The schedule we received indicated 9 signal interconnect projects that should be ready to let for 2009. The geographical breakdowns by county are given in Figure 3.2.

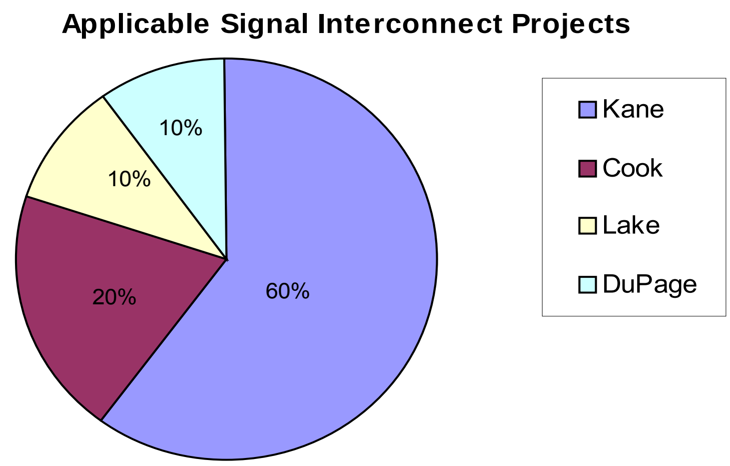


Figure 3.2: Applicable Signal Interconnect Projects

We then cross-referenced our random sample list with the IDOT letting list for 2009, which resulted in only one initially selected intersection improvement project and two signal interconnect projects. Hence, the previous random sampling method was augmented by "randomly" choosing additional project sites with the feasible letting dates that will enable the "after" data collection to occur no later than 2010. This resulted in 3 additional intersection improvement projects and 2 additional signal interconnect projects being selected in order to maintain 4 projects for each category. The final list of the "before" intersection improvement projects and signal interconnect projects are as follows.

(I) Intersection Improvement Projects

1. Dundee and Summit, Elgin, Kane, IL
2. Dunham at Sterns and IL 25, Elgin, Kane, IL
3. Governors Hwy and Poplar, Richton Park, Cook, IL
4. River Rd and Winona, Schiller Park, Cook, IL

(II) Signal Interconnect Projects

1. Peterson Ave from Cicero to Ridge, Chicago, Cook, IL
2. Naperville Rd from Elm to Danada, Wheaton, DuPage, IL
3. Randall Rd from Main to Orchard, Batavia, Kane, IL
4. Randall Rd from Corporate Pkwy to Huntley, Carpentersville, Kane, IL

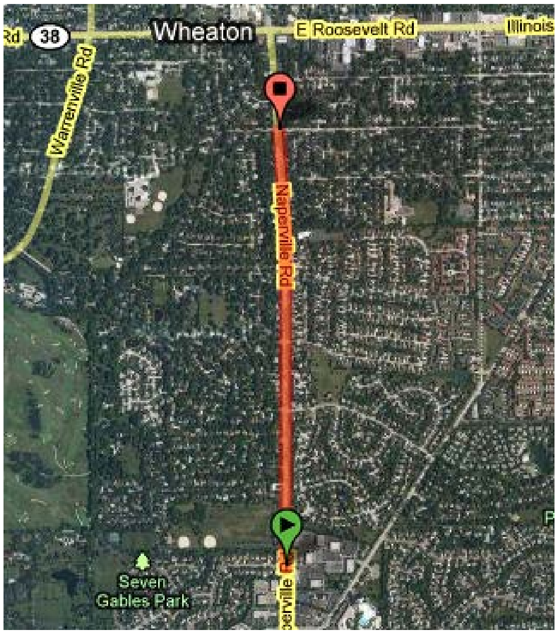
The four selected intersection improvement projects consisted of two projects in Kane and two projects in Cook (see Figure 3.3 for the description of the selected sites). The four selected signal interconnect projects consisted of two from Kane County, one from Cook County, and one from DuPage county, which accurately represents the applicable projects.

As mentioned earlier, when those eight projects were chosen during Phase 1, they were expected to be completed by the time the second phase of the project started in fall 2010 so the "after" traffic conditions could be evaluated. However, none of the four selected intersection improvement projects were completed by early spring 2011, which was the window for our project data collection, due to various reasons. In the signal interconnect projects, only the Naperville Rd in Wheaton and Randall Rd in Batavia were confirmed completed. In other words, we were able to collect "after" traffic data only at two project sites, i.e., Naperville Rd in Wheaton and Randall Rd in Batavia, for traffic improvement project evaluation.

Table 3.1: Final traffic improvement projects confirmed for "before" and "after" study

Signal Interconnect			
Project site	**County**	**No. of intersections**	**Data collection status**
Naperville Rd from Elm to Danada, Wheaton	DuPage, IL	4	**Before**: 10/29/08 7:00am-7:15am, 10/30/08 7:45am-8:00am, 11/5/08 4:45pm-5:00pm, and 11/13/08 5:00pm-5:15pm **After**: 5/17/11 and 5/18/2011 3pm-6pm
Randall Rd from Main to Orchard, Batavia	Kane, IL	2	**Before**: 9/9/09 7am-8am, 9/22/09 7am-8am **After**: 5/11/11 7am-10am, 5/11/11 2:45pm-5:45pm
Intersection Improvement: None			

Figure 3.3: The final project sites

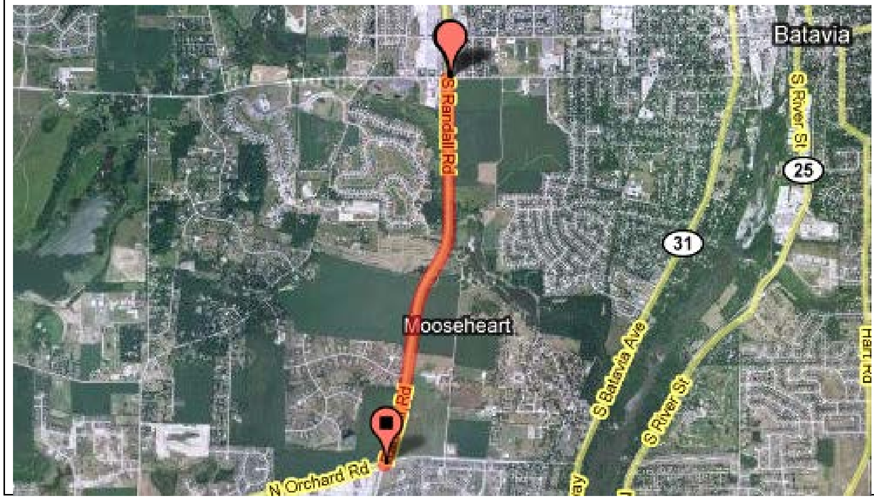


(1) Naperville Road between Elm Street and Danada Drive, Wheaton, DuPage, IL

The corridor of Naperville Road from Elm to Danada is located in the western suburb of Wheaton and serves as a connection to Roosevelt Rd (IL rte 38) and Butterfield Rd (IL rte 56). The land use bordering the study area is mostly residential. There are also some office buildings at Danada Drive and a church and park along the roadway. Naperville is a four lane arterial throughout the 1.1-mile corridor from Danada to Elm and consists of four signalized intersections.

(2) Randall Rd between Main and Orchard, Batavia, Kane, IL

The corridor of Randall Road from Main to Orchard is located in the far western suburb of Batavia. Randall Road is a major north-south arterial in Kane County. The land use bordering the study area is largely farmland. There are also some subdivisions to the north and south of the corridor; in addition there is a shopping plaza, "The Shoppes at Windmill Place" located directly north of the Main street intersection. Randall Road is a four lane arterial throughout the 2.0-mile corridor from Main Street to Orchard Road and consists of two signalized intersections. Pace route 529 services Randall Road for the entirety of the study area.



In the remainder of post-project evaluation in this report, we will focus on those two projects where the effects of the CMAQ improvements are compared using speed measurements. Detailed "before" and "after" LOS intersection analyses on all project sites (i.e., eight "before" projects and two "after" projects) are available in Appendix D.

3.4 DATA REQUIREMENTS AND COLLECTION PROCEDURE

The "before" data collection was carried out at each of the eight selected sites during fall 2008 and summer and fall 2009. The "after" data collection at the two eligible sites was carried out in May 2011. Figure 3.4 is the data collection worksheet used in the study. It consists of five sets of data: (1) general information including project site and data collection date and time, (2) intersection geometry including lane configuration for each approach, (3) traffic volumes at each travel direction, (4) signal timing and plan, and (5) average travel speeds at the intersection.

3.4.1 AVERAGE TRAVEL SPEED

The primary surrogate measure of air quality benefits from the signal interconnect and the intersection improvement projects is the speed improvement. Therefore, the average traveling speeds along the study corridors were recorded manually by the "floating car method". A research member driving the study corridor conducts this method and maintains the average speed of the surrounding vehicles while recording the travel time from one study boundary to the other. Many engineers also note the instantaneous vehicle speeds when entering a study intersection and between intersections in order to help visualize the speed-position graph and note where delays occur on the corridor. In an effort to maintain the same level of accuracy of a GPS transponder we recorded the instantaneous speeds every minute and recorded the travel time of the corridor. With the recorded travel time and the length of the corridor we were able to calculate the average vehicle speed and determine the slow regions from the instantaneous speeds.

3.4.2 OTHER TRAFFIC DATA

Other traffic data were also collected in the study in order to properly account for effects of other traffic parameters on travel speed and to create a functional simulation model. The UIC team collected the necessary data such as: multiple 15-minute turning movement counts, recorded signal phase timings and lane configuration, and average vehicle speed. The 15-minute turning movement counts were conducted with one counter per intersection approach. Fifteen minutes is the standard interval given by the Highway Capacity Manual (HCM) to detail traffic volumes and create peak hour factors. All of the site counts covered at least half an hour or more of peak period data. After each count the data sheets were collected and the data was entered into excel spreadsheets. Also data on lane configuration data were recorded during the field visit.

The signal timing of each of the phases was also recorded at the same time when the traffic data were collected. The green time, yellow time, red time, and all red time was recorded for each phase and a phasing diagram was constructed, as can be seen from Figure 3.4, which is the sample data collection worksheet used in the study. Problems arose when many of the signals had multiple actuated phases and did not maintain an equal cycle length. Because of the multiple actuated phases, the data collectors were instructed to record the phase multiple times to determine the average time for each phase. A better solution would be to obtain a copy of the implemented signal timing plans for the selected sites with actuated signals from the responsible agencies in order to properly analyze the intersection, which we were not be able to obtain at this time.

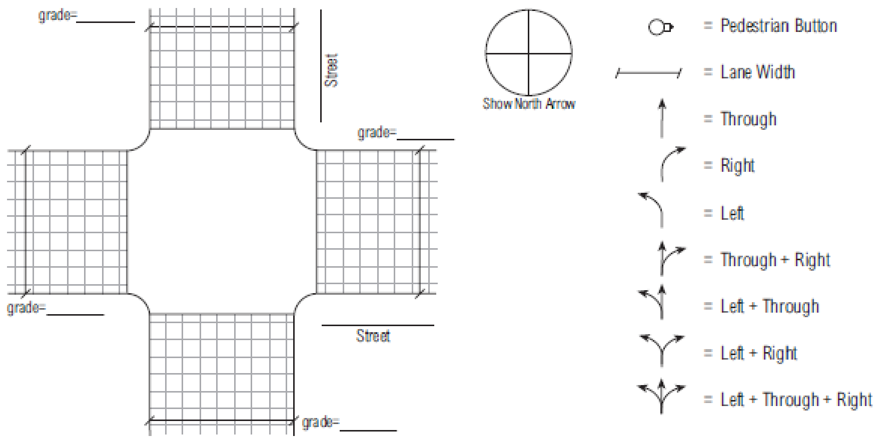
The number of surveyors needed per site was estimated from the roadway average daily traffic (ADT), and the number of intersection approaches. For each intersection in a selected project, a minimum of one person per approach was assigned; for roadways with heavy ADT volumes (> 30000 vehicles) we assigned two people per approach. The number of people at each site is specified under the respective project heading.

Figure 3.4: Sample Data Collection Worksheet

General Information

Analyst	______	Intersection	______
Date Performed	______	Area Type	______
Analysis Time Period	______	Analysis Year	______

Intersection Geometry



Volumes

	EB			WB			NB			SB		
	Lt	Thru	Rt	Lt	Thru	Rt	Lt	Thru	Rt	Lt	Thru	Rt
Volume [veh/hr]												
Heavy Vehicles [%]												
Peak Hour Factor												
Pretimed or Actuated												
Pedestrian Volume [ped/hr]												
Bicycle Volume [bike/hr]												
Parking [Yes or No]												
Parking Maneuvers [#/hr]												
Bus Stopping [Buses/hr]												

Signal Phasing Plan

Phase	1	2	3	4	5	6	7	8
G								
Y								
AR								

Vehicle Speed—Corridor (Minimum 2000ft)

Direction	EB	WB	NB	SB
Average Vehicle Speed [mph]				

3.4.3 *Impacted boundaries of Project Site in Data Collection*

In principle, data collection must be carried out in all intersections where traffic operation is expected to be impacted by the project, which may go beyond the intersections at which the investment will take place. In reality, however, the impacted boundaries are difficult to draw without a comprehensive network level analysis, which requires necessary data collection and coding of the regional network, which is far beyond the resources of the current study. Hence, in this study we considered only the "direct" impact at the intersections where the investment occurred and conducted the data collection at those intersections only. The potential impact beyond the investment site was not considered in the analysis.

3.5 Data Analysis Methods

Data analysis consists of (1) comparison study of the before and after conditions from direct observations, and (2) level-of-service (LOS) analyses of the before and after conditions from the field measurements respectively. The field collected data on the worksheets were entered into electronic data spreadsheets. Data is organized by intersection. For each study intersection, there are four categories of data: intersection geometry (number of lanes, lane groups, lane width, exclusive turn lanes/bays, crosswalks, etc., near-side/far-side bus stop), traffic volume and other factors by approach (hourly volume, % heavy vehicles, pedestrian volume, bicycle volume, parking lane, parking maneuvers, bus stopping), signal plan (pretimed or actuated, number of phases, sequence of phases, green, yellow and red time in each phase), and average travel speed by approach.

Direct comparisons of the before and after speeds, traffic volumes and other parameters are conducted to show the observed change in traffic condition before and after the investment.

The individual intersection LOS and the corridor LOS are also determined for the before and after scenarios respectively by running the collected data through the Highway Capacity Software (HCS) but not directly used in the analysis. LOS defines how smooth traffic operation is on a roadway section. Specifically for a signalized intersection corridor, the amount of delay per vehicle (or slow-down of traffic) at an intersection determines the performance level of the intersection. Therefore, LOS analysis gives us a sense of the traffic condition at the intersections. Intersection LOS analysis and detailed HCS input and output files for these two intersections are given in Appendix D.

3.6 Before And After Comparison

This section presents the average peak hour traffic speed through the entire study corridor of each of the two signal interconnect projects. Detailed time of day and day of week speed observations can be found in Appendix D.

Note that the speed data was collected slightly differently in Phase I (before) and Phase II (after) of the study. In Phase I, the total travel distance and run time along the study corridor were recorded by the floating car and the average speed was derived by dividing the corridor travel distance by the corresponding run time. In Phase II, travel distance and run time were recorded for each intersection from mid-block upstream to mid-block downstream. Therefore, average travel speed can be derived at each intersection of the study corridor as well as for the entire corridor itself.

(1) Naperville Road between Elm Street and Danada Drive, Wheaton, DuPage, IL

Table 3.2: Average Traffic Speed on Naperville Road: Before versus After

Study Corridor: Naperville between Elm and Danada				
	Before		After	
Summary	SB	NB	SB	NB
Measured corridor length (miles)	1.32	1.32	1.37	1.37
Average run time (sec)	156	156	150.8	146
Average speed (mph)	30.6	30.6	32.8	33.9
Average speed improvement			7.15%	10.68%

The average speeds in Table 3.2 represent the average through traffic traveling speed on Naperville Avenue in both the southbound and northbound directions between Elm Street and Danada Street over a number of repeated field measurements during the morning and/or evening peak hours on the data collection dates noted in Table 3.1. The field observations reveal that there is a 7.15% and 10.68% improvement on the southbound and northbound direction respectively. That equates 2.8 mph and 3.2 mph increase in the southbound and northbound respectively.

(2) Randall Rd between Main and Orchard, Batavia, Kane, IL

Table 3.3: Average Traffic Speed on Randall Rd: Before versus After

Study Corridor: Randall between Main and Orchard				
	Before		After	
Summary	SB	NB	SB	NB
Corridor length (miles)	2.78	2.78	2.51	2.51
Average run time (sec)	288	258	246	261
Average speed (mph)	34.8	38.8	36.8	34.6
Average speed improvement			5.81%	-10.83%

Again the average speeds in Table 3.3 represent the average through traffic traveling speed on Randall Street in both the southbound and northbound directions between Main Street and Orchard Street over a number of repeated field measurements during the morning and/or evening peak hours on the data collection dates. The field observations reveal that while there is a 5.81% improvement in speed (representing a 2 mph increase) on the southbound direction the northbound direction suffers a speed reduction of almost 11%, i.e., a 4.2 mph decrease in speed. However, these observations are based on an uneven mix of AM and PM data, so are not less comparable.

CHAPTER 4: CONCLUSIONS

A total of 18 bicycle and pedestrian facilities and two signal interconnect projects were analyzed using a before and after evaluation design and field-measured observations, to determine the level of expected outcomes from CMAQ investments.

The analysis of the non-motorized projects showed a wide range of usage levels in the different sites and that substitution of motorized modes resulted (from Single Occupant Vehicles to bicycle and pedestrian modes), potentially leading to improved air quality outcomes. Respondents reported using the facilities for a wide variety of purposes including recreation, commuting and other purposes.

The propensity for previously exclusive car users for a trip type to switch to using a non-motorized facility for a particular trip purpose has a highly significant negative correlation with bicycle facilities, and the population density and the percent of population with no cars in surrounding census tracts, while the distance from city center (intersection of State and Madison Streets in the City of Chicago) has a highly significant positive correlation. The propensity has a significant positive correlation with the Average Daily Traffic in highway links in surrounding census tracts and is significantly positively correlated with the percent of population who speak limited or no English in surrounding areas. Finally, the ability to connect directly to a transit station has a weaker level of significant positive correlation and the recreational usage levels has a weaker level of negative correlation with the propensity to switch from being exclusively an SOV user for the trip purpose.

Our analysis found that depending on the location and overall sociodemographic, transportation and other characteristics of the surrounding areas, there are likely to be at least four groupings of CMAQ-funded projects that exhibit various combinations propensity to switch and overall use levels. These groupings are formed by different mixtures of the above factors and obtained through a cluster analysis. These are:

(1) Cluster A: Long-Distance Transit-Based Commuting Facilities: Facilities that lead to the highest levels of switching in from solo car use and with greatly lower levels of usage on an hourly volume basis are located in extremely low-density areas that are farthest away from the center of the City of Chicago; these facilities connect a large share of users to public transportation thereby increasing the ability of users to use the facility for part of their commuting trip.

(2) Cluster B: Recreational Facilities for Discretionary Usage: Facilities that lead to high levels of switching from solo car use but with fairly low levels of total usage tend to be also located far away from the city center and have high levels of Annual Average Daily Traffic, with large share of young users who primarily tend to use the facilities for recreational purposes.

(3) Cluster C: Non-motorized Commuting Facilities in Extremely High Density Areas: Facilities with high volumes of non-motorized commuters who are able to make door-to-door commuting connectivity using the facilities in very high density areas that are located close to the center of the city but with a low proportion of users of all ages who switched from motorized modes prior to using the CMAQ-funded facility.

(4) Cluster D: Non-motorized Commuting and Mixed Use Facilities in High Density Areas close to downtown Chicago, which may have the lowest proportion of users who switched from motorized modes prior to using the CMAQ-funded facility but with high levels of use by large proportions of

young users for a wide variety of purposes including commuting, running errands and for recreational purposes.

Although data on 4 intersection improvement and 4 signal interconnect projects were collected for the "before" period of a before-and-after evaluation of traffic outcomes, only two signal interconnect projects were completed within the timeline of the project. The field observations reveal that there is a 7.15% and 10.68% improvement on the southbound and northbound direction respectively in one of the signal interconnect sites, which equates to a 2.8 mph and 3.2 mph increase in the southbound and northbound respectively. Field observations in the other location revealed that while there is a 5.81% improvement in speed (representing a 2mph increase) on the southbound direction, the northbound direction suffered a speed reduction of almost 11%, i.e., a 4.2 mph decrease in speed. Due to the extremely small sample size of completed before-and-after cases, we do not consider the results of the roadway project analysis to be conclusive or generalizable in any way.

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1) Chicago Metropolitan Agency for Planning (2011). CMAQ Project Application Information Booklet. Federal Fiscal Year 2012-2016. Accessed from http://www.cmap.illinois.gov/cmaq/improvement-program-fy10-11 on July 10, 2011.
2) Federal Highway Administration (2006). *The Congestion Mitigation and Air Quality (CMAQ) Improvement Program under the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users. Interim Guidance.* Oct 31, 2006. Accessed from http://www.fhwa.dot.gov/environment/air_quality/cmaq/policy_and_guidance/cmaq06gd.pdf on Nov 15, 2011.
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APPENDIX A: BICYCLE AND PEDESTRIAN SURVEY INSTRUMENT

SRL CASEID #___________

DATE ________________

INTERVIEWER #_________

SURVEY OF BICYCLE AND PEDESTRIAN PATH USERS

1. What are the reasons you use this path?
   (CHECK ALL THAT APPLY)
   - 1☐ Commute to work (including part of commute to work)
   - 2☐ Errands/personal business (such as shopping, banking)
   - 3☐ Recreation
   - 4☐ Other → ____

2. Why did you choose to use this path today?
   (CHECK ALL THAT APPLY)
   - 1☐ Convenience (includes directness of route or other routes are less desirable)
   - 2☐ Recreation/Exercise
   - 3☐ Environment
   - 4☐ No other way to make this trip
   - 5☐ Less costly alternative
   - 6☐ Other → ____________________

3. How else could you have made this trip?
   (CHECK ALL THAT APPLY)
   - 1☐ Private car
   - 2☐ Shared car ride
   - 3☐ Public transit (bus, vanpool, train)
   - 4☐ Walked or biked elsewhere
   - 5☐ Would not have made this trip
   - 6☐ Other

Path Location: ____________________

Circle one: Biking Walking

Time: ____________________

Gender: Male Female

Direction of Travel

Circle one: North East South West

4. How many times per week do you typically use this path during the summer, winter and the fall and spring months? For example, a full-time worker who works 5 days a week would typically make 10 one-way trips to and from their workplace using this path.

During the summer months? (June, July, August)	During the winter months? (Dec., Jan., Feb.)	During the spring and fall months? (March, April, May / Sept., Oct., Nov.)
_______ one-way trips per week	_______ one-way trips per week	_______ one-way trips per week
If less than once per week → Please specify the approximate number of trips per summer month on this path. ______	If less than once per week → Please specify the approximate number of trips per winter month on this path. ______	If less than once per week → Please specify the approximate number of trips per spring and fall month on this path. ______

(Please turn over)

5a. Do you always use this path for your trips for the purpose indicated in Question 1 above?

☐ Yes (Please go to Question 6) ☐ No

5b. What are the reasons for not using this path for all of your trips for the purpose indicated in Question 1 above? (CHECK ALL THAT APPLY)

1☐ Need car
2☐ Weather conditions
3☐ Personal safety
4☐ Family reasons (drop off/pick up partner, children)
5☐ Other (please specify)____

6. As a result of using this path, are you able to:

a. Access your final destination directly?.. ☐ Yes ☐ No
b. Access public transportation, which then takes you to your final destination? ...... ☐ Yes ☐ No
c. Access your final destination by car from a convenient parking place close by? .... ☐ Yes ☐ No

6d. How much time do you typically spend on this path for this trip? ___ minutes

6e. How long is your overall (door-to-door) trip? This will include time off of this path. ______minutes

6f. In what month/year did you first begin using this path?___/______ Month / Year

7. Before you began using this path for this type of trip (such as work or shopping), what type of transportation did you use? (CHECK ALL THAT APPLY)

1☐ Car
2☐ Public Transit
3☐ Bicycle
4☐ Walk
5☐ Other → (if carpool or vanpool, typically with how many other people)___________________
6☐ Didn't make this type of trip (Please go to Question 9)

8. When you previously made this trip …

a. What was the distance to your final travel destination? ______ miles
b. How much time did it take to travel to your destination? ____ hours and ____ minutes
c. How many times per week did you make this trip to your destination? _______ per week
d. How many times per week did you make this trip to your destination during each of the following seasons?

______ times per week during the summer months;
_____ times per week during the winter months; and
______ times per week during the spring and fall months

9. What year were you born? ________________

10. GENDER: 1☐ Male 2☐ Female

11. Number of adults 18 years of age or older in household (including yourself)? __________ # adults

12. Number of children under 18 in household? .... _________ # children

13. How many vehicles are available for use in your household?......................... _________ # vehicles

14. What is the closest major street intersection to your home? ___________________________________

15. What is the closest major street intersection where you leave the path? _________________________

16. What is the closest major street intersection to your final destination?

____

APPENDIX B: ENUMERATION FORM

ENUMERATING FORM

DATE:
SHIFT: AM / PM
LOCATION: ____________________________________
INTERVIEWERS: ________________________________

	Time	Gender	Race	Direction of Travel	Trail Use	Approximate Age	Outcome
	Military Time	Male / Female	White / Black / Other	North / East / South / West	Walk / Bike	17 or less / 18 to 25 / 26 to 35 / 36 to 45 / 46 to 55 / 56 to 65 / 65 +	Complete / Refusal / Not Asked
1		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	C☐ R☐ NA☐
2		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	C☐ R☐ NA☐
3		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	C☐ R☐ NA☐
4		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	C☐ R☐ NA☐
5		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	C☐ R☐ NA☐
6		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	C☐ R☐ NA☐
7		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	C☐ R☐ NA☐
8		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	C☐ R☐ NA☐
9		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	C☐ R☐ NA☐
10		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	C☐ R☐ NA☐
11		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	C☐ R☐ NA☐
12		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	C☐ R☐ NA☐
13		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	C☐ R☐ NA☐
14		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	C☐ R☐ NA☐
15		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	C☐ R☐ NA☐

APPENDIX C: REFUSAL FORM

REFUSAL FORM

DATE:
SHIFT: AM / PM
LOCATION: ____________________________________
INTERVIEWERS: ________________________________

	Time	Gender	Race	Direction of Travel	Trail Use	Approximate Age	Notes
	Military Time	Male / Female	White / Black / Other	North / East / South / West	Walk / Bike	17 or less / 18 to 25 / 26 to 35 / 36 to 45 / 46 to 55 / 56 to 65 / 65 +	Fill in if needed
1		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	
2		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	
3		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	
4		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	
5		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	
6		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	
7		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	
8		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	
9		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	
10		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	
11		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	
12		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	
13		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	
14		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	
15		M☐ F☐	W☐ B☐ O☐	N☐ E☐ S☐ W☐	W☐ B☐	17☐ 18☐ 26☐ 36☐ 46☐ 56☐ 65☐	

APPENDIX D: TRAFFIC ANALYSIS

D.1 INTERSECTION LEVEL-OF-SERVICE (LOS)

Intersection LOS was estimated individually by using the Highway Capacity Software (HCS) 2000. Table D.1 summarizes the two signal interconnect projects that have the complete “before” and ‘after” information, i.e., Naperville Rd between Danada and Longfellow and Randall Rd between Main Street and Orchard Street. Detailed HCS input and output files for these two intersections can be found in Appendix D. The Appendix also includes the detailed HCS inputs and outputs for the “before” analysis of the other “before” projects that were not chosen for the “after” study.

It must be pointed out that the following “before” and “after” LOS analyses used the same signal timing and phasing configuration due to the fact that the signal interconnect improvement plans were not available to us at the point when this report was written – it will require considerable amount of effort to obtain the information. Therefore, in this analysis we applied a presumably worse scenario for the “after” condition (i.e., without the improved signal configuration) under the assumption that the improved signal interconnect would make the LOS better than in the “before” condition. So the expected “after” LOS should be similar to the “before” LOS. Table 3.4 confirms that expectation. In fact, the slight worse LOS at some of the intersections on Naperville Rd in the “after” condition provides an argument for needing a signal interconnect improvement. Nonetheless, all intersections seem to be operating at the LOS no worse than D in the current condition.

Table D.1: Completed signal interconnect project LOS: Before and After

			Before		After	
Intersection	**Street**	**Approach**	**Approach LOS**	**Intersection LOS**	**Approach LOS**	**Intersection LOS**
Naperville and Danada	Naperville	SB	C	C	D	D
		NB	C		C	
	Danada	WB	D		D	
		EB	D		D	
Naperville and Elm	Naperville	SB	A	A	A	B
		NB	A		A	
	Elm	WB	D		C	
		EB	C		C	
Naperville and Farnham	Naperville	SB	B	C	B	B
		NB	B		B	
	Farnham	WB	D		C	
		EB	D		C	
Naperville and Longfellow	Naperville	NB	B	B	C	C
		SB	B		C	
	Longfellow	WB	C		C	
		EB	C		C	
Randall and Main	Randall	SB	D	E	E	D
		NB	E		D	
	Main	WB	D		D	
		EB	F		D	
Randall and Orchard	Randall	SB	C	D	C	D
		NB	C		C	
	Orchard	WB	E		E	
		EB	E		D	