# Traffic Calming Evaluation and Monitoring

## Plainsboro Township, NJ

prepared for:

**Keep Middlesex Moving, Inc.**

prepared by:

**Voorhees Transportation Policy Institute**

Edward J. Bloustein School of Planning and Public Policy

Rutgers, The State University of New Jersey

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Alan M. Voorhees Transportation Center

THE STATE UNIVERSITY OF NEW JERSEY RUTGERS

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# Evaluation and Monitoring

## Plainsboro Township, NJ

Final Report

prepared for:

**Keep Middlesex Moving, Inc.**
100 Bayard Street, 2nd Floor
New Brunswick, New Jersey 08901
Phone 732/745-4490
Fax 732/745-7482
kmm@kmm.org

prepared by:

**Voorhees Transportation Policy Institute**
Alan M. Voorhees Transportation Center
Edward J. Bloustein School of Planning and Public Policy
Rutgers, The State University of New Jersey
33 Livingston Avenue, Suite 500
New Brunswick, New Jersey 08901
732/932-6812 x700 – 732/932-3714 (fax)
http://www.policy.rutgers.edu/tpi

Michael King, Project Manager
Jon Carnegie, Senior Project Manager
Reid Ewing, Project Director
Joshua Schneider, Graduate Assistant

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# *I. INTRODUCTION*

Traffic calming has its modern roots in 1968 Delft, Netherlands where a group of citizens placed planters in the middle of their neighborhood streets to slow drivers down. In the next decades the movement spread across northern Europe to the extent that many towns have traffic-calmed residential areas, national design manuals have been re-written and developers now regularly produce low speed “home zones”. Traffic calming has been extended to higher order roadways and small town main streets and exported to the rest of Europe, Australia, Japan and most recently North America. The New Jersey Department of Transportation is currently embracing traffic calming via a new chapter in their Roadway Design Manual.

In January 2001, Keep Middlesex Moving, Inc. (KMM) contracted with the Voorhees Transportation Policy Institute, a unit of the Edward J. Bloustein School of Planning and Public Policy at Rutgers, the State University of New Jersey, to design and test a prototype traffic calming evaluation and monitoring methodology. The intent of the project was to provide KMM with a practical evaluation tool to assist municipalities in central New Jersey to assess the effectiveness of local traffic calming initiatives. In addition, the project was intended to demonstrate the methodology by using it to evaluate a planned traffic calming project in Plainsboro Township, New Jersey.

This report completes the Plainsboro Township Traffic Calming Evaluation and Monitoring Project. In it, the prototype traffic calming evaluation and monitoring methodology is explained and the impacts of the first phase of the Plainsboro Road traffic calming project, completed in December 2001, are quantified, qualified and evaluated. The evaluation and monitoring methodology is designed to be easily replicable and transferable to other locations.

## *II. EVALUATION AND MONITORING METHODOLOGY*

Traditional roadway improvement projects in the United States have generally been auto-oriented. Most seek to improve travel conditions for motorists and increase traffic flow and/or speed. Traffic calming projects, where changes in a roadway's design seek to "reduce traffic speeds and cut-through volumes in the interest of street safety, livability, and other public purposes,"[1] differ in a variety of ways. As such, an evaluation of traffic calming effectiveness must be holistic and comprehensive. The draft New Jersey Department of Transportation's traffic calming policy highlights three performance objectives common to most traffic calming projects: reduce vehicle speed, reduce pedestrian exposure risk and increase driver predictability.

Vehicle speed is the single highest determinant of crash rates and severity. Exposure risk is the amount of time that pedestrians and cyclists are exposed to traffic and its inherent dangers. Driver predictability describes the ability of pedestrians, cyclists and other motorists to best predict the speed and actions of drivers. Together with vehicle volume, noise and a cost-benefit analysis, these three characteristics provide a framework to assess the effectiveness of traffic calming projects and are the basis for the prototype evaluation methodology described in this report.

Table 1 presents the six performance measures and indicators thereof used as part of the evaluation methodology. These may be used to evaluate a spectrum of traffic calming projects and can be utilized over time to monitor the short, medium, and long term effectiveness of specific interventions.

| Performance Measure | Indicator |
|---|---|
| Vehicle Speed | ▪ Vehicle speed<br>▪ Travel time |
| Pedestrian Exposure Risk | ▪ Physical characteristics of roadway<br>▪ Pedestrian crossing time |
| Driver Predictability | ▪ Vehicle speed<br>▪ Physical characteristics of roadway |
| Traffic Volume | ▪ Daily/peak hour traffic volume<br>▪ Vehicle mix<br>▪ Vehicle diversions |
| Noise | ▪ Ambient noise levels<br>▪ Peak noise level |
| Cost-benefit | ▪ Crash rates |

**Table 1: Traffic Calming Performance Measures**

[1] Ewing, R. *Traffic Calming: State of the Practice*, ITE, 1999, p. 3

The key to an effective evaluation strategy is to collect appropriate data and observations both before and after the proposed traffic calming project is completed. This ensures that there is comparable information on which to base an assessment of effectiveness. Too often, evaluation is considered only after construction is complete, when it is too late to collect data on conditions before the installation. In addition, it is important that the evaluation be based on a series of data points that occur over time. Therefore, effective evaluation relies on a commitment to ongoing monitoring over an appropriate period of time. For instance a comprehensive evaluation and monitoring program includes observations before installation, upon completion of construction, six months after construction, and annually thereafter for three years. This will provide a complete and comprehensive review of a project's effectiveness relative to each of the recommended performance measures.

The recommended evaluation methodology requires that the following data collection and analysis be undertaken.

<u>Document physical and visual characteristics</u>

Physical and visual characteristics are used to support a qualitative assessment of improvements made to the environment and to assess pedestrian exposure risk and driver predictability. As such, the visual characteristics of the study area or subject roadway segment should be documented both prior to and after the traffic calming project is completed. This can be done using standard print or slide photography, digital photography, and/or video. Take care to ensure that the before and after photographs are taken from a similar perspective to facilitate visual comparisons.

In addition, the physical characteristics of the subject roadway should be documented. Important characteristics include: the existing cross-section of the road, including the overall width of the travel way and the allocation of space to autos, pedestrians and bicycles; turning radii; location of traffic signals and other traffic control devices; and the presence and location of crosswalks and medians. Post construction conditions should be similarly documented.

<u>Document traffic characteristics</u>

Vehicle volumes and speed should be documented along the subject roadway both prior to and after the traffic calming project is completed. In addition, depending on the traffic calming installation, it may be advisable to monitor traffic volumes on adjacent or alternate routes that may be impacted by diverted traffic. Finally, depending on the traffic calming project, the mix of vehicle types using the roadway may be important. For instance, if one of the traffic calming objectives is to discourage truck traffic, then it would be important to monitor vehicle mix. An automatic traffic recorder (ATR) can be used to quantify each of these data elements.

Vehicle speed is most often expressed in terms of the $85^{th}$ percentile speed, a measure of the $15^{th}$ fastest vehicle out of a hundred. It is the industry standard in determining the prevailing speed of a street. Vehicle volume is most often expressed in terms of average daily traffic (ADT) or peak hour traffic and vehicle mix is expressed in terms of the percent of auto, truck and bus traffic. Depending on the location of the traffic calming project, adjustments for monthly and daily traffic fluctuations may be needed to account for regularly occurring changes (e.g., seasonal) in overall traffic patterns. Adjustment factors are available from the Department of Transportation (DOT) and other sources for many locations where permanent traffic monitoring stations are maintained.

Data on existing traffic characteristics may be available from a variety of existing sources, including: past traffic or transportation studies; traffic impact analyses related to the local development review process; and local, county, state department of transportation, or Metropolitan Planning Organization (MPO) traffic monitoring programs.

Document travel time

Travel time is an important measure of roadway performance. Critics of traffic calming often argue that slower travel speed results in longer travel time. While this is a logical conclusion, the relationship is not always true, especially if the objective is to moderate and balance traffic speeds, not necessarily reduce traffic volume. For this reason, travel time should be measured and analyzed. This can be done by observing travel time both before and after the traffic calming installation. To collect observed travel time data, drive the subject roadway segment a minimum of six times under typical travel conditions and average the travel times.

Quantify exposure risk

One quantifiable measure of pedestrian safety is exposure risk to traffic. Exposure risk is expressed as the amount of time a pedestrian is exposed to on-coming vehicular traffic, when they are most in danger of being involved in a traffic incident. To calculate exposure risk, divide the width of the street by the typical pedestrian walk speed. Pedestrians walk at between 2.8 and 7 feet per second. For example if the street is 70 feet wide, the pedestrian exposure risk is in the range of 10-25 seconds. The lower the exposure risk, the more safe the pedestrian environment is.

Assess driver predictability

An overall measure of roadway safety is driver predictability. Driver predictability can be assessed by examining the physical characteristics of the roadway and making a qualitative judgment regarding the ability of pedestrians, cyclists, and other motorists to predict the speed and actions of drivers. For example, if the speeds on a street are relatively constant, then crossing pedestrians will be better able to judge how much time they have to cross the street. Similarly, if an intersection is channelized, a driver will know where to steer and where others will be, than if the intersection is open and unmarked.[2]

Document pedestrian and bicycle activity

A common objective of traffic calming is to improve the pedestrian and bicycle environment, thereby increasing pedestrian and bicycle activity along the traffic calmed roadway segment. Pedestrian and bicycle counts should be taken before and after the project is completed. Such counts can be obtained through video or field observation by physically counting pedestrians and cyclists at various locations along the subject route.

[2] For more information on driver predictability see *Roundabouts: An Informational Guide*, FHWA-RD-00-067, 2000; "Literature Review on Vehicle Travel Speeds and Pedestrian Injuries," NHTSA, DOT HS 809 021, 1999; *An Improved Traffic Environment*, Road Data Laboratory, Road Standards Division Report 106, Danish Road Directorate, 1993; *Bausteine 12: Verkehrsberuhigung und Strassenraumgestaltung* (*Traffic Calming and Designing the Right-of-Way*), Research Institute for City and Regional Planning and Development, Dortmund, Germany, 1992.

Document noise levels

In roadway projects, changes in speed or variability of speed may affect noise levels. A change of 10 dB either doubles or halves the noise level. It is generally accepted that noise levels above 50 dB are bothersome to humans. It is also important to compare ambient to peak levels, for what is often objectionable is the peak sounds relative to background (ambient) noise. Noise levels are monitored using a decibel reader next to the side of the roadway. One must be cognizant of reflected noise, the dampening affect of foliage and the sound of wind, trying to minimize their impact on the readings. A two minute sample is sufficient for a before-after comparison.

Document existing crash rates

Crash (accident) rates are a measure of safety that can be quantified in terms of cost to community and society. As such they can be used to perform a simple cost-benefit assessment. Crash rates can be calculated using police accident reports and should be derived from a multi-year analysis if practical. A three year analysis is preferred. Total number of crashes, crash severity, and monetary value of crashes should be compiled. Injury incidents involving a vehicle and bicycle and/or pedestrian should be adjusted upwards by 50% to account for underreporting.[3]

Perform cost-benefit analysis

Analyzing the cost-benefit of a traffic calming project allows one to assess the potential rate of return on investment. While no quantitative cost-benefit analysis can capture the entire spectrum of value to the community, it can provide important insights. In roadway projects, there are a number of factors which may be quantified and utilized in a cost-benefit analysis. These include: vehicle speed and volume, travel time, pedestrian activity, real estate value, transit use and efficiency of trips.

From a safety perspective, the most telling of these factors is vehicle speed. Performing a cost-benefit analysis based on vehicle speed is fairly straightforward if the before-after speed differential, existing crash rates, severity and their monetary value are known. The relationship between vehicle speed and crash rates can be used to forecast future crash rates and cost multipliers can be used to calculate costs to community.

Table 2 presents the multipliers used by the Federal Highway Administration in determining comprehensive costs related to traffic crashes. The multipliers include direct (property damage, emergency medical services (EMS), medical treatment, lost productivity, insurance payouts) and indirect (insurance premiums, automobile safety features) costs. They do not include more speculative societal costs such as disrupted commuting patterns, moving to a different neighborhood, changing job location, etc.

[3] Various reports comparing hospital admissions to police reports indicate that pedestrian and bicycle injuries are underreported from 35 to 80%. The 50% chosen is a conservative number. Fatality numbers were not adjusted, as they are generally accurate. Vehicle-vehicle numbers were assumed to be correct as crash data typically includes information from insurance companies as well.

| Severity | Description | Cost |
|---|---|---|
| F | fatality | $2,600,000 |
| A | incapacitating injury | $180,000 |
| B | evident injury | $36,000 |
| C | possible injury | $19,000 |
| PDO | property damage only | $ 2000 |

**Table 2: FHWA Comprehensive Crash Costs (1994 Dollars)**[4]

These multipliers can be applied to existing crash rates to estimate the approximate annual cost to community of the existing roadway configuration and safety conditions.

All other factors being equal, if the speed on the street is lowered, then the severity of any future conflicts will summarily be lowered. Table 3 shows the relationship between vehicle speed and collision rates. Other research suggests that a 3 mph vehicle speed reduction will reduce pedestrian fatalities by 10% and make another 20% less severe.[5] Documentation of vehicle speed before and after construction of the traffic calming project will yield a speed differential rate that can be used to forecast potential reduction in vehicle crashes. This can be an interim surrogate for post-construction observed crash data.

| Speed reduction, mph | Collision reduction |
|---|---|
| 6 | 42% |
| 3 | 15% |
| 1 | 5% |

**Table 3: Speed-collision Relationship**[6]

Multiplying projected or observed post-construction crash data by the appropriate multiplier and adjusting for inflation will provide a projected annual cost to community based on the traffic calmed roadway safety conditions. The difference between this and the annual cost to community based on pre-construction conditions will provide an estimate of potential cost saving from the traffic calming project relative to the cost of construction. Once post-construction crash rate data are available the cost-benefit analysis should be confirmed.

[4] Homberger, et al, *Fundamentals of Traffic Engineerin*g, 14th Edition, Institute of Transportation Studies, 1996, p. 9-13. The FHWA divides crashes into five categories while the Plainsboro Road data only used four categories. To balance these ‘other injury’ was assigned the mid-point between ‘B-evident injury’ and C-possible injury’: $25,000.
[5] A.J. McLean, et al., “Vehicle Travel Speeds and the Incidence of Fatal Pedestrian Collisions,” *Accident Analysis and Prevention*, Vol. 29, No. 5, 1997, pp. 667-674.
[6] D.J. Finch, P. Kompfner, C.R. Lockwood and G. Maycock, *Speed, Speed Limits and Accidents*, Transport Research Laboratory (Crowthorne, UK), Report 58, 1994; Barbara Preston, "Cost Effective Ways to Make Walking Safer for Children and Adolescents," *Injury Prevention*, 1995, pp. 187-190; C.N. Kloeden, A.J. McLean, V.M. Moore and G. Ponte, “Travelling Speed and the Risk of Crash Involvement,” NHMRC, Adelaide, Australia, 1998 (http://plato.raru.adelaide.edu.au/speed/index.html).

Consider air quality impacts

Changes in vehicle speed can affect air quality. Vehicles pollute the most at extremely low or high speeds or under hard acceleration. There are three basic pollutants considered in most air quality analyses: carbon monoxide (CO), volatile organic compounds (VOC) and nitrogen dioxide (NOX). In general, vehicles emit less CO and VOC at higher speeds (45 mph), with less NOX occurring at lower speeds (20 mph), although there is some debate as to the 'optimal' air quality traffic speed. The impact of traffic calming projects on air quality will depend on a variety of factors, including: average vehicle speed before and after the intervention, changes in acceleration/deceleration patterns, and the pollutant being measured.

Factors such as trip diversion, trip consolidation, trip elimination (forgoing driving for walking, cycling or the train) should also be considered. Diverting trips to other modes can result in less air pollution overall. Finally, many traffic calming installations include amenities such as trees and plantings, the air cleansing benefits of which should also be considered. To fully assess air quality impacts, a carefully crafted, comprehensive study is necessary.[7]

[7] For more information on air quality and emissions see the CMAQ website: http://www.fhwa.dot.gov/environment/cmaqpgs/index.htm and the reports: *A Sampling of Emissions Analysis Techniques for Transportation Control Measures*, final report. Cambridge Systematics for Federal Highway Administration, 2000; *Off-Model Air Quality Analysis: A Compendium of Practice*. Federal Highway Administration Southern Resource Center, 1999; *TTI CM/AQ Evaluation Model User's Guide and Workshop Training Materials*, Research Report 1358-1. Texas Transportation Institute, 1995; *TCM Quick Response Handbook: Tools for Local Planners*. Sarah Siwek and Apogee Research for North Jersey Transportation Planning Authority, undated.

## *III. APPLYING THE METHODOLOGY*

As previously noted, this study has two primary objectives: to develop a replicable traffic calming evaluation and monitoring methodology, and to apply the methodology to the Plainsboro Road Traffic Calming Project.

Table 4 summarizes the findings based on the performance measures outlined above. The remainder of this section documents how the methodology was used to evaluate the project's effectiveness. It should be noted that the report only presents findings based on pre-construction conditions and conditions immediately following the completion of the project. Further monitoring is recommended but was not within the scope of this study.

| Performance Measure | Result |
|---|---|
| Vehicle Speed | • $85^{th}$ percentile speed fell by two (2) mph<br>• maximum speeds not affected<br>• no significant impact on travel time |
| Exposure Risk | • pedestrian crossing time decreased by 21%<br>• enhanced by the raised median and signals |
| Driver Predictability | • signals, curbs, median, redesigned intersections and striping patterns work together to manage driver behavior |
| Vehicle Volume | • no significant impact |
| Noise | • relative difference between ambient and peak noise levels fell from 26 decibels to 20 decibels<br>• landscaping will decrease noise levels |
| Cost-benefit | • projected to save drivers, residents and government 1.7 million dollars over the next three years in direct and indirect costs, based on predicted crash rate reduction |

**Table 4: Summary of Key Findings**

**VISUAL DOCUMENTATION**

The first phase of the Plainsboro Road Traffic Calming Project contained four major components:

- a raised median between the intersection with Hunters Glen Drive and Deer Creek Drive and the intersection with Thoreau Drive and Davison park,
- a redesigned intersection with Hunters Glen Drive and Deer Creek Drive including signals, bike lanes and textured crosswalks,
- a realigned and redesigned intersection with Thoreau Drive and Davison park including signals, bike lanes and textured crosswalks, and
- curbs and sidewalks along the corridor.

To complement the still photographs two sets of before-after videos were taken. The first was taken while driving eastbound along the corridor and shows the new signals, intersections and median: DRIVE-BEFORE.MOV and DRIVE-AFTER.MOV. The second focuses specifically on the median section including the curbs and sidewalks: MEDIAN-BEFORE.MOV and MEDIAN-AFTER.MOV.

**Figure 1: May 2001 between Hunters Glen-Deer Creek and Thoreau-park**

**Figure 2: Jan 2002 between Hunters Glen-Deer Creek and Thoreau-park**

**Figure 3: May 2001 at Hunters Glen-Deer Creek Intersection**

**Figure 4: Jan 2002 at Hunters Glen-Deer Creek Intersection**

**Figure 5: May 2001 at Thoreau-park Intersection**

**Figure 6: Jan 2002 at Thoreau-park Intersection**

## SPEED

Vehicle Speed

Speeds as recorded by an automatic traffic recorder (ATR) placed at the median location show that the hourly average and 85$^{th}$ percentile speeds fell by two to three miles per hour. An average of the hourly maximum speeds recorded showed no change.

| | | Average | 85$^{th}$ percentile | Maximum |
|---|---|---|---|---|
| WB | Before | 46 | 51 | 61 |
| | After | 44 | 49 | 61 |
| | Difference | **-2** | **-2** | **0** |
| | | | | |
| EB | Before | 47 | 52 | 62 |
| | After | 44 | 49 | 62 |
| | Difference | **-3** | **-3** | **0** |

**Table 5: Speeds at Median, mph**

The observed change in 85$^{th}$ percentile speeds is consistent with recent research showing that a 1-foot change in lane width equals a 2-3 mph change in vehicle speed.[8] At the median, the lanes were reduced from 12 to 10.5 feet wide. Based on this reduction, speeds could be expected to decrease 3-4 mph.

By recording both volume and speed, the ATRs permit a look at their relationship, or lack thereof. In the case of Plainsboro Road, vehicle volume swings widely between the middle of night and rush hour (99-100%), while the 85$^{th}$ percentile speeds remain relatively constant (11-18%). In essence, the travel speed along Plainsboro Road is constant regardless of the amount of traffic. This non-relationship may be contrary to the general perception that drivers drive faster in rush hour or that there is more speeding in the middle of the night. In fact the eastbound after survey shows a slight decrease in speeds when there are the most vehicles. The median and signals did not significantly alter this relationship.

| | | Range of 85$^{th}$ Percentile Speeds, mph | | Range of Volumes | |
|---|---|---|---|---|---|
| WB | Before | 45 - 54 | 17% | 7 - 1392 | 99% |
| | After | 45 - 55 | 18% | 5 - 1398 | 100% |
| EB | Before | 48 - 54 | 11% | 7 - 1503 | 100% |
| | After | 46 - 53 | 13% | 3 - 1499 | 100% |

**Table 6: Speed-Volume Relationship**

[8] K. Fitzpatrick and P. Carlson, "Design Factors that Affect Driver Speed on Suburban Streets," paper presented at the 80$^{th}$ Annual Meeting, Transportation Research Board, Washington, D.C., 2001.

Vehicle Travel Times

Vehicle travel time was measured along the study corridor from the bridge at Plainsboro's eastern municipal boundary with Cranbury Township and the jug handle intersection with old Plainsboro Road. This corridor is 1.8 miles long. Travelling at a constant 45 mph (the posted speed limit) one would expect to travel this distance in 2 minutes and 24 seconds.

Before construction of the project commenced, a series of six timing runs were made along the corridor in each direction during the noon time period. The average trip took 2:49 minutes. After the installation, the same trip took 2:42 minutes, seven seconds (4%) faster. This change is not statistically significant, yet shows that lowered speeds did not affect overall travel times.

| | **WB** | **EB** | **Average** |
|---|---|---|---|
| Before | 2:52 | 2:46 | 2:49 |
| After | 2:47 | 2:37 | 2:42 |
| Difference | -5 seconds | -9 seconds | **-7 seconds** |

**Table 7: Travel Times**

## EXPOSURE RISK

Exposure risk is the time which a person is exposed to on-coming traffic when crossing a street. A basic measure of exposure risk is the width of the street. In the before condition, Plainsboro Road was approximately 64 feet wide at the location where the median was installed. After construction, Plainsboro Road was effectively transformed into two 26.5-foot wide road segments separated by a landscaped median. Before construction, crossing the street took 9 to 23 seconds. Now it takes between 8 and 19 seconds, respectively. This differential indicates that pedestrian safety as measured by exposure risk, increased 21 percent.

| | Pavement width | Crossing time 2.8 fps | Crossing time 7.0 fps |
|---|---|---|---|
| Before | 64 feet | 23 sec. | 9 sec. |
| After | 53 feet | 19 sec. | 7.5 sec. |
| Difference | | **21 %** | **21 %** |

**Table 8: Pedestrian Crossing Time**

More importantly, with the median, pedestrians and cyclists now have the opportunity to cross the street in segments. All things being equal, it is safer to cross a one-way street, because there is only one direction of traffic to contend with. For an illustration of before and after conditions, see the following videos: MEDIANXING-BEFORE.MOV and MEDIANXING-AFTER.MOV. In the former, the woman crossing the street waits with no protection for vehicles to yield to her. In the latter, the man waits atop the raised median while vehicle pass both behind and in front of him.[9]

**Figure 7: Before - Flush Median**

**Figure 8: After - Raised Median**

[9] These videos were shot using time-lapse photography (2 frames per second) which was then placed in video format.

## DRIVER PREDICABILITY

An overall measure of roadway safety is driver predictability: the ability of pedestrians, cyclists and other motorists to predict the speed and actions of drivers. The addition of a median and curbs increases driver predictability by keeping vehicles on the roadway and in their half of the roadway. While not a safety panacea, traffic signals direct drivers to stop for pedestrians, which makes crossing the street easier and more predictable. Signals also create gaps in the traffic stream which make crossing mid-block easier. Striped bike lanes and stop lines at the intersection help to organize the area so that all users are better informed of others' actions. By removing the free-right turn lanes from the Hunters Glen-Deer Creek intersection drivers must now turn more slowly, and more predictably.

To illustrate these improvements, before and after videos at the crosswalk adjacent to the park were taken: CROSSWALK-BEFORE.MOV and CROSSWALK-AFTER.MOV. In the first, the rollerbladers wait in the median as the first vehicle stops and yields. As they complete their crossing, the second vehicle suddenly brakes. Failing to yield is a common source of vehicle-pedestrian incidents. In the latter, the woman with a stroller and dog leisurely completes her crossing at the light.[10]

[10] These videos were shot using time-lapse photography (2 frames per second) which was then placed in video format.


**Figure 9: Before – Stop Sign, Island**

**Figure 10: After – Signal, Larger Island, Crosswalk and Channelization**

**Figure 11: Before - No Signal**

**Figure 12: After - Signal, Stop Line and Bike Lanes**

**Figure 13: Before - Free Right Turn Lane**

**Figure 14: After - No Free Right Turn Lane**

**VOLUME**

Vehicle Volume

Vehicle volume counts on Plainsboro Road were taken before and after construction. The before surveys were taken during the month of May. The after counts were performed in January and February.[1] The counts were adjusted for monthly and daily traffic fluctuations using adjustment factors, developed by the NJDOT based on continuous traffic survey data.[2] Dividing the counts by a factor gives an adjusted volume, which can be compared directly to surveys performed on other days or in other months.

| Month | Day | Actual Volume | Factor | Adjusted Volume | Average |
|---|---|---|---|---|---|
| May 01 | Fri | 9035 | 1.171 | 7715 | |
| May 01 | Sat | 5823 | 0.847 | 6876 | |
| | | | | Before | 7296 |
| | | | | | |
| Jan 02 | Wed | 8051 | 1.042 | 7729 | |
| Jan 02 | Thurs | 7975 | 1.047 | 7620 | |
| | | | | After | 7674 |
| | | | | | |
| | | | | **change** | **+5%** |

**Table 1: Volume Change - Westbound**

| Month | Day | Actual Volume | Factor | Adjusted Volume | Average |
|---|---|---|---|---|---|
| May 01 | Tues | 10013 | 1.117 | 8967 | |
| | | | | Before | 8967 |
| | | | | | |
| Feb 02 | Wed | 9159 | 1.056 | 8670 | |
| Feb 02 | Thurs | 8636 | 1.061 | 8138 | |
| | | | | After | 8404 |
| | | | | | |
| | | | | **change** | **-6%** |

**Table 2: Volume Change - Eastbound**

As evidenced in Table 1 and Table 2, the project had a neutral impact on overall traffic volumes. Westbound traffic rose by five percent, while eastbound traffic fell six percent. This is consistent with the nature of the installation, which was not designed to affect volume.

[1] Only days where full counts were performed are used. The before counts bracketed Memorial Day, so that Monday is not used.
[2] The lasted and closest volume differentials available were taken in 1998 along Route 1 at the Forestal Road underpass.

Vehicle Diversion

Vehicle diversion is a common concern related to many traffic calming projects. In the case of Plainsboro Road there are few potential diversion routes. Because Scudders Mill Road becomes Plainsboro Road, it is a natural eastbound route from Route 1 to Exit 8A of the NJ Turnpike. Westbound, the more direct route is Dey Road, which has a sign directing traffic to Plainsboro off Route 130.

Travelling westbound it is possible to avoid the traffic calmed segment of Plainsboro Road by turning south on George Davison Road or north on Scotts Corner Road, see Figure 15. The former takes one to Route 615 and Princeton Junction, the latter takes one to Dey Road and Scudders Mill Road, although both are rather circuitous. Travelling eastbound it is possible to avoid the new median and signals by turning east on Dey Road.

While vehicle volumes on these potential diversion routes were not counted, it can be inferred from the vehicle volume counts for Plainsboro Road that significant diversion is not occurring. However, the six percent fewer eastbound vehicles suggests that drivers may be opting for Dey Road. Future vehicle volume monitoring is recommended on both Plainsboro Road and Dey Road. To fully analyze potential diversion scenarios a comprehensive origin-destination survey could be performed.

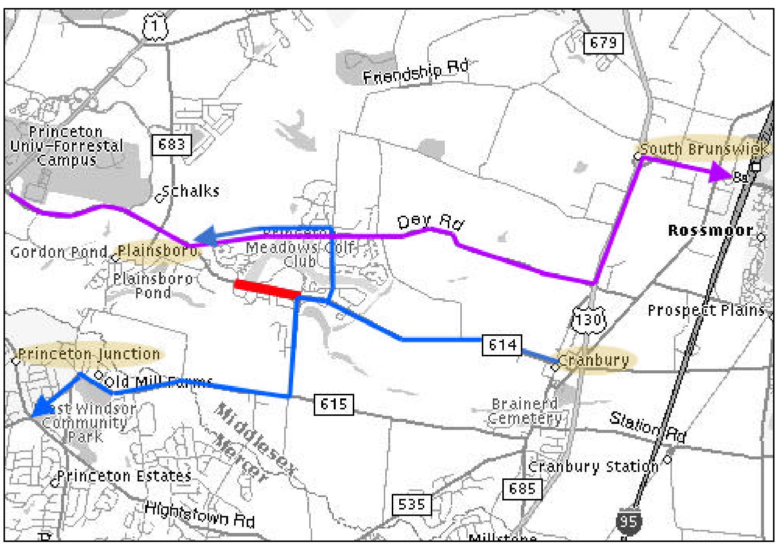


**Figure 1: Possible Diversion Routes**

Vehicle Mix

The mix of vehicles traveling on Plainsboro Road was unaffected by the medians and signals. Before the installation, 98.6 percent of all traffic were cars, motorcycles, vans, SUVs, and light trucks. After the medians, curbs and signals were installed, this percentage totaled 98.7. This is consistent with the nature of this installation, which was not designed to affect traffic mix.

Pedestrian and Cyclist Volume

Before and after counts of pedestrian and cyclists showed a 30 percent drop, which can be attributed to seasonal differences. Non-commuting walking and cycling rates experience far greater seasonal and weather-related fluctuations than driving rates. The before count occurred close to Memorial Day, while the after counts were taken in mid-January. For a more accurate assessment, additional counts should be performed in the future.

| | Pedestrians | Bicyclists | Total |
|---|---|---|---|
| Before (summer) | 76 | 14 | 90 |
| After (winter) | 54 | 9 | 63 |
| difference | -29% | -36% | **-30%** |

**Table 3: Pedestrian and Bicycle Volumes**

While this project is not related to any new pedestrian generator (school, playground, shopping center) which would directly increase pedestrian activity in the area, the new signals, textured crosswalks, bus shelters, curbs, sidewalks, and trees lay the groundwork for future increases in pedestrian and bicycle trips.

**Figure 2: Before – No Signal, Striped Crosswalk**

**Figure 3: After – Signal, Textured Crosswalk**

**Figure 4: Before – No Bus Shelter**

**Figure 5: After – Bus Shelter**

**Figure 6: Before - No Curbs, Sidewalk, Or Trees**

**Figure 7: After - Curbs, Sidewalk, Trees**

**Figure 8: Before – Dirt Path**

**Figure 9: After – Concrete Walk**

## NOISE

In roadway projects, changes in speed or variability of speed may affect noise levels. Measurements taken in May, just before construction, showed a variation of 26 decibels between the ambient noise levels (when there was no traffic) and the peak noise levels (typically when an accelerating truck or speeding car passed). As discussed above a change of 10 dB doubles the noise level.

After measurements were taken in January, when foliage and weather conditions were not similar. For this reason, it was not possible to provide a strict before-after comparison. Yet one may compare the ambient/peak differential, which provides some control. After installation, the differential fell to 20 decibels.

| | Ambient | Peak | Difference |
|---|---|---|---|
| Before | 54 | 81 | **-26** |
| After | 65 | 85 | **-20** |

**Table 4: Noise Levels, dB**

The lower noise differential may be attributed to a few items. On winter days, ambient noise levels are generally higher, for there is more wind and less sound-absorbing foliage. With the additional traffic signals, drivers would coast when the light is red yet accelerate to make the next light. The median screens some noise, and will shield more as the foliage increases. During the summer months this effect will be more apparent. Ultimately, noise monitoring should be repeated when foliage and weather conditions are similar to the before condition.

## COST-BENEFIT

Analyzing the cost-benefit of a project allows one to determine the rate of return on investment. While no quantitative cost-benefit analysis can capture the entire spectrum of value to the community, it can provide a good foundation for discussion.

Adding a median and timed signals to Plainsboro Road has reduced vehicle speeds by approximately 2 mph overall. Directly at the median, the 85th percentile speed went down 3 mph. Away from the median the speed dropped an average of 1.5 mph.

| Location | Dir. | Before Speed | After Speed | difference |
|---|---|---|---|---|
| Centers-Wyndhurst to Hunters Glen-Deer Creek | WB | 52 | 50 | -2 |
| | EB | 51 | 52 | +1 |
| Hunters Glen-Deer Creek to Thoreau-park (median) | WB | 52 | 49 | -3 |
| | EB | 51 | 48 | -3 |
| Thoreau-park to Davison-Tamarron | WB | 50 | 48 | -2 |
| | EB | 51 | 48 | -3 |
| **average** | | **51** | **49** | **-2** |

**Table 5: 85th Percentile Speeds along Plainsboro Road, mph**

Twenty-nine months (January 1996 – May 1998) of crash (accident) data for the Plainsboro Road study corridor was compiled by type and severity. It was not possible to assign a location to each incident, so data for the entire corridor was aggregated. The incidents involving a vehicle and bicycle or pedestrians were adjusted upwards by 50% to account for underreporting. Annually, this section of Plainsboro Road witnesses approximately 38 crashes.

| Crash Type | Fatal | Severe Injury | Other Injury | Property Damage Only | Total | Annual Rate |
|---|---|---|---|---|---|---|
| Vehicle-Vehicle | 1 | 0 | 24 | 54 | 79 | 33 |
| Vehicle-Bicycle/Pedestrian | 1 | 6 | 4.5 | 1.5 | 13 | 5 |
| **Total** | 2 | 6 | 28.5 | 55.5 | 92 | **38** |

**Table 6: Crashes along Plainsboro Road, Adjusted for Underreporting (1996-98)**

Multiplying the crash numbers in Table 6 by those in **Error! Reference source not found.** and adjusting for inflation[3] yields an annual pre-construction cost to community of $3,870,601.

Factoring the crash numbers in Table 6 by the speed-crash relationships shown in **Error! Reference source not found.**, one can predict the number of crashes will fall to 34 per year.

[3] The FHWA numbers are based on 1994 dollars. To adjust for inflation an annual factor of 3.5% was used. The numbers presented are 2002 dollars.

| Crash Type | Fatal | Severe Injury | Other Injury | Property Damage Only | Total | Annual Rate |
|---|---|---|---|---|---|---|
| Vehicle-Vehicle | 0.9 | 0 | 21.6 | 48.6 | 71.1 | 29 |
| Vehicle-Bicycle/Pedestrian | 0.8 | 4.9 | 4.4 | 1.8 | 11.9 | 5 |
| **Total** | 1.7 | 4.9 | 26 | 50.4 | 83 | **34** |

**Table 7: Projected Crashes along Plainsboro Road**

Multiplying the forecasted crash data by the associated costs and adjusting for inflation gives an annual post-construction cost to community of $3,300,743. The difference between pre- and post-construction costs is $596,859. As such, this project can be projected to save drivers, residents and government approximately 1.7 million dollars over the next three years in direct and indirect costs.

| | |
|---|---|
| Previous crash costs | $3,870,601 |
| Projected crash costs | $3,300,743 |
| Projected annual savings | $569,859 |
| Projected savings over 3 years | $1,709,576 |

**Table 8: Projected Savings**

It should be noted that other changes, such as traffic signals, the median which gives pedestrians a safer crossing and reduces head-on collisions, and curbs which keep errant vehicles on the roadway also impact safety. In addition, it should be noted that increases in bicycle and pedestrian traffic may increase the number of incidents. Finally, the reader should note that other factors such as tax revenues, property values, environmental impact, and travel mode share are important cost-benefit indicators that were not within the scope of this study.[4]

[4] For more information on cost-benefit analysis see T. Litman, "Traffic Calming Benefits, Costs and Equity Impacts", Victoria Transport Policy Institute, 1999 (www.vtpi.org), and K. Ozbay et al, "Estimation and Evaluation of Full Marginal Costs of Highway Transportation in New Jersey", *Journal of Transportation and Statistics* vol. 4 no. 1, USDOT, April 2001, pp. 81-103.

**AIR QUALITY**

Measuring the precise impact of the Plainsboro Road traffic calming project on overall air quality was outside the scope of this analysis; however, several general observations can be made. The 2-3 mph documented speed change will have a negligible impact on overall emissions. At the same time the more constant speeds observed after the traffic calming intervention and the additional trees and foliage now present in the study area will provide a positive air quality benefit. Finally, the new/improved pedestrian and cyclist facilities provided by the project set the stage for increased non-vehicle trips and increased transit use. More detailed studies are needed to quantify air quality benefits and to assess air quality benefits over time.

# *IV. DATA*

The complete set of before and after data is contained in the Appendices DATA-BEFORE.PDF and DATA-AFTER.PDF.

**Voorhees Transportation Policy Institute**
Alan M. Voorhees Transportation Center
Edward J. Bloustein School of Planning and Public Policy
Rutgers, The State University of New Jersey
33 Livingston Avenue, Suite 500
New Brunswick, New Jersey 08901
732/932-6812 x700 – 732/932-3714 (fax)
http://www.policy.rutgers.edu/tpi

**Keep Middlesex Moving, Inc.**
MIDDLESEX COUNTY'S TRANSPORTATION
MANAGEMENT ASSOCIATION
100 Bayard Street, 2nd Floor
New Brunswick, New Jersey 08901
Phone 732/745-4490
Fax 732/745-7482
kmm@kmm.org