GPI
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Engineering and Construction Services

Signal Optimization Report
August 2016

Broadway Traffic Signalization Study (Part 2 of 2) Kingston, New York

Prepared for:

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1.0 Introduction

The Broadway Traffic Signalization Study and Design project was initiated by the City of Kingston utilizing a New York State Energy Research Development Authority (NYSERDA) grant. The goals of this project are to improve traffic flow and reduce delays within the Broadway corridor, which in turn will improve operations for all modes of travel (vehicular, transit, pedestrian and bicycle), while reducing fossil fuel consumption and greenhouse gas emissions. All of which will improve the quality of life along Broadway.

This project, which focuses on the seven signalized intersections along Broadway between St. James Street and East Chester Street, is being progressed simultaneously and implemented in conjunction with the Broadway Connectivity Design project, whose goal is to create a more livable, vibrant community through a combination of complete streets strategies and improved multi-modal connectivity. The Broadway Connectivity project is currently in preliminary design and is proposed to go to construction in 2017.

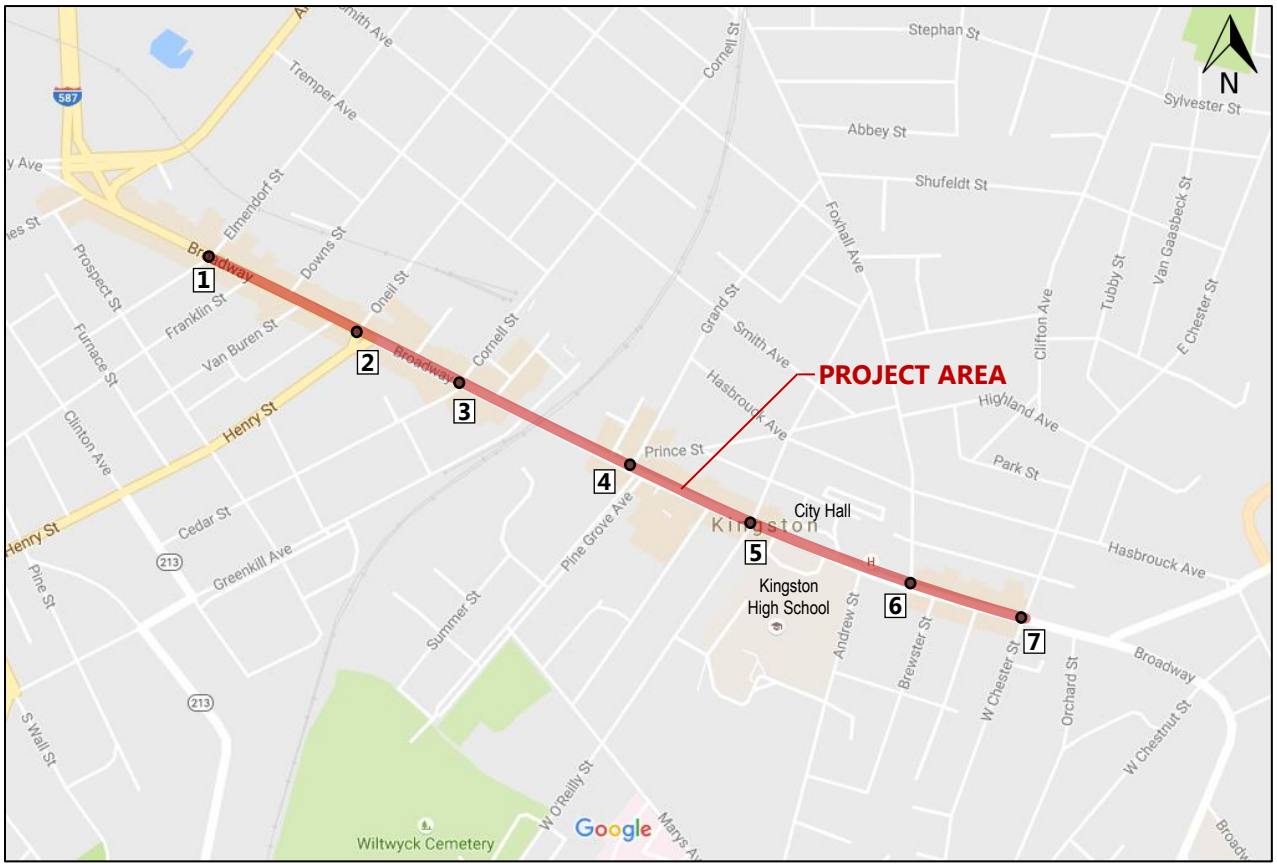
The Broadway Traffic Signalization Study/Design project is to be completed in three Phases as discussed below:

1. **Traffic Signalization Study** – This study is being documented in two separate reports, the first being the Existing Conditions Report, submitted in November 2015, which detailed the existing traffic signal equipment and traffic conditions. The second being this Traffic Signal Optimization Report that outlines the future "Build" condition analysis, findings and recommendations. For purposes of this analysis, it is assumed that the "cycle track" alternative for the Broadway corridor, between Elmendorf St and Grand Street, will be constructed in conjunction with any future traffic signal improvements.
2. **Signal Improvement Design** – Once recommendations from the Signalization Study have been reviewed and approved by the City of Kingston, design plans will be developed for the implementation of signal improvements. This design effort will include both preliminary and final design for these improvements, which will be completed using New York State Department of Transportation (NYSDOT) and City standards, and in accordance with the Manual on Uniform Traffic Control Devices. It is anticipated that the four signals within the "cycle track" area will require complete equipment replacement to accommodate the "cycle track", and their design plans will be incorporated into the plan set being developed for the Broadway Connectivity project. Improvements at the remaining three signals will be completed as a maintenance function by the City, and separate plans for these locations will be developed and submitted to the City's engineering department for implementation.
3. **Equipment Installation and Final Reporting** – Implementation of the signal improvements will be performed through separate construction contracts. During the equipment installation, construction inspection and support will be provided, and after construction a field review of traffic conditions will be performed. A Final Project Summary Report discussing the improvements made and their effect on various Measures of Effectiveness (MOE's) will be issued.

The document that follows is the second report of the Traffic Signalization Study and outlines the "Build" condition analysis and findings, as well as recommendations for signal system optimization to minimize delay, emissions and user costs.

2.0 Project Area

This project area extends from St. James Street to East Chester Street along Broadway in downtown Kingston. This nearly one mile section of roadway includes seven (7) signalized intersections, which are described later in this report. The Broadway corridor consists of a four lane cross section within the western half of the corridor and a two lane section within the eastern half of the corridor. Turn lanes are present at only a few locations and on-street parking is prevalent throughout the entire corridor. The posted speed limit is 30 mph along Broadway, as it is throughout the City. The corridor location is shown on the Map Below.



PROJECT LOCATION MAP

The seven signalized intersection to be reviewed as part of this study include:

1. Elmendorf Street/Liberty Street and Broadway
2. O'Neil Street/Henry Street and Broadway
3. Cornell Street/Cedar Street and Broadway
4. Grand Street/Pine Grove Avenue and Broadway
5. East/West O'Reilly Street and Broadway
6. Foxhall Road and Broadway
7. East/West Chester Street and Broadway

The existing geometry and traffic control details for each of these intersections can be found in the Existing Conditions Report.

3.0 Future "No-Build" and "Build" Conditions

Currently there are plans to implement roadway geometric and streetscaping improvements within the Broadway Corridor to improve safety and aesthetics, enhance pedestrian and bicycle facilities and provide area connectivity for the many bicycle trails and routes the converge onto Broadway. This "Broadway Connectivity" project is currently in design and construction is expected to begin in 2017 and be completed in 2018. Because of the timing of that project, it was determined that the signal optimization for the Broadway corridor should consider and incorporate the improvements proposed under that project in the Build Condition analysis.

For the No-Build Condition, it is assumed that all geometric and signal timings will remain as they are currently in the field. This condition only applies if the Broadway Connectivity project does not move forward, and will provide a good baseline to determine the benefits of both the cycle track improvements and the signal optimization.

3.1 Traffic Volumes

With an anticipated completion date of 2018 for the Broadway Connectivity project, all analysis for this Signalization Study will focus on a 2018 design year for optimization.

Using the 2015 traffic volumes shown in the Existing Conditions Report and adjusting using a 0.5% per year traffic growth, which is a conservative estimate of growth based on historic traffic volume data obtained for the corridor, 2018 peak hour traffic volumes were developed for the AM and PM peak hour. A diagram showing these volumes is included in Appendix A of this report.

It is assumed that these volumes are reasonable for analysis purposes for both the "No-Build" and "Build" condition (with and without the cycle track). It is hoped that there will be a slight mode shift from vehicular traffic to bicycle traffic because of the addition of the cycle track in the Build condition, but it is felt that this shift will not be significant enough to affect the analysis, so no traffic volume adjustment was made between the two conditions.

Example Cycle Track, located on 15th Street, Washington DC

3.2 Broadway Connectivity Project Geometric Improvements

The Broadway Connectivity project includes many streetscaping improvements and other enhancements, but the main focus that will impact traffic operations is the improved bicycle facilities, which will feature a "Cycle Track" along the north side of Broadway between Elmendorf

Street and Grand Street. This cycle track will be a two-way bicycle only facility separated from the vehicular travel lanes (see example on previous page).

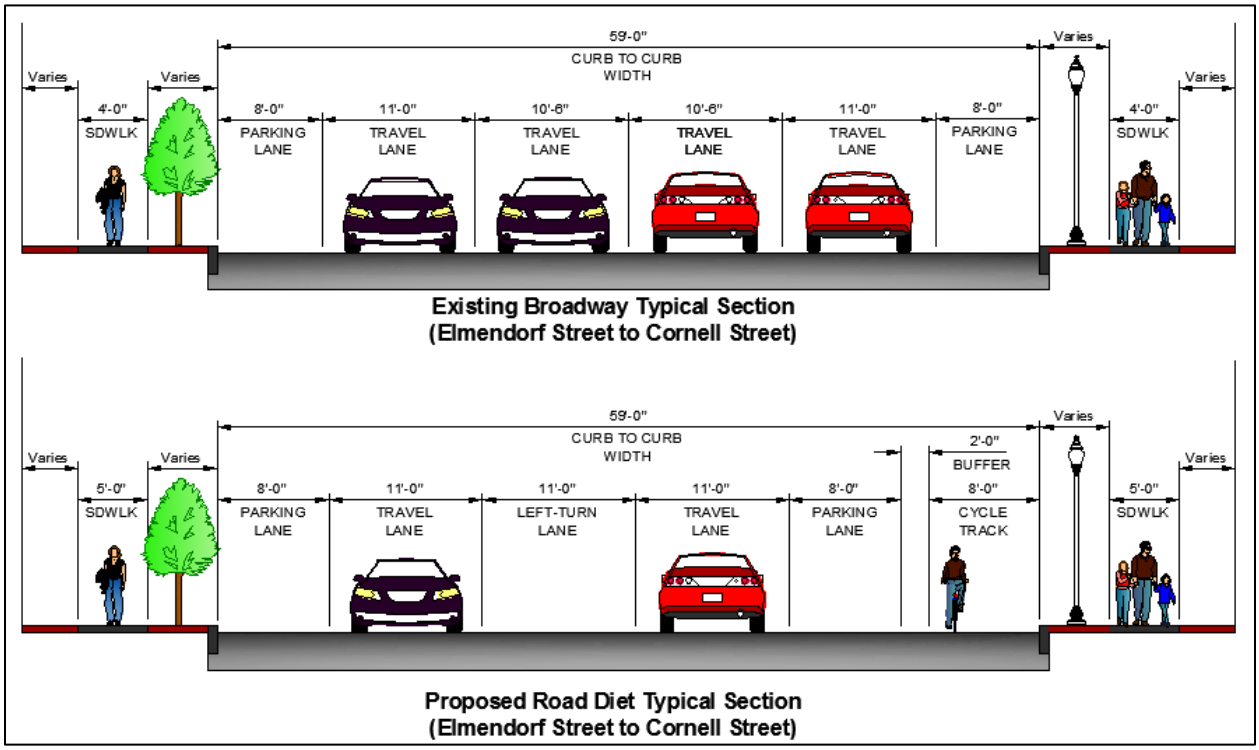
A goal of the Connectivity project is to stay within the existing curb-to-curb width of the existing roadway. As such, the incorporation of this cycle track, will entail the removal of some parking, and will require a "Road Diet" between Elmendorf St and Grand Street. This will affect four of the seven traffic signals within the study corridor.

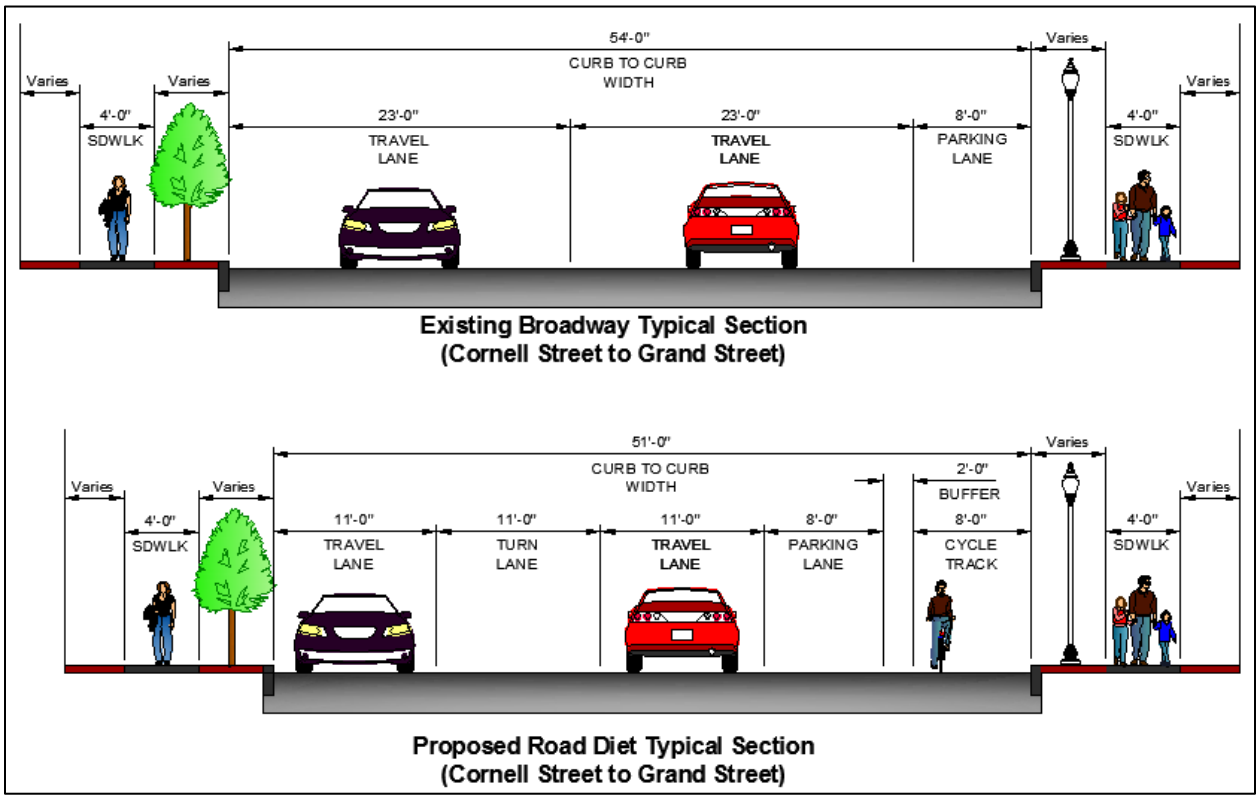
For Elmendorf Street to Cornell Street (see typical section figure below) this Road Diet will consist of reducing the existing four-lane roadway section (2-eastbound lanes & 2-westbound lanes) to a three-lane section (1-eastbound lane, 1-westbound lane and a center left turn lane). It will also feature on-street parking on both sides of the roadway and the cycle track lanes.

For Cornell Street to Grand Street (see typical section on next page), the existing two 23' wide lanes will be reduced to 11' and the remaining width will be used for a center left turn lane & median and for the cycle track. This area will continue to include on-street parking on the north side of the roadway, but it will be shifted to provide a buffer between the vehicular traffic and bicyclists. The curb to curb width will be reduced by 3 feet in this area.

Concept Plans for the proposed Cycle Track layout are located in Appendix B of this Report.

Since the cycle track does not extend any farther east than Grand Street, geometrics at the remaining three traffic signals within the study corridor will remain as existing for the Build Condition analysis.





3.3 Cycle Track Effect on Traffic Signals

Incorporation of the cycle track concept into the corridor's traffic signal system will require several changes at the intersections of Broadway at Elmendorf/Liberty, Broadway at O'Neil/Henry, Broadway at Cornell/Cedar and Broadway at Grand/Pine Grove. First, NYSDOT will not allow permissive left turn movements (turning on green ball indication without a green turn arrow) at these signalized intersections, as they are concerned that drivers unfamiliar with the cycle track concept will not be aware of the contraflow bicycle traffic, which could contribute to accidents. As a result, these four signals will need to be modified to allow only protected left turns from the eastbound approach. Additionally, bicycle signals will need to be installed at each intersection and clearance times must be lengthened for the Broadway through movements to address the additional time required for bicycles to clear the intersection. Finally at each of these signals, southbound right turn on red vehicles will have a tendency to "creep up" closer to the intersection before turning, which would cause them to block the bike lanes. As this would cause an unsafe condition for bicyclists, right turn on red movements at these intersections must be prohibited.

Given the required modifications to accommodate the cycle track, each of the four traffic signals located within the cycle track area will be replaced. Design Plans for these replacements will be developed as part of the Broadway Connectivity project and improvements will be constructed concurrently with the cycle track roadway improvements.

3.4 Traffic Simulation Model Development

Traffic simulation modeling for the Broadway corridor was performed utilizing the Synchro/Simtraffic Software Package developed by Trafficware LLC. The software uses car movement and traffic control logic similar to real world driver conditions. Parameters such as gap acceptance, speeds, driver aggressiveness and vehicle type are stochastically applied (randomly distributed based on a probability curve) to the model, and vehicle statistics are recorded on a second by second basis. Because of the stochastic nature of these models, different random seeds can generate different output values, similar to how traffic varies slightly from day to day on a roadway. As a result, multiple model runs (10 each) were conducted and averaged to determine the result values for alternative comparison.

As presented in the Existing Conditions Report, The existing conditions for both the AM and PM peak hours were modeled using this software and were calibrated to match real world conditions. These models and associated calibration parameters were used as a base for the No-Build Condition Models.

The simulation models were then modified to reflect the geometric changes for the cycle track. Left turn phasing, clearance intervals and turn restriction, as discussed previously, were changed to create the Build Condition models. To operate efficiently, vehicle detection will need be added to each of the new left turn lanes as part of the traffic signal redesigns within the cycle track area. The Build Condition models reflect this change in detection as well.

Models were developed for the AM and PM peak hour for each condition, and three separate conditions were reviewed. They include the following:

Condition 1: **No-Build** – Uses existing road geometry and signal timings.

Condition 2: **Build (Uncoordinated)** – Reflects geometric and traffic control changes required for the Cycle Track, and optimized each traffic signal as an isolated intersection. This condition has no signal coordination or interconnect.

Condition 3: **Build (Coordinated)** – Reflects geometric and traffic control changes required for the Cycle Track, and optimized the complete signal network within the corridor as a whole to minimize travel times and delays. This condition assumes that signals timings will be coordinated and that all seven signals will be incorporated into a single interconnected signal system.

4.0 Future Operating Conditions

4.1 Level of Service Criteria

Traffic operational conditions are typically described in terms of level of service (LOS) as defined by the Highway Capacity Manual (HCM 2010) published by the Transportation Research Board (TRB). Level of service is a letter grade representation of traffic delay and congestion at a particular location. LOS ranges from "A" to "F" with LOS A representing the best operating condition with unrestricted flow and little or no delay per vehicle, and LOS F representing the worst conditions, with high congestion, long delays and poor traffic operations. LOS C or better is generally desirable, but LOS D is generally acceptable during peak periods

The level of service criteria for an intersection is based on the individual delay experienced by each vehicle at that intersection; while the overall level of service for an urban corridor is based on the average travel speed within the corridor as it relates to the base free-flow speed, which for Broadway is assumed to be the speed limit of 30 mph. The level of service criteria for both signalized intersections and urban corridors are shown in Table 1 below.

Table 1
Level of Service Criteria

LOS	**Signalized Intersection** Delay Per Vehicle (sec.)	**Urban Corridor** as a Percentage of Base Free-Flow Speed	**Urban Corridor** with 30 mph Base Free-Flow Speed
A	$\leq$ 10.0	> 85%	> 25.5 mph
B	> 10.0 and $\leq$ 20.0	> 67% and $\leq$ 85%	> 20.1 mph and $\leq$ 25.5 mph
C	> 20.0 and $\leq$ 35.0	> 50% and $\leq$ 67%	> 15.0 mph and $\leq$ 20.1 mph
D	> 35.0 and $\leq$ 55.0	> 40% and $\leq$ 50%	> 12.0 mph and $\leq$ 15.0 mph
E	> 55.0 and $\leq$ 80.0	> 30% and $\leq$ 40%	> 9.0 mph and $\leq$ 12.0 mph
F	> 80.0	$\leq$ 30%	$\leq$ 9.0 mph

4.2 Results of Analysis

For both the AM peak hour and the PM peak hour of each analysis condition, Simtraffic traffic simulation models were developed. Each model was run 10 times using different random seeds and the outputs averaged to obtain the measures of effectiveness (MOE's) summarized in the table on the next page. Simulation model output sheets for each of the analyses are included in Appendix C of this report.

It should be noted when reviewing the analysis results that the Build Condition MOE's at each individual intersection are not always an improvement over the No-Build condition. This is because the addition of the cycle track in the Build condition introduces several factors that reduce capacity in order to fit the additional bike lanes and/or improve safety. These factors include reducing the number of travel lanes between Elmendorf to Cornell, adding protected only left turn phasing at the four signals within the cycle track area, and increasing clearance times so bicyclists can safely traverse each intersection at the end of their signal phase.

Table 2
Simulation Model MOE Summary

Intersection Performance		AM Peak Hour			PM Peak Hour		
		Nobuild Cond. 1	Uncoord Cond. 2	Coord. Cond. 3	Nobuild Cond. 1	Uncoord Cond. 2	Coord. Cond. 3
Broadway at Elmendorf St./ Liberty St.	Eastbound	B (19.9)	B (11.4)	B (12.4)	B (15.4)	B (13.4)	B (14.2)
	Westbound	C (22.6)	B (14.3)	A (9.0)	C (21.4)	C (23.6)	B (12.4)
	Southbound	B (18.0)	D (40.1)	D (48.0)	C (20.7)	D (42.5)	D (46.6)
	Overall	**C (21.0)**	**B (14.1)**	**B (12.5)**	**B (18.5)**	**B (19.7)**	**B (15.0)**
Broadway at O'Neil St./ Henry St.	Eastbound	B (19.8)	B (16.9)	B (17.5)	B (18.2)	B (17.1)	B (15.9)
	Westbound	B (18.4)	C (21.2)	B (10.1)	B (18.0)	C (22.2)	B (10.8)
	Northbound	B (16.0)	C (27.7)	C (31.6)	B (15.3)	C (23.1)	C (29.0)
	Southbound	B (17.5)	D (38.2)	D (45.7)	C (21.3)	D (35.7)	D (46.3)
	Overall	**B (18.8)**	**C (20.5)**	**B (16.7)**	**B (18.1)**	**C (21.4)**	**B (17.6)**
Broadway at Cornell St./ Cedar St.	Eastbound	C (21.6)	B (18.4)	C (23.2)	C (33.5)	C (25.0)	C (30.6)
	Westbound	B (17.0)	C (23.7)	C (23.6)	C (26.4)	D (37.7)	D (49.6)
	Northbound	B (15.5)	D (36.5)	C (34.3)	B (15.6)	E (72.4)	D (39.7)
	Southbound	B (19.3)	E (59.7)	D (47.8)	C (20.4)	F (217.6)	E (62.1)
	Overall	**B (18.8)**	**C (26.3)**	**C (26.9)**	**C (27.0)**	**E (58.3)**	**D (42.8)**
Broadway at Grand St./ Pine Grove Ave.	Eastbound	B (14.8)	C (21.1)	C (25.3)	B (18.4)	C (24.0)	C (30.8)
	Westbound	C (32.9)	D (40.0)	D (38.5)	D (36.6)	D (38.0)	D (43.8)
	Northbound	D (41.8)	E (62.2)	E (58.8)	D (45.6)	F (94.6)	E (61.6)
	Southbound	B (17.5)	C (20.1)	C (24.2)	B (15.0)	C (20.8)	C (23.3)
	Overall	**C (22.0)**	**C (29.0)**	**C (31.3)**	**C (25.0)**	**C (34.1)**	**D (35.7)**
Broadway at E. O'Reilly St./ W. O'Reilly St.	Eastbound	B (20.0)	B (11.2)	B (12.8)	B (17.8)	B (12.5)	B (12.0)
	Westbound	B (19.8)	B (11.4)	A (9.8)	C (22.1)	B (13.8)	B (10.4)
	Northbound	C (22.3)	B (15.8)	B (16.3)	C (21.7)	B (15.8)	B (16.5)
	Southbound	C (20.1)	B (15.1)	B (13.7)	C (20.6)	B (14.5)	B (14.8)
	Overall	**C (20.2)**	**B (12.2)**	**B (12.2)**	**B (20.0)**	**B (13.5)**	**B (12.3)**
Broadway at Foxhall Rd.	Eastbound	C (26.9)	A (6.8)	A (5.3)	C (33.3)	A (10.0)	A (6.7)
	Westbound	C (20.2)	A (4.8)	A (6.4)	B (19.2)	A (6.6)	A (7.7)
	Southbound	B (11.2)	A (9.8)	B (10.8)	B (15.4)	B (15.5)	B (16.6)
	Overall	**C (22.6)**	**A (6.2)**	**A (6.2)**	**C (25.7)**	**A (9.5)**	**A (8.4)**
Broadway at East Chester St./ West Chester St.	Eastbound	B (13.0)	A (9.9)	A (8.5)	B (14.3)	B (11.3)	A (9.6)
	Westbound	B (10.4)	A (7.9)	A (7.4)	C (31.3)	C (20.6)	C (21.8)
	Northbound	C (20.6)	B (12.8)	B (13.6)	C (20.1)	B (12.7)	B (15.1)
	Southbound	C (33.8)	B (20.0)	C (22.0)	C (29.7)	C (20.4)	C (20.7)
	Overall	**B (17.5)**	**B (11.8)**	**B (11.6)**	**C (22.8)**	**B (15.9)**	**B (15.9)**
Corridor Performance							
Average Travel Time (seconds)	Eastbound	245.8	209.0	210.5	266.2	221.6	220.6
	Westbound	261.7	246.4	226.7	275.2	273.4	255.1
Corridor Level of Service (Avg. Travel Speed-MPH)	Eastbound	D (13.8)	C (16.2)	C (16.1)	D (14.1)	C (15.3)	C (15.3)
	Westbound	D (12.9)	D (13.7)	D (14.9)	D (12.3)	D (12.4)	D (13.3)
Total Number of Stops		5,896	5,121	4,644	6,898	6,600	5,959
Overall Vehicle Hours of Delay (VHD)		54.1	50.4	49.4	67.9	82.7	70.2
Fuel Consumed (gallons)		74.5	72.0	71.9	85.8	88.0	85.0
HO Emissions (g)		1,430 g	1,291 g	1,249 g	758 g	750 g	681 g
CO Emissions (g)		26,675 g	26,796 g	26,114 g	20,796 g	20,139 g	18,924 g
NOx Emissions (g)		4,139 g	3,800 g	3,692 g	2,724 g	2,652 g	2,489 g
Total Emissions (kg)		**35.3 kg**	**31.9 kg**	**31.1 kg**	**24.3 kg**	**23.5 kg**	**22.1 kg**

4.3 Evaluation of Results

4.3.1 Intersection Operations

In the 2018 No-Build condition (condition #1), all intersections are expected to operate LOS C or better overall with no approach dropping below LOS D. However, that condition does not include the cycle track, which as stated earlier sacrifices some vehicular capacity for improved bicycle operations and increased safety.

When the cycle track is added, as in the Build condition, the lower traffic carrying capacity has a negative impact on level of service at the most heavily traveled intersections, namely the Broadway at Cornell St./Cedar St. intersection and the Broadway at Grand St./Pine Grove Avenue. If the signal timings are simply optimized and not coordinated with adjacent signals at those locations (condition #2), level of service drops from LOS B to LOS C in the AM peak hour and from LOS C to LOS E in the PM peak hour at the Cornell/Cedar intersection. This uncoordinated condition also includes LOS F failing operations on the southbound approach at Cornell and the northbound approach at Pine Grove.

By interconnecting the traffic signals and coordinating the signal timings to provide better progression through the corridor (condition #3), the intersection level of service at both Cornell/Cedar and Grand/Pine Grove are brought to an acceptable LOS D and all approaches will operating at LOS D or better, except for the southbound approach at Cornell Street and the northbound approach at Pine Grove Avenue, which operate at LOS E.

4.3.2 Corridor Operations

Several Measures of Effectiveness can be considered when evaluating a corridor. Travel times, speeds, vehicle hours of delay (VHD), user costs, fuel and emissions are MOE's relevant to this project; with VHD being the most telling. As the table shows, the combined VHD per day in the two peak hours in the No-Build condition (condition #1) is 122.0 hours (54.1 in the AM & 67.9 in the PM). In the Build condition with uncoordinated signals (condition #2), the delay increases to 133.1 hours (50.4 AM/82.7 PM) because of the capacity reducing improvements to create the cycle track. However, if those signals are coordinated (condition #3), the overall combined peak hour VHD decreases to 119.6 hours(49.4 AM/70.2 PM), which is a 2% improvement over the No-Build condition and 10% improvement over the Build condition with uncoordinated traffic signals (condition #2).

Similar comparisons for fuel and emissions reveal that the Build condition with coordinated traffic signals also consumes the least amount of fuel daily in the peak hours; 156.9 gallons (71.9 AM/85.0 PM) versus 160.3 gallons (74.5 AM/85.8 PM) in the No-Build condition (a 2% savings), and produced the fewest emissions; 53.2 kg (31.1 AM/22.1 PM) versus 59.6 kg (35.3 AM/24.3 PM) in the No-Build condition (an 11% savings). Using uncoordinated signals in the Build condition also provides benefit in these environmental areas over the No-Build condition, but to a much lesser extent.

Finally, when evaluating the operations of a corridor, travel times and speeds are important

considerations. In the No-Build Condition the corridor level of service is LOS D in both directions. In the Build condition, while the westbound travel direction remains LOS D, travel speed will increase by 2 mph in the AM peak hour (16% improvement) and 1 mph in the PM peak hour (8% improvement) in the Build condition with coordinated traffic signals.

For the eastbound direction the speed improvement is similar with a 17% improvement in the AM and a 9% improvement in the PM. However, this is enough to affect a change in level of service in this direction, as the level of service improves from LOS D to LOS C.

The table below summarized the Corridor MOE evaluation:

Table 3
Corridor MOE Evaluation
(Combined AM & PM Peak Hour Statistics)

		No-Build (Condition #1)	Build - Uncoord. (Condition #2)		Build - Coordinated (Condition #3)	
		Value	Value	Percent Change*	Value	Percent Change*
Vehicle Hours of Delay (VHD)		122.0 hrs.	133.1 hrs.	+9.1%	119.6 hrs.	-2.0%
Fuel Consumption		160.3 gal.	160.0 gal.	-0.2%	156.9 gal.	-2.1%
Emissions		59.6 kg	55.4 kg	-7.0%	53.2 kg	-10.7%
Eastbound Travel Times	AM Peak	245.8 sec.	209.0 sec.	-15.0%	210.5 sec.	-14.4%
	PM Peak	266.2 sec.	221.6 sec.	-16.7%	220.6 sec.	-17.1%
Westbound Travel Times	AM Peak	261.7 sec.	246.4 sec.	-5.8%	226.7 sec.	-13.4%
	PM Peak	275.2 sec.	273.4 sec.	-0.7%	255.1 sec.	-7.3%

* Percent change compared to No-Build Condition.

4.3.3 User Cost Analysis

In reviewing the evaluation details, it is clear that Condition #3, which includes interconnected and coordinated traffic signals, is the best performing of the options considered and should be considered the preferred alternative. To quantify the benefit of this alternative over the other conditions, a user cost analysis, which considered the average cost of time for roadway users as well as the cost of fuel, was performed.

Based on NYS Department of Labor Statistics, unemployment in Ulster County is at approximately 4% (at the time of this report), and the median salary is $40,490. This would indicate that for every labor force age person within the county, the average hourly cost is $18.69 [1-0.04 unemployment x $40,490 mean salary/(52 weeks x 40 hour per week)] If we assume an average vehicle occupancy of 1.2 workforce age persons per vehicle during the peak hours, the average user cost per vehicle related to time delay is $22.43 per hour [$18.69 x 1.2].

Reviewing current data for fuel costs, it appears the average fuel cost in NY State is currently around $2.30 per gallon. As such, that number will be used in the analysis to estimate the fuel cost benefit.

Based on the numbers above, Condition #3 (cycle track with interconnected coordinated signals) is expected to save users 2.4 hours of delay and 3.4 gallons of fuel over the No-Build condition (no cycle track & no signal changes) during the weekday daily commuter peak hours (AM+PM) on an average day. Additionally, Condition #3 is expected to save 13.5 VHD and 3.1 gallons of fuel over Condition #2 (cycle track with uncoordinated signals) during these hours each day. The comparison to Condition #2 is important because the cycle track alternative inherently reduces capacity in favor of safety and multi-model mobility, so the comparison between Condition #3 and the No-Build Condition includes the effect of both the geometric and signal changes. Only the comparison between Condition #3 and Condition #2 can break out the actual effect of signal coordination alone.

It should be noted that there will be benefits during the non-peak weekday hours and weekend hours as well, but since those hours were not reviewed and to be conservative, they were not included in this analysis.

Calculations for the annualized peak hour user cost savings that result from the proposed improvements is as follows:

User Cost Savings of Build Condition with Coordinated Signals over No-Build Condition

Time: 2.4 hours x 260 work days x $22.43 = $13,996.32
Fuel: 3.4 gallons x 260 work days x $2.30 = $2,033.20

Annual Peak Hour User Cost Savings (rounded) = $16,000 (over Condition #1)

User Cost Savings of Build Condition with Coordinated Signals over Uncoordinated Signals

Time: 13.5 hours x 260 work days x $22.43 = $78,729.30
Fuel: 3.1 gallons x 260 work days x $2.30 = $1,853.80

Annual Peak Hour User Cost Savings (rounded) = $80,500 (over Condition #2)

It should also be noted that the Build condition with coordinated traffic signals will also reduce greenhouse emissions by over 1,650 kg per year (6.4 kg per day). This is an important environmental benefit, but is indeterminable as a user cost.

4.4 Improvement Recommendations

As the analysis shows, the best performing Build condition alternative includes interconnected and coordinated traffic signals. This section discusses the traffic signal improvements necessary to implement this interconnect and optimize signal timings and performance. Table 4 at the end of this section summarizes the recommended traffic signal improvements and Table 5 outlines the estimated costs of improvements at each intersection.

4.4.1 Signal System Interconnection

Based on information included in the Existing Conditions Report, there may be an existing conduit between each of the traffic signals that could be used for a hardwire interconnect system, but little is known about this infrastructure. It is not currently in use and given that the age and condition are unknown, it is felt that a wireless radio interconnect would be the best option for this corridor. Radio interconnects have been used at dozens of locations within NY State, including many NYSDOT systems, and have been found to be extremely reliable and cost effective. Radio interconnects also provide the ability to connect back to a central computer location without running additional infrastructure conduits outside of the roadways right-of-way.

Additionally, we recommend having a central computer for the system, which would allow City signal maintenance personnel to remotely monitor operations, troubleshoot problems and adjust timings. This would significantly improve the City's ability to maintain these signals, and will serve as a base station to eventually connect remotely to any signal within the City for improved monitoring, maintenance and data gathering. Cost for the central computer server, terminal and control software will be approximately $30,000.

4.4.2 Broadway at Elmendorf St./Liberty St.

This intersection is within the cycle track area of the corridor. As a result, it will require a complete replacement with pole relocations and additions to accommodate bicycle signals for cycle track control, improved pedestrian accommodations and the addition of an eastbound protected left turn signal head. The signal will also include side street and left turn lane vehicle detection, a new signal controller capable of signal interconnection and coordination, and a wireless interconnect spread spectrum radio, antenna and interface. The estimated cost of these improvements is approximately $175,000.

However, most of that cost is a direct result of needs related to the cycle track, not the signal coordination. The actual cost of equipment necessary to implement the signal interconnect (new controller, radio interconnect system and left turn lane detection) would only equal approximately $25,000. The remaining $150,000 is only necessary if the cycle track alternative in constructed. Plans for the signal improvements at this location will be developed as part of the Broadway Connectivity project and the improvements will be constructed with the construction of the cycle track improvements.

4.4.3 Broadway at O'Neil St./Henry St,

This intersection is also within the cycle track area of the corridor. Improvements and construction costs will be as described in section 4.4.2 above.

4.4.4 Broadway at Cornell St./Cedar St.

This intersection is also within the cycle track area of the corridor. Improvements and construction costs will be as described in section 4.4.2 above.

4.4.5 Broadway at Grand St./Pine Grove Ave.

This intersection is also within the cycle track area of the corridor. Improvements and construction costs will be as described in section 4.4.2 above.

4.4.6 Broadway at E./W. O'Reilly St.

Located outside the cycle track area of the corridor, this signal does not require significant improvements. It is recommended that the signal controller unit within the cabinet be replaced and radio interconnect equipment be added to allow the signal interconnect. Other than that, it is also recommended that the pedestrian signals, pushbuttons and wiring be replaced to upgrade the pedestrian crossings with countdown timers and pushbutton compliant with current Public Rights-Of-Way Accessibility Guidelines (PROWAG) requirements. As there are no dedicated left turn phasing along Broadway at this intersection, vehicular detection improvements are not necessary. Side street detection will continue to be through the use of microwave detectors. All vehicular signal heads are 8" diameter at this intersection, and it would be preferred to change these to 12" diameter heads with backplates for improved safety. However, it is unlikely that the current mast arm poles can support the increased load, so a complete signal replacement (and the high cost associated with that) would be required to do so. As the 8" heads are allowed by the Manual on Uniform traffic Control Devices (MUTCD) and meet minimum State standards, it is acceptable for them to remain in place at this time.

Recommended improvement costs at this intersection will equal approximately $30,000. These improvements should be able to be made as a maintenance upgrade to this intersection; however, detailed signal modification sketch plans and notes will still be developed and provided to the city for their use and implementation. This will be done during the Signal Improvement Plan phase of this project, which will begin after City approval of the recommendations in this report.

4.4.7 Broadway at Foxhall Road

This intersection is also outside the cycle track area of the corridor. Improvements will be similar to those described in section 4.4.6 above; controller and pedestrian accommodation replacements and the addition of a radio interconnect. However, since this intersection is a T-intersection instead of a full 4-way intersection, costs to replace the pedestrian facilities will be slightly lower. Improvement costs at this intersection are estimated at $25,000 and sketch plans detailing these improvements will be developed in the Signal Improvement Plan phase of this project.

4.4.8 Broadway at E./W. Chester St.

This intersection is also outside the cycle track area of the corridor and Improvements will be similar to those described in section 4.4.6 above; controller and pedestrian accommodation replacements and the addition of a radio interconnect. Improvement costs at this intersection are estimated at $30,000 and sketch plans detailing these improvements will be developed in the Signal Improvement Plan phase of this project.

Table 4
Summary of Recommended Traffic Signal Improvements

Improvement	Intersection						
	Elmendorf	O'Neil	Cornell	Grand	O'Reilly	Foxhall	Chester
Signal System Central Computer	Installed at Office Location Designated by City (e.g. DPW Offices)						
Replace All Signal Equipment	✓	✓	✓	✓			
Replace Signal Controller	✓	✓	✓	✓	✓	✓	✓
Add Wireless Interconnect for Signal Coordination	✓	✓	✓	✓	✓	✓	✓
Signal Timing Optimization and Coordination	✓	✓	✓	✓	✓	✓	✓
Add Eastbound Left Turn Phasing	✓	✓	✓	✓			
Add Left Turn Vehicle Detection	✓	✓	✓	✓			
Restrict Southbound Right Turns on Red	✓	✓	✓	✓			
Upgrade Pedestrian Signals	✓	✓	✓	✓	✓	✓	✓

Table 5 summarizes the recommended traffic signal improvement costs, as discussed above. These modifications are broken down by those required to add signal coordination only (assuming the cycle track was not moved forward), and those necessary to modify the traffic signals to accommodate the cycle track alternative roadway geometry.

Table 5
Cost of Recommended Traffic Signal Improvements

Intersection	Signal Coordination Costs	Cycle Track Improvement Costs	Total Improvement Costs
Broadway at Elmendorf/Liberty	$25,000	$150,000	$175,000
Broadway at O'Neil/Henry	$25,000	$150,000	$175,000
Broadway at Cornell/Cedar	$25,000	$150,000	$175,000
Broadway at Grand/Pine Grove	$25,000	$150,000	$175,000
Broadway at E./W. O'Reilly	$30,000	---	$30,000
Broadway at Foxhall	$25,000	---	$25,000
Broadway at E./W. Chester	$30,000	---	$30,000
Central Computer Improvements	$30,000	---	$30,000
Subtotal (Construction Costs)	***$215,000***	***$600,000***	***$815,000***
25% Design/Inspection/Contingencies	$55,000	$150,000	$205,000
Total Costs	**$270,000**	**$750,000**	**$1.02M**

4.5 Benefit/Cost Ratio

To estimating the benefit of traffic signal coordination within the Broadway corridor, the design and construction costs were compared to the user cost savings discussed in section 4.3.3 of this report. For this comparison, the $270,000 Total Cost listed in Table 5 for the signal coordination improvements was converted to an annualized value using a Capital Recovery Factor (CRF) that was based on a 4% annual interest rate over the assumed 10 year design life of each traffic signal. The CRF resulting from these conditions is 0.12329. Applying this towards the total costs yields an annualized cost to implement the signal coordination improvements of $33,290.

As mentioned previously, the cycle track geometric changes between the No-Build and Build conditions cause reduced vehicular capacity, which in turn increases the delay within the corridor irrespective of any traffic signal changes. As such, a comparison of the Build with coordination (condition #3) condition and the No-Build (condition #1) condition will not produce a Benefit to Cost (B/C) ratio that would relevantly describe the benefit of the signal coordination alone. Only a comparison of the Build with coordination (condition #3) and the Build without coordination (condition #2) conditions would provide this information.

Reviewing these numbers, it can be seen that the annualized benefit of the signal coordination, compared to the uncoordinated build condition, is $80,500, and the annualized cost to implement these improvements is $33,290. This annual cost savings of over $47,000 a year results in a B/C ratio of 2.4, meaning the user benefit of this project is nearly two and a half times greater than the cost to implement. This is a significant benefit making signal coordination very desirable within the Broadway corridor.

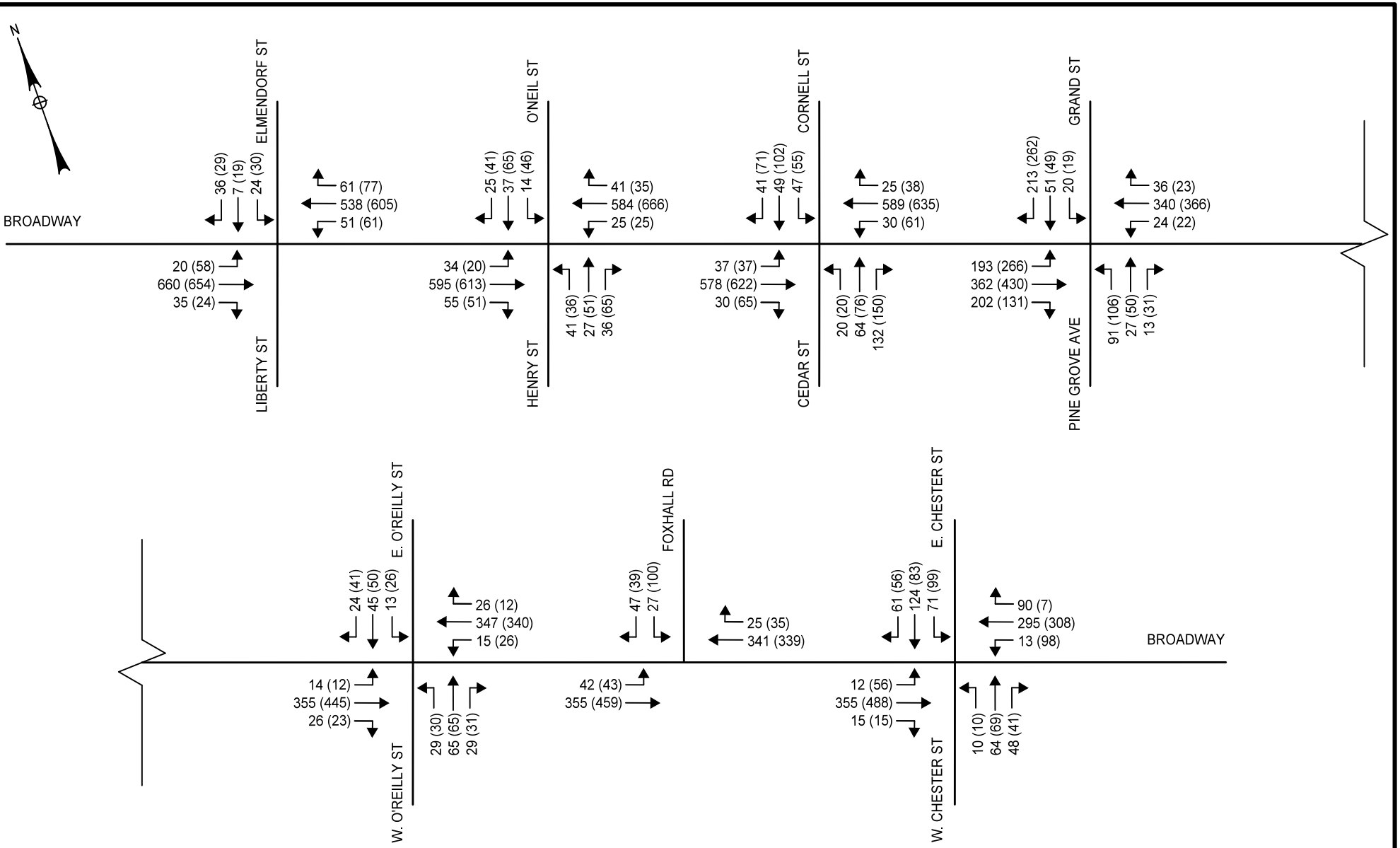
5.0 Conclusion & Summary

The preceeding Signal Optimization Report is the second part of the overall ***Traffic Signalization Study*** being performed for the Broadway Corridor, between Elmendorf St/Liberty St and E./W. Chester St, in the City of Kingston. For this study, part 1, the Existing Conditions Report, include an inventory of existing traffic signal equipment; traffic volumes information; and traffic operational analysis for existing traffic conditions. This signal optimization Report continues that analysis and includes the analysis for future traffic operational conditions; a cost-benefit analysis; and recommended improvements to optimize the signal timings and reduce delays, fuel comsumption and greenhouse gas emissions. The following are key points from this report.

- The signalization improvement project is being combined with the Broadway Connectivity project, which features the addition of a cycle track along Broadway between Elmendorf St. and Grand St., for design and construction. This will reduce overall implementation costs regarding mobilization & construction inspection.
- The inclusion of the cycle track along Broadway will require several geometric and traffic signal modifications that reduce the traffic carrying capacity of the roadway, including a road diet to reduce the number of vehicular lanes through that area, increased all red clearance times to accommodate bicycle clearances and the addition of protected only left turn phasing at four traffic signals. These modifications increase bicycle mobility and safety throughout the corridor, but at the sacrifice of vehicular levels of service.
- With the inclusion of the cycle track, Build condition levels of service worsen in some locations because of these capacity reducing modifications unless signal improvements are made and signal timings are optimized and coordinated. With signal improvement and coordination, the vehicle hours of delay, fuel consumption and emissions are all reduced compared to both the No-Build condition and Build condition without signal coordination.
- Overall, signal coordination in the Build condition results in a significant benefit to the Corridor. Compared to the Build condition with uncoordinated signals, traffic signal coordination is expected to save more than $47,000 per year over implementation costs. This equates to a benefit to cost (B/C) ratio of 2.4.

Based on the analysis above, signal interconnection and coordination is justified and highly recommended. With the implementation of signal coordination, delay and emissions are greatly reduced (compared to the uncoordinated condition), which is paramount once the cycle track alternative is progressed and vehicle capacity is reduced along the roadway to accommodate the increased bicycle mobility and safety. Signal improvements for the signals within the cycle track area are being progressed as part of the Broadway Connectivity project. Signal improvements for the remaining three signals within the corridor will be detailed in separate sketch plans once City concurrence with this report is received.

APPENDIX A
Traffic Volume Diagram



NOTE:
XX (XX) - AM (PM) PEAK HOUR TRAFFIC VOLUMES

Greenman-Pedersen
CONSULTING ENGINEERS
GPI
80 Wolf Road
Suite 300
Albany, NY 12205

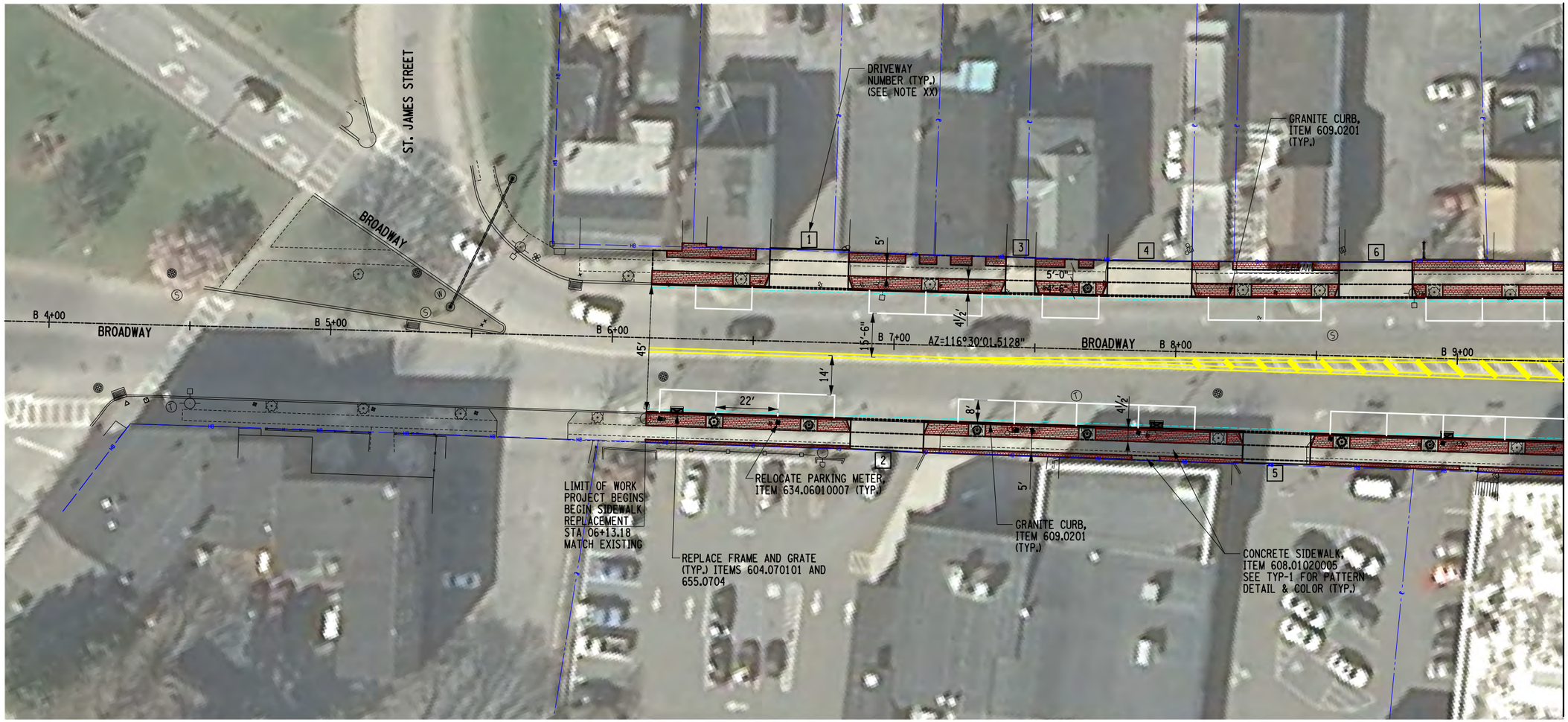
BROADWAY SIGNALIZATION
CITY OF KINGSTON
ULSTER COUNTY, NEW YORK

ETC 2018 PEAK HOUR TRAFFIC VOLUMES

JOB NO.	SCALE:	DATE:	FIGURE NO.
2015053.00	NO SCALE	FEBRUARY 2016	1

APPENDIX B

Cycle Track Concept Plans



MATCHLINE PMP-2

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AS-BUILT REVISIONS
DESCRIPTION OF ALTERATIONS:

NOT FOR CONSTRUCTION

KINGSTON CONNECTIVITY PROJECT	PIN 8780.49	BRIDGES	CULVERTS	ALL DIMENSIONS IN ft UNLESS OTHERWISE NOTED
BROADWAY	UTILQLVL			PAVEMENT MARKING PLANS
SHWY3				
SHWY4				
COUNTY: ULSTER REGION: 8				

CONTRACT NUMBER DL34880

DRAWING NO. PMP-1
SHEET NO. XX

GPI GREENMAN-PEDERSEN, INC. CONSULTING ENGINEERS

CITY OF KINGSTON

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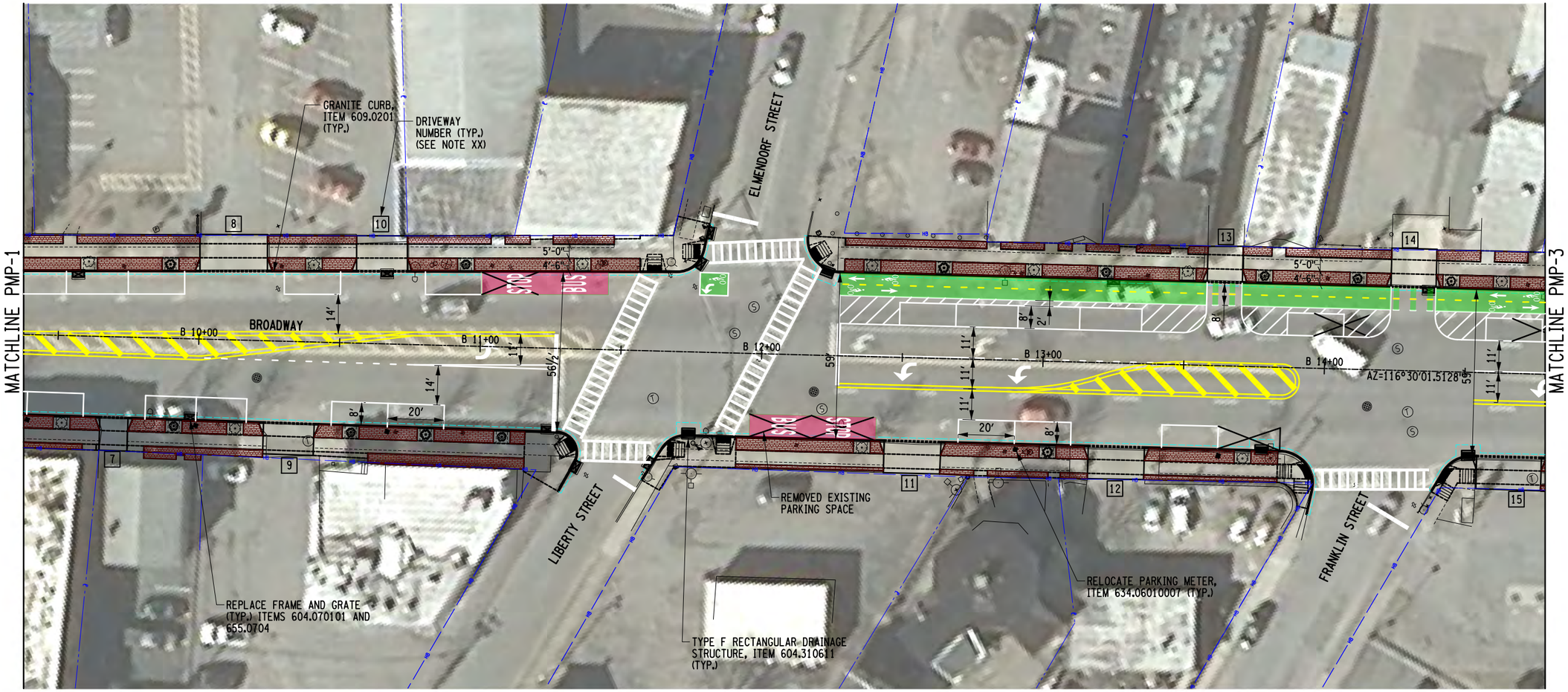

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SHWY4				
COUNTY: ULSTER REGION: 8				

CONTRACT NUMBER DL34880
DRAWING NO. PMP-2
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IT IS A VIOLATION OF LAW FOR ANY PERSON, UNLESS THEY ARE ACTING UNDER THE DIRECTION OF A LICENSED PROFESSIONAL ENGINEER, ARCHITECT, LANDSCAPE ARCHITECT, OR LAND SURVEYOR, TO ALTER AN ITEM IN ANY WAY. IF AN ITEM BEARING THE STAMP OF A LICENSED PROFESSIONAL IS ALTERED, THE ALTERING ENGINEER, ARCHITECT, LANDSCAPE ARCHITECT, OR LAND SURVEYOR SHALL STAMP THE DOCUMENT AND INCLUDE THE NOTATION "ALTERED BY" FOLLOWED BY THEIR SIGNATURE, THE DATE OF SUCH ALTERATION, AND A SPECIFIC DESCRIPTION OF THE ALTERATION.

GPI GREENMAN-PEDERSEN, INC. CONSULTING ENGINEERS

CITY OF KINGSTON

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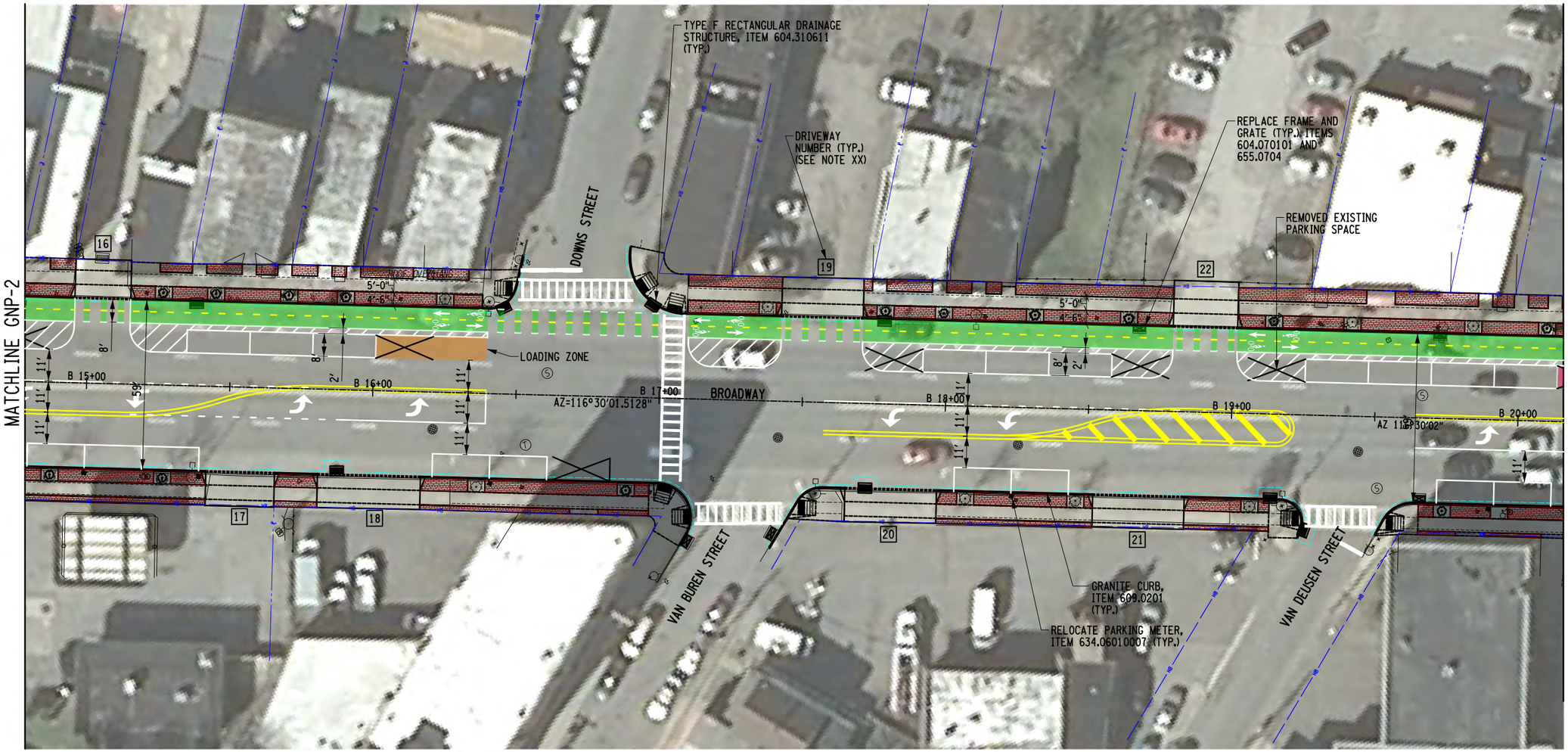

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GPI GREENMAN-PEDERSEN, INC. CONSULTING ENGINEERS

CITY OF KINGSTON

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CITY OF KINGSTON

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MATCHLINE PMP-4

MATCHLINE PMP-6

TYPE F RECTANGULAR DRAINAGE STRUCTURE, ITEM 604.310611 (TYP.)

CONNELL STREET

REMOVED EXISTING PARKING SPACE

THOMAS STREET

5'-0"

8'

2'

STOP

BUS

B 26+00

58'

11'

B 27+00

BROADWAY

AZ=116°30'01.5128"

B 28+00

B 29+00

B 30+00

51'

8'

29

27

28

CEDAR STREET

RELOCATE PARKING METER, ITEM 634.06010007 (TYP.)

REPLACE FRAME AND GRATE (TYP.) ITEMS 604.070101 AND 655.0704

DRIVEWAY NUMBER (TYP.) (SEE NOTE XX)

GRANITE CURB, ITEM 609.0201 (TYP.)

20 0 20 40 60 80'

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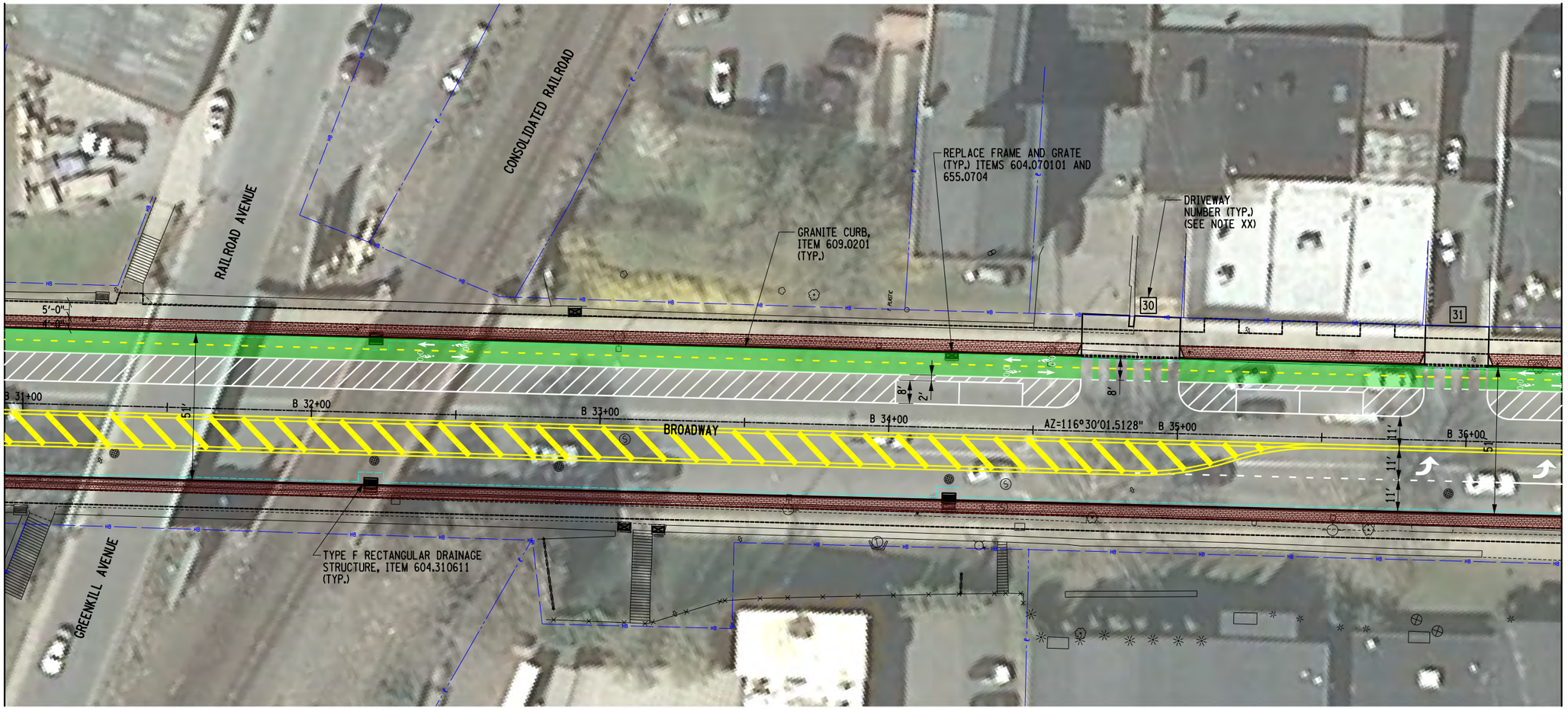

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SHWY4				DRAWING NO. PMP-6 SHEET NO. XX
COUNTY: ULSTER REGION: 8				

GPI GREENMAN-PEDERSEN, INC. CONSULTING ENGINEERS

CITY OF KINGSTON

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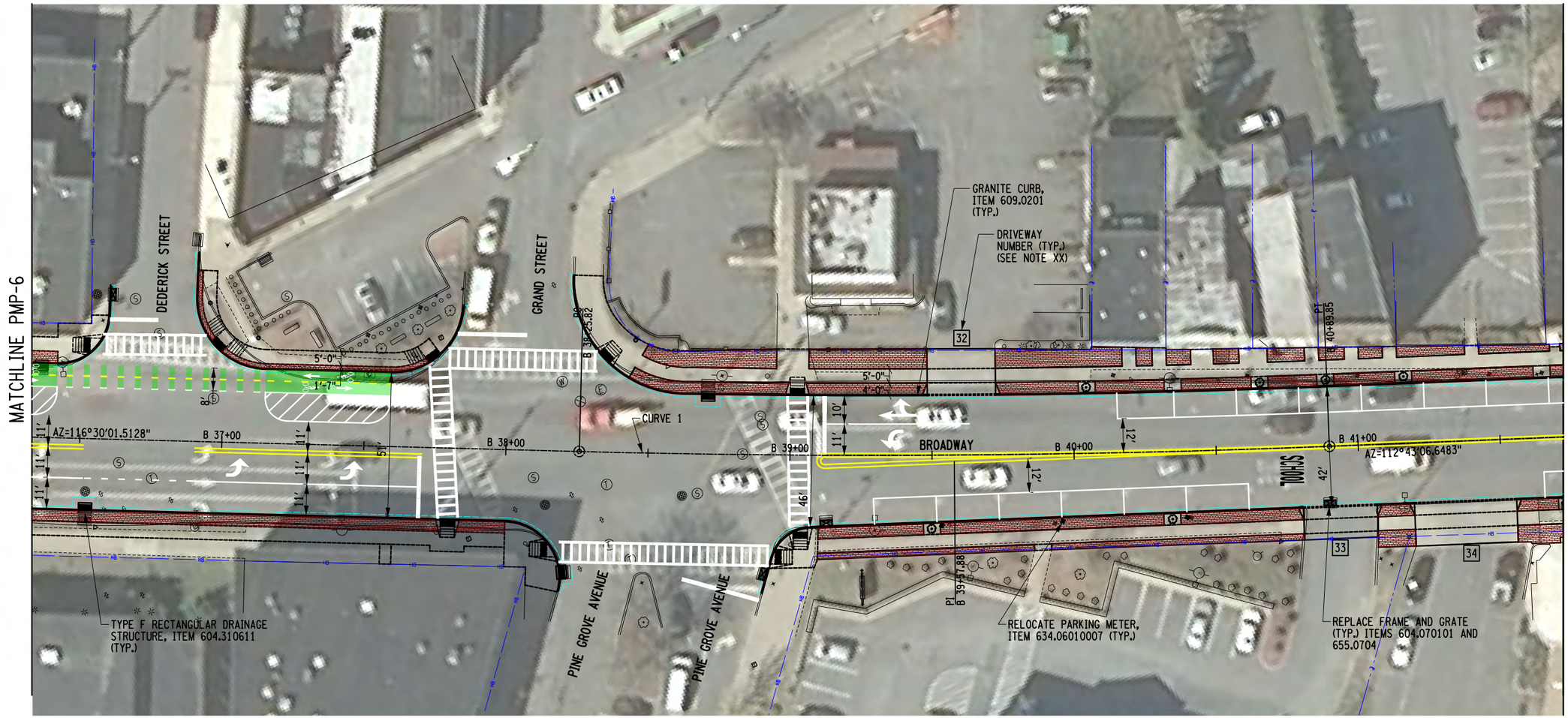

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CURVE 1
P.C. = B 38+25.82
P.T. = B 40+89.85
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L = 264.03'
Δ = 3°46'54.86"L

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DESCRIPTION OF ALTERATIONS:

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KINGSTON CONNECTIVITY PROJECT
BROADWAY
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COUNTY: ULSTER REGION: 8

PIN 8780.49
UTILQLVL

BRIDGES

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ALL DIMENSIONS IN ft UNLESS OTHERWISE NOTED

PAVEMENT MARKING PLANS

CONTRACT NUMBER DL34880

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GPI GREENMAN-PEDERSEN, INC. CONSULTING ENGINEERS

CITY OF KINGSTON

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APPENDIX C

Simulation Model Output Sheets

APPENDIX C-1

2018 No-Build Condition

1: Liberty St/Elmendorf St & Broadway Performance by approach

Approach	EB	WB	SB	All
Denied Delay (hr)	0.3	0.0	0.0	0.3
Denied Del/Veh (s)	1.5	0.0	0.2	0.7
Total Delay (hr)	4.0	4.2	0.3	8.6
Total Del/Veh (s)	19.9	22.6	18.0	21.0
Stop Delay (hr)	2.5	2.5	0.3	5.3
Stop Del/Veh (s)	12.3	13.6	16.8	13.1
Total Stops	449	388	55	892
Stop/Veh	0.62	0.58	0.79	0.61
Travel Dist (mi)	132.7	114.0	9.3	256.0
Travel Time (hr)	9.7	8.9	0.8	19.3
Avg Speed (mph)	14	13	12	13
Fuel Used (gal)	4.8	4.9	0.3	10.0
Fuel Eff. (mpg)	27.7	23.3	26.8	25.5
HC Emissions (g)	107	111	3	222
CO Emissions (g)	1903	2082	83	4068
NOx Emissions (g)	271	314	10	596

2: Henry St/O'Neil St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.1
Denied Del/Veh (s)	0.0	0.0	1.6	0.8	0.2
Total Delay (hr)	3.9	3.5	0.5	0.4	8.2
Total Del/Veh (s)	19.8	18.4	16.0	17.5	18.8
Stop Delay (hr)	3.1	2.5	0.4	0.3	6.3
Stop Del/Veh (s)	15.7	13.0	14.2	16.0	14.4
Total Stops	406	360	45	47	858
Stop/Veh	0.57	0.53	0.44	0.60	0.54
Travel Dist (mi)	121.0	80.2	4.2	12.4	217.8
Travel Time (hr)	8.9	6.8	0.7	0.9	17.3
Avg Speed (mph)	14	12	7	14	13
Fuel Used (gal)	5.1	3.8	0.2	0.5	9.5
Fuel Eff. (mpg)	23.9	21.3	19.7	27.6	23.0
HC Emissions (g)	108	77	4	10	199
CO Emissions (g)	2179	1594	71	183	4028
NOx Emissions (g)	307	224	8	25	564

3: Cedar St /Cornell St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.0	0.0	0.3	0.2	0.1
Total Delay (hr)	3.9	3.2	1.0	0.7	8.9
Total Del/Veh (s)	21.6	17.0	15.5	19.3	18.8
Stop Delay (hr)	3.0	2.2	0.9	0.7	6.6
Stop Del/Veh (s)	16.2	11.4	13.6	17.3	14.0
Total Stops	459	381	163	103	1106
Stop/Veh	0.70	0.56	0.72	0.75	0.65
Travel Dist (mi)	78.7	134.4	55.8	17.8	286.6
Travel Time (hr)	7.2	8.9	3.3	1.5	20.9
Avg Speed (mph)	11	15	17	12	14
Fuel Used (gal)	3.8	5.5	1.8	0.7	11.9
Fuel Eff. (mpg)	20.8	24.2	30.7	25.3	24.2
HC Emissions (g)	70	98	23	8	199
CO Emissions (g)	1456	2044	466	191	4157
NOx Emissions (g)	208	301	65	24	598

4: Pine Grove Ave./Grand St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.3	0.3
Denied Del/Veh (s)	0.1	0.0	0.7	3.2	0.7
Total Delay (hr)	3.3	3.9	1.6	1.5	10.2
Total Del/Veh (s)	14.8	32.9	41.8	17.5	22.0
Stop Delay (hr)	2.3	3.1	1.5	1.3	8.2
Stop Del/Veh (s)	10.5	26.4	39.4	15.2	17.7
Total Stops	474	333	116	238	1161
Stop/Veh	0.59	0.79	0.87	0.78	0.69
Travel Dist (mi)	158.6	55.5	11.6	19.9	245.7
Travel Time (hr)	10.1	6.2	2.1	2.7	21.0
Avg Speed (mph)	16	9	6	8	12
Fuel Used (gal)	6.3	2.8	0.8	1.1	10.9
Fuel Eff. (mpg)	25.3	20.1	15.2	18.6	22.6
HC Emissions (g)	108	41	9	17	175
CO Emissions (g)	2258	850	231	396	3734
NOx Emissions (g)	330	118	25	46	519

5: W. O'Reilly St/E. O'Reilly St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.2	0.1	0.2	0.2	0.1
Total Delay (hr)	2.3	2.3	0.8	0.5	5.9
Total Del/Veh (s)	20.0	19.8	22.3	20.1	20.2
Stop Delay (hr)	1.7	1.5	0.7	0.4	4.3
Stop Del/Veh (s)	14.6	13.2	20.0	18.2	15.0
Total Stops	231	227	96	63	617
Stop/Veh	0.56	0.55	0.76	0.72	0.59
Travel Dist (mi)	56.2	72.1	12.1	8.0	148.5
Travel Time (hr)	4.6	5.2	1.3	0.8	12.0
Avg Speed (mph)	12	14	9	10	12
Fuel Used (gal)	2.3	3.0	0.6	0.4	6.2
Fuel Eff. (mpg)	24.0	24.4	21.5	22.5	23.9
HC Emissions (g)	38	50	5	2	96
CO Emissions (g)	746	974	145	71	1936
NOx Emissions (g)	111	150	16	7	284

6: Broadway & Foxhall Ave Performance by approach

Approach	EB	WB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.0	0.0	0.2	0.0
Total Delay (hr)	3.2	2.1	0.2	5.6
Total Del/Veh (s)	26.9	20.2	11.2	22.6
Stop Delay (hr)	2.4	1.6	0.2	4.2
Stop Del/Veh (s)	19.9	15.3	10.4	17.1
Total Stops	280	222	44	546
Stop/Veh	0.65	0.58	0.58	0.62
Travel Dist (mi)	74.1	45.2	7.1	126.4
Travel Time (hr)	6.2	4.0	0.6	10.8
Avg Speed (mph)	12	11	13	12
Fuel Used (gal)	3.2	2.0	0.3	5.5
Fuel Eff. (mpg)	22.8	22.2	27.5	22.8
HC Emissions (g)	55	34	3	93
CO Emissions (g)	1072	714	70	1856
NOx Emissions (g)	161	99	9	270

7: W. Chester St/E. Chester St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.1	0.0	0.0	0.2
Denied Del/Veh (s)	0.0	1.3	0.2	0.4	0.6
Total Delay (hr)	1.4	1.2	0.8	2.4	5.8
Total Del/Veh (s)	13.0	10.4	20.6	33.8	17.5
Stop Delay (hr)	1.0	0.9	0.7	2.2	4.8
Stop Del/Veh (s)	9.0	8.0	18.4	30.3	14.4
Total Stops	187	196	106	227	716
Stop/Veh	0.47	0.49	0.79	0.88	0.60
Travel Dist (mi)	48.1	35.4	11.0	23.5	118.0
Travel Time (hr)	3.4	2.8	1.3	3.5	10.9
Avg Speed (mph)	14	13	9	7	11
Fuel Used (gal)	2.0	1.4	0.5	1.3	5.3
Fuel Eff. (mpg)	23.6	25.5	20.9	17.5	22.3
HC Emissions (g)	42	21	9	21	93
CO Emissions (g)	850	480	210	472	2012
NOx Emissions (g)	124	59	25	54	262

Total Network Performance

Denied Delay (hr)	0.9
Denied Del/Veh (s)	1.1
Total Delay (hr)	54.1
Total Del/Veh (s)	63.5
Stop Delay (hr)	40.0
Stop Del/Veh (s)	47.0
Total Stops	5896
Stop/Veh	1.92
Travel Dist (mi)	1763.0
Travel Time (hr)	128.9
Avg Speed (mph)	14
Fuel Used (gal)	74.5
Fuel Eff. (mpg)	23.7
HC Emissions (g)	1430
CO Emissions (g)	29675
NOx Emissions (g)	4169

Arterial Level of Service: EB Broadway

Cross Street	Node	Delay (s/veh)	Travel time (s)	Dist (mi)	Arterial Speed
Henry St	2	19.5	44.1	0.2	14
Cedar St	3	20.7	38.1	0.1	12
Pine Grove Ave.	4	13.9	42.3	0.2	18
W. O'Reilly St	5	20.1	40.0	0.1	12
Foxhall Ave	6	25.3	50.4	0.2	13
W. Chester St	7	13.2	30.9	0.1	14
Total		112.6	245.8	0.9	14

Arterial Level of Service: WB Broadway

Cross Street	Node	Delay (s/veh)	Travel time (s)	Dist (mi)	Arterial Speed
Foxhall Ave	6	20.8	38.0	0.1	12
E. O'Reilly St	5	19.9	45.5	0.2	14
Grand St	4	32.9	52.0	0.1	9
Cornell St	3	16.8	45.4	0.2	16
O'Neil St	2	18.4	35.5	0.1	13
Elmendorf St	1	20.4	45.3	0.2	14
Total		129.1	261.7	0.9	13

Intersection: 1: Liberty St/Elmendorf St & Broadway

Movement	EB	EB	WB	WB	SB
Directions Served	L	TR	L	TR	LTR
Maximum Queue (ft)	137	562	135	571	86
Average Queue (ft)	20	247	45	227	34
95th Queue (ft)	79	506	118	443	70
Link Distance (ft)		965	841	841	700
Upstream Blk Time (%)		0		0	
Queuing Penalty (veh)		0		0	
Storage Bay Dist (ft)	75				
Storage Blk Time (%)	0	26			
Queuing Penalty (veh)	2	5			

Intersection: 2: Henry St/O'Neil St & Broadway

Movement	EB	EB	WB	WB	NB	NB	SB	SB
Directions Served	LT	TR	LT	TR	L	T	L	TR
Maximum Queue (ft)	279	246	246	317	72	97	39	96
Average Queue (ft)	149	130	108	169	27	22	8	29
95th Queue (ft)	245	227	209	276	65	66	29	71
Link Distance (ft)	841	841	562	562		248		837
Upstream Blk Time (%)								
Queuing Penalty (veh)								
Storage Bay Dist (ft)					50		75	
Storage Blk Time (%)					6	3		1
Queuing Penalty (veh)					2	1		0

Intersection: 3: Cedar St /Cornell St & Broadway

Movement	EB	EB	WB	WB	NB	SB
Directions Served	LT	TR	LT	TR	LTR	LTR
Maximum Queue (ft)	335	297	160	321	179	138
Average Queue (ft)	160	123	102	138	77	62
95th Queue (ft)	284	243	176	242	146	115
Link Distance (ft)	562	562		1001	1304	694
Upstream Blk Time (%)						
Queuing Penalty (veh)						
Storage Bay Dist (ft)			60			
Storage Blk Time (%)			16	27		
Queuing Penalty (veh)			52	90		

Intersection: 4: Pine Grove Ave./Grand St & Broadway

Movement	EB	EB	EB	WB	WB	NB	NB	SB	SB
Directions Served	L	T	R	L	TR	LT	R	LT	R
Maximum Queue (ft)	215	278	117	100	424	196	59	257	74
Average Queue (ft)	98	112	54	16	176	72	7	93	61
95th Queue (ft)	182	221	101	61	345	153	33	208	84
Link Distance (ft)		1001	1001		622	454		344	
Upstream Blk Time (%)								0	
Queuing Penalty (veh)								0	
Storage Bay Dist (ft)	340			50			150		45
Storage Blk Time (%)		0		1	40	3		16	16
Queuing Penalty (veh)		0		5	10	0		35	12

Intersection: 5: W. O'Reilly St/E. O'Reilly St & Broadway

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	LTR	LTR
Maximum Queue (ft)	405	397	146	112
Average Queue (ft)	155	150	60	45
95th Queue (ft)	342	318	113	87
Link Distance (ft)	622	894	502	490
Upstream Blk Time (%)	0			
Queuing Penalty (veh)	1			
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 6: Broadway & Foxhall Ave

Movement	EB	EB	WB	SB
Directions Served	L	T	TR	LR
Maximum Queue (ft)	54	400	319	90
Average Queue (ft)	27	180	159	32
95th Queue (ft)	56	336	265	69
Link Distance (ft)		894	592	487
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)	20			
Storage Blk Time (%)	20	41		
Queuing Penalty (veh)	74	17		

Intersection: 7: W. Chester St/E. Chester St & Broadway

Movement	EB	EB	WB	WB	NB	SB
Directions Served	L	TR	LT	R	LTR	LTR
Maximum Queue (ft)	64	317	220	160	140	295
Average Queue (ft)	8	123	102	31	68	135
95th Queue (ft)	42	265	186	92	124	244
Link Distance (ft)		592	464		436	478
Upstream Blk Time (%)						0
Queuing Penalty (veh)						0
Storage Bay Dist (ft)	210			130		
Storage Blk Time (%)		3	4			
Queuing Penalty (veh)		0	4			

Network Summary

Network wide Queuing Penalty: 311

1: Liberty St/Elmendorf St & Broadway Performance by approach

Approach	EB	WB	SB	All
Denied Delay (hr)	0.3	0.0	0.0	0.3
Denied Del/Veh (s)	1.6	0.0	0.1	0.7
Total Delay (hr)	3.2	4.5	0.5	8.2
Total Del/Veh (s)	15.4	21.4	20.7	18.5
Stop Delay (hr)	2.0	2.4	0.4	4.8
Stop Del/Veh (s)	9.7	11.4	19.0	11.0
Total Stops	351	421	67	839
Stop/Veh	0.47	0.56	0.82	0.53
Travel Dist (mi)	136.8	129.2	10.9	277.0
Travel Time (hr)	9.1	9.8	0.9	19.8
Avg Speed (mph)	16	13	12	14
Fuel Used (gal)	4.7	5.5	0.4	10.6
Fuel Eff. (mpg)	28.8	23.7	25.1	26.0
HC Emissions (g)	45	58	4	107
CO Emissions (g)	1031	1322	106	2459
NOx Emissions (g)	140	193	13	347

2: Henry St/O'Neil St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.1	0.1
Denied Del/Veh (s)	0.0	0.0	1.1	1.4	0.2
Total Delay (hr)	3.6	3.7	0.6	0.9	8.9
Total Del/Veh (s)	18.2	18.0	15.3	21.3	18.1
Stop Delay (hr)	2.8	2.6	0.6	0.8	6.8
Stop Del/Veh (s)	14.3	12.5	13.4	19.4	13.9
Total Stops	384	380	60	102	926
Stop/Veh	0.54	0.51	0.39	0.67	0.53
Travel Dist (mi)	122.1	88.8	6.0	23.9	240.7
Travel Time (hr)	8.6	7.4	0.9	2.0	18.9
Avg Speed (mph)	14	12	7	13	13
Fuel Used (gal)	4.9	4.2	0.3	0.9	10.3
Fuel Eff. (mpg)	25.0	21.1	19.4	25.8	23.3
HC Emissions (g)	45	44	2	6	96
CO Emissions (g)	1189	1165	53	164	2571
NOx Emissions (g)	157	158	6	20	341

3: Cedar St /Cornell St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.1
Denied Del/Veh (s)	0.1	0.0	0.3	0.3	0.1
Total Delay (hr)	7.0	5.6	1.1	1.3	15.0
Total Del/Veh (s)	33.5	26.4	15.6	20.4	27.0
Stop Delay (hr)	5.7	4.0	1.0	1.1	11.8
Stop Del/Veh (s)	27.3	19.1	13.4	17.8	21.3
Total Stops	649	547	177	174	1547
Stop/Veh	0.87	0.72	0.69	0.75	0.78
Travel Dist (mi)	89.0	150.6	62.8	30.3	332.7
Travel Time (hr)	10.7	11.9	3.8	2.6	29.0
Avg Speed (mph)	8	13	17	12	11
Fuel Used (gal)	4.9	6.5	2.0	1.2	14.7
Fuel Eff. (mpg)	18.3	23.0	30.8	25.1	22.7
HC Emissions (g)	34	63	15	9	121
CO Emissions (g)	1012	1581	363	253	3209
NOx Emissions (g)	130	222	48	29	428

4: Pine Grove Ave./Grand St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.1	0.3	0.3
Denied Del/Veh (s)	0.0	0.0	1.0	3.2	0.7
Total Delay (hr)	4.4	4.3	2.5	1.4	12.5
Total Del/Veh (s)	18.4	36.6	45.6	15.0	25.0
Stop Delay (hr)	3.0	3.5	2.4	1.2	10.0
Stop Del/Veh (s)	12.6	29.7	43.1	12.9	20.0
Total Stops	533	344	177	248	1302
Stop/Veh	0.62	0.82	0.90	0.74	0.72
Travel Dist (mi)	171.6	55.4	17.1	21.8	265.9
Travel Time (hr)	11.6	6.6	3.3	2.7	24.2
Avg Speed (mph)	15	8	5	9	11
Fuel Used (gal)	7.1	2.9	1.2	1.1	12.2
Fuel Eff. (mpg)	24.2	19.4	14.5	19.7	21.7
HC Emissions (g)	57	27	8	7	99
CO Emissions (g)	1586	647	267	261	2760
NOx Emissions (g)	217	86	26	27	357

5: W. O'Reilly St/E. O'Reilly St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.0	0.0	0.2	0.2	0.1
Total Delay (hr)	2.5	2.4	0.8	0.7	6.3
Total Del/Veh (s)	17.8	22.1	21.7	20.6	20.0
Stop Delay (hr)	1.7	1.8	0.7	0.6	4.7
Stop Del/Veh (s)	12.0	16.4	19.6	18.5	15.0
Total Stops	264	228	95	88	675
Stop/Veh	0.53	0.59	0.74	0.77	0.60
Travel Dist (mi)	66.8	68.8	12.2	10.7	158.4
Travel Time (hr)	5.2	5.2	1.3	1.1	12.8
Avg Speed (mph)	13	13	9	10	12
Fuel Used (gal)	2.7	2.8	0.6	0.5	6.6
Fuel Eff. (mpg)	24.4	24.3	21.6	22.2	23.9
HC Emissions (g)	19	27	5	4	54
CO Emissions (g)	495	641	140	110	1386
NOx Emissions (g)	72	94	15	12	193

6: Broadway & Foxhall Ave Performance by approach

Approach	EB	WB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.0	0.0	0.2	0.0
Total Delay (hr)	4.8	2.0	0.6	7.5
Total Del/Veh (s)	33.3	19.2	15.4	25.7
Stop Delay (hr)	3.6	1.5	0.6	5.7
Stop Del/Veh (s)	25.0	14.4	13.9	19.7
Total Stops	394	207	83	684
Stop/Veh	0.75	0.55	0.58	0.66
Travel Dist (mi)	92.1	45.1	13.3	150.6
Travel Time (hr)	8.6	3.9	1.2	13.7
Avg Speed (mph)	11	12	11	11
Fuel Used (gal)	4.2	2.1	0.5	6.8
Fuel Eff. (mpg)	22.2	21.2	24.6	22.1
HC Emissions (g)	27	20	4	51
CO Emissions (g)	724	530	130	1384
NOx Emissions (g)	104	71	14	189

7: W. Chester St/E. Chester St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.1	0.0	0.0	0.1
Denied Del/Veh (s)	0.0	0.7	0.2	0.3	0.3
Total Delay (hr)	2.3	3.6	0.7	2.0	8.6
Total Del/Veh (s)	14.3	31.3	20.1	29.7	22.8
Stop Delay (hr)	1.6	3.1	0.6	1.8	7.1
Stop Del/Veh (s)	9.8	27.5	18.0	26.8	19.0
Total Stops	293	328	94	210	925
Stop/Veh	0.51	0.80	0.78	0.85	0.68
Travel Dist (mi)	70.1	36.0	10.0	22.5	138.6
Travel Time (hr)	5.2	5.1	1.1	3.0	14.5
Avg Speed (mph)	14	7	9	7	10
Fuel Used (gal)	3.1	2.0	0.5	1.2	6.8
Fuel Eff. (mpg)	22.9	17.9	21.1	18.5	20.5
HC Emissions (g)	20	12	2	8	42
CO Emissions (g)	622	411	97	281	1412
NOx Emissions (g)	90	42	9	28	170

Total Network Performance

Denied Delay (hr)	1.0
Denied Del/Veh (s)	1.0
Total Delay (hr)	67.9
Total Del/Veh (s)	70.7
Stop Delay (hr)	51.2
Stop Del/Veh (s)	53.2
Total Stops	6898
Stop/Veh	1.99
Travel Dist (mi)	1997.2
Travel Time (hr)	152.4
Avg Speed (mph)	13
Fuel Used (gal)	85.8
Fuel Eff. (mpg)	23.3
HC Emissions (g)	758
CO Emissions (g)	20796
NOx Emissions (g)	2724

Arterial Level of Service: EB Broadway

Cross Street	Node	Delay (s/veh)	Travel time (s)	Dist (mi)	Arterial Speed
Henry St	2	18.2	43.1	0.2	14
Cedar St	3	32.9	50.2	0.1	9
Pine Grove Ave.	4	16.0	45.1	0.2	16
W. O'Reilly St	5	18.2	37.8	0.1	13
Foxhall Ave	6	32.4	58.0	0.2	11
W. Chester St	7	14.2	32.0	0.1	14
Total		131.8	266.2	0.9	13

Arterial Level of Service: WB Broadway

Cross Street	Node	Delay (s/veh)	Travel time (s)	Dist (mi)	Arterial Speed
Foxhall Ave	6	19.8	37.0	0.1	12
E. O'Reilly St	5	21.9	47.8	0.2	14
Grand St	4	36.7	55.8	0.1	9
Cornell St	3	24.3	53.0	0.2	14
O'Neil St	2	18.2	35.6	0.1	12
Elmendorf St	1	21.1	46.0	0.2	14
Total		141.9	275.2	0.9	12

Intersection: 1: Liberty St/Elmendorf St & Broadway

Movement	EB	EB	WB	WB	SB
Directions Served	L	TR	L	TR	LTR
Maximum Queue (ft)	149	399	120	611	97
Average Queue (ft)	45	183	39	226	42
95th Queue (ft)	117	341	89	478	81
Link Distance (ft)		965	841	841	700
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (ft)	75				
Storage Blk Time (%)	3	20			
Queuing Penalty (veh)	19	12			

Intersection: 2: Henry St/O'Neil St & Broadway

Movement	EB	EB	WB	WB	NB	NB	SB	SB
Directions Served	LT	TR	LT	TR	L	T	L	TR
Maximum Queue (ft)	261	261	252	300	70	96	79	122
Average Queue (ft)	140	124	114	170	24	31	27	47
95th Queue (ft)	236	219	215	274	59	74	61	95
Link Distance (ft)	841	841	562	562		248		837
Upstream Blk Time (%)								
Queuing Penalty (veh)								
Storage Bay Dist (ft)					50		75	
Storage Blk Time (%)					5	6	1	3
Queuing Penalty (veh)					3	2	1	1

Intersection: 3: Cedar St /Cornell St & Broadway

Movement	EB	EB	WB	WB	NB	SB
Directions Served	LT	TR	LT	TR	LTR	LTR
Maximum Queue (ft)	465	434	160	511	208	180
Average Queue (ft)	216	167	126	199	81	97
95th Queue (ft)	378	340	190	415	160	161
Link Distance (ft)	562	562		1001	1304	694
Upstream Blk Time (%)	0	0				
Queuing Penalty (veh)	0	0				
Storage Bay Dist (ft)			60			
Storage Blk Time (%)			35	34		
Queuing Penalty (veh)			128	129		

Intersection: 4: Pine Grove Ave./Grand St & Broadway

Movement	EB	EB	EB	WB	WB	NB	NB	SB	SB
Directions Served	L	T	R	L	TR	LT	R	LT	R
Maximum Queue (ft)	284	327	141	93	461	265	196	205	71
Average Queue (ft)	120	132	40	15	191	105	21	81	61
95th Queue (ft)	223	250	100	59	392	199	88	177	83
Link Distance (ft)		1001	1001		622	454		344	
Upstream Blk Time (%)					0			0	
Queuing Penalty (veh)					0			0	
Storage Bay Dist (ft)	340			50			150		45
Storage Blk Time (%)	1	0		0	41	7		11	19
Queuing Penalty (veh)	2	0		1	9	2		30	13

Intersection: 5: W. O'Reilly St/E. O'Reilly St & Broadway

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	LTR	LTR
Maximum Queue (ft)	376	446	132	120
Average Queue (ft)	165	153	58	58
95th Queue (ft)	326	346	109	104
Link Distance (ft)	622	894	502	490
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 6: Broadway & Foxhall Ave

Movement	EB	EB	WB	SB
Directions Served	L	T	TR	LR
Maximum Queue (ft)	45	521	292	130
Average Queue (ft)	25	238	146	57
95th Queue (ft)	54	447	255	109
Link Distance (ft)		894	591	487
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)	20			
Storage Blk Time (%)	19	45		
Queuing Penalty (veh)	88	20		

Intersection: 7: W. Chester St/E. Chester St & Broadway

Movement	EB	EB	WB	WB	NB	SB
Directions Served	L	TR	LT	R	LTR	LTR
Maximum Queue (ft)	207	315	436	105	123	233
Average Queue (ft)	39	160	184	8	58	114
95th Queue (ft)	122	299	349	61	100	199
Link Distance (ft)		591	464		436	478
Upstream Blk Time (%)			1			
Queuing Penalty (veh)			0			
Storage Bay Dist (ft)	210			130		
Storage Blk Time (%)		4	25			
Queuing Penalty (veh)		2	2			

Network Summary

Network wide Queuing Penalty: 466

APPENDIX C-2

2018 Build Condition
with Isolated Uncoordinated Traffic Signals

1: Liberty St/Elmendorf St & Broadway Performance by approach

Approach	EB	WB	SB	All
Denied Delay (hr)	0.2	0.0	0.0	0.2
Denied Del/Veh (s)	0.9	0.0	0.2	0.5
Total Delay (hr)	2.3	2.7	0.8	5.7
Total Del/Veh (s)	11.4	14.3	40.1	14.1
Stop Delay (hr)	1.2	1.5	0.7	3.4
Stop Del/Veh (s)	5.9	8.1	38.4	8.4
Total Stops	283	264	58	605
Stop/Veh	0.39	0.40	0.85	0.41
Travel Dist (mi)	132.7	114.1	9.0	255.7
Travel Time (hr)	7.9	7.3	1.1	16.4
Avg Speed (mph)	17	16	8	16
Fuel Used (gal)	4.5	4.4	0.5	9.4
Fuel Eff. (mpg)	29.2	25.7	19.9	27.1
HC Emissions (g)	104	97	4	204
CO Emissions (g)	1853	1784	99	3736
NOx Emissions (g)	281	282	11	574

2: Henry St/O'Neil St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.1	0.0	0.0	0.1
Denied Del/Veh (s)	0.1	0.3	1.5	0.8	0.3
Total Delay (hr)	3.4	4.1	0.8	0.8	9.0
Total Del/Veh (s)	16.9	21.2	27.7	38.2	20.5
Stop Delay (hr)	1.9	2.6	0.8	0.8	6.0
Stop Del/Veh (s)	9.6	13.5	25.7	36.1	13.6
Total Stops	322	373	61	63	819
Stop/Veh	0.45	0.54	0.58	0.84	0.52
Travel Dist (mi)	121.2	80.7	4.4	12.1	218.4
Travel Time (hr)	8.3	7.4	1.0	1.3	18.1
Avg Speed (mph)	15	11	4	9	12
Fuel Used (gal)	4.5	3.7	0.3	0.5	9.0
Fuel Eff. (mpg)	26.8	22.0	14.5	22.0	24.1
HC Emissions (g)	90	63	5	12	170
CO Emissions (g)	1639	1197	100	219	3155
NOx Emissions (g)	254	177	11	29	471

3: Cedar St /Cornell St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.0	0.0	0.2	0.2	0.1
Total Delay (hr)	3.4	4.6	2.3	2.3	12.5
Total Del/Veh (s)	18.4	23.7	36.5	59.7	26.3
Stop Delay (hr)	2.2	3.0	2.1	2.2	9.6
Stop Del/Veh (s)	12.1	15.7	34.0	56.9	20.1
Total Stops	337	395	191	127	1050
Stop/Veh	0.51	0.57	0.86	0.91	0.61
Travel Dist (mi)	78.5	136.1	54.7	18.4	287.7
Travel Time (hr)	6.6	10.3	4.6	3.1	24.6
Avg Speed (mph)	12	13	12	6	12
Fuel Used (gal)	3.5	5.8	2.1	1.1	12.5
Fuel Eff. (mpg)	22.6	23.6	26.2	16.4	23.1
HC Emissions (g)	61	89	22	13	185
CO Emissions (g)	1171	1849	470	300	3790
NOx Emissions (g)	178	273	61	33	546

4: Pine Grove Ave./Grand St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.3	0.3
Denied Del/Veh (s)	0.1	0.0	0.6	2.9	0.7
Total Delay (hr)	4.7	4.7	2.3	1.7	13.4
Total Del/Veh (s)	21.1	40.0	62.2	20.1	29.0
Stop Delay (hr)	3.3	4.0	2.2	1.5	11.0
Stop Del/Veh (s)	14.9	33.5	59.8	17.7	23.7
Total Stops	467	370	124	231	1192
Stop/Veh	0.59	0.87	0.93	0.74	0.72
Travel Dist (mi)	156.2	55.4	11.9	20.5	244.0
Travel Time (hr)	11.3	7.0	2.8	3.0	24.1
Avg Speed (mph)	14	8	4	8	10
Fuel Used (gal)	6.1	2.9	1.0	1.2	11.1
Fuel Eff. (mpg)	25.6	19.0	12.6	17.7	21.9
HC Emissions (g)	104	37	10	16	167
CO Emissions (g)	2114	801	258	392	3566
NOx Emissions (g)	305	104	26	44	479

5: W. O'Reilly St/E. O'Reilly St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.0	0.0	0.2	0.1	0.1
Total Delay (hr)	1.3	1.3	0.6	0.4	3.5
Total Del/Veh (s)	11.2	11.4	15.8	15.1	12.2
Stop Delay (hr)	0.8	0.8	0.5	0.3	2.4
Stop Del/Veh (s)	6.7	7.2	13.5	13.3	8.3
Total Stops	190	184	101	60	535
Stop/Veh	0.47	0.46	0.73	0.71	0.52
Travel Dist (mi)	55.1	70.2	13.3	7.8	146.5
Travel Time (hr)	3.5	4.2	1.2	0.7	9.6
Avg Speed (mph)	16	17	11	11	15
Fuel Used (gal)	2.2	2.5	0.6	0.3	5.6
Fuel Eff. (mpg)	24.6	28.3	24.2	25.1	26.2
HC Emissions (g)	38	37	4	2	81
CO Emissions (g)	826	756	133	68	1783
NOx Emissions (g)	119	112	15	7	253

6: Broadway & Foxhall Ave Performance by approach

Approach	EB	WB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.0	0.0	0.2	0.0
Total Delay (hr)	0.8	0.5	0.2	1.5
Total Del/Veh (s)	6.8	4.8	9.8	6.2
Stop Delay (hr)	0.3	0.2	0.2	0.7
Stop Del/Veh (s)	2.9	2.3	8.6	3.1
Total Stops	108	76	60	244
Stop/Veh	0.26	0.21	0.82	0.28
Travel Dist (mi)	73.1	44.3	6.8	124.2
Travel Time (hr)	3.8	2.3	0.5	6.6
Avg Speed (mph)	19	19	13	19
Fuel Used (gal)	2.7	1.7	0.2	4.6
Fuel Eff. (mpg)	27.3	25.9	28.6	26.9
HC Emissions (g)	42	27	3	72
CO Emissions (g)	856	604	68	1528
NOx Emissions (g)	134	88	8	230

7: W. Chester St/E. Chester St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.1	0.0	0.0	0.2
Denied Del/Veh (s)	0.0	1.2	0.2	0.3	0.5
Total Delay (hr)	1.1	0.9	0.5	1.4	3.8
Total Del/Veh (s)	9.9	7.9	12.8	20.0	11.8
Stop Delay (hr)	0.7	0.6	0.4	1.2	3.0
Stop Del/Veh (s)	6.8	5.7	11.0	17.0	9.1
Total Stops	185	198	88	205	676
Stop/Veh	0.47	0.50	0.69	0.80	0.58
Travel Dist (mi)	47.5	34.8	10.5	23.2	115.9
Travel Time (hr)	3.0	2.5	0.9	2.4	8.8
Avg Speed (mph)	16	15	12	10	13
Fuel Used (gal)	1.8	1.4	0.4	1.1	4.6
Fuel Eff. (mpg)	26.8	25.6	24.8	21.5	25.0
HC Emissions (g)	32	18	7	19	75
CO Emissions (g)	632	450	159	421	1663
NOx Emissions (g)	93	57	19	51	219

Total Network Performance

Denied Delay (hr)	0.8
Denied Del/Veh (s)	1.0
Total Delay (hr)	50.4
Total Del/Veh (s)	59.4
Stop Delay (hr)	36.2
Stop Del/Veh (s)	42.7
Total Stops	5121
Stop/Veh	1.68
Travel Dist (mi)	1756.7
Travel Time (hr)	124.8
Avg Speed (mph)	14
Fuel Used (gal)	72.0
Fuel Eff. (mpg)	24.4
HC Emissions (g)	1291
CO Emissions (g)	26796
NOx Emissions (g)	3800

Arterial Level of Service: EB Broadway

Cross Street	Node	Delay (s/veh)	Travel time (s)	Dist (mi)	Arterial Speed
Henry St	2	15.4	40.1	0.2	16
Cedar St	3	15.0	32.4	0.1	14
Pine Grove Ave.	4	17.5	45.9	0.2	16
W. O'Reilly St	5	11.5	31.3	0.1	15
Foxhall Ave	6	6.6	32.0	0.2	20
W. Chester St	7	9.9	27.3	0.1	16
Total		75.7	209.0	0.9	16

Arterial Level of Service: WB Broadway

Cross Street	Node	Delay (s/veh)	Travel time (s)	Dist (mi)	Arterial Speed
Foxhall Ave	6	5.2	22.7	0.1	20
E. O'Reilly St	5	11.6	37.0	0.2	18
Grand St	4	39.9	58.8	0.1	8
Cornell St	3	22.8	51.4	0.2	14
O'Neil St	2	21.1	38.5	0.1	12
Elmendorf St	1	13.2	38.0	0.2	16
Total		113.8	246.4	0.9	14

Intersection: 1: Liberty St/Elmendorf St & Broadway

Movement	EB	EB	WB	WB	SB
Directions Served	L	TR	L	TR	LTR
Maximum Queue (ft)	82	572	134	448	113
Average Queue (ft)	16	171	42	165	47
95th Queue (ft)	52	412	108	360	96
Link Distance (ft)		965		842	701
Upstream Blk Time (%)		0			
Queuing Penalty (veh)		0			
Storage Bay Dist (ft)	50		60		
Storage Blk Time (%)	1	17	3	16	
Queuing Penalty (veh)	8	4	20	8	

Intersection: 2: Henry St/O'Neil St & Broadway

Movement	EB	EB	WB	WB	NB	NB	SB	SB
Directions Served	L	TR	L	TR	L	T	L	TR
Maximum Queue (ft)	164	503	174	515	88	91	50	117
Average Queue (ft)	40	200	29	250	34	27	10	43
95th Queue (ft)	109	406	105	478	75	70	34	92
Link Distance (ft)		842		565		252		841
Upstream Blk Time (%)				0				
Queuing Penalty (veh)				1				
Storage Bay Dist (ft)	90		100		50		75	
Storage Blk Time (%)	1	17	0	23	12	6	0	3
Queuing Penalty (veh)	6	6	0	6	3	3	0	0

Intersection: 3: Cedar St /Cornell St & Broadway

Movement	EB	EB	WB	WB	NB	SB
Directions Served	L	TR	L	TR	LTR	LTR
Maximum Queue (ft)	138	495	194	499	375	259
Average Queue (ft)	38	191	40	263	122	108
95th Queue (ft)	101	395	132	456	279	212
Link Distance (ft)		565		1001	1310	699
Upstream Blk Time (%)		0			0	
Queuing Penalty (veh)		2			0	
Storage Bay Dist (ft)	65		120			
Storage Blk Time (%)	5	20	0	26		
Queuing Penalty (veh)	31	7	0	8		

Intersection: 4: Pine Grove Ave./Grand St & Broadway

Movement	EB	EB	WB	WB	NB	NB	SB	SB
Directions Served	L	TR	L	TR	LT	R	LT	R
Maximum Queue (ft)	299	414	124	454	241	92	243	120
Average Queue (ft)	128	176	26	208	93	10	82	83
95th Queue (ft)	238	332	95	401	205	64	185	134
Link Distance (ft)		1001		622	465		344	
Upstream Blk Time (%)				0			0	
Queuing Penalty (veh)				1			0	
Storage Bay Dist (ft)	225		50			150		45
Storage Blk Time (%)	1	4	1	46	9		17	26
Queuing Penalty (veh)	6	9	3	12	1		39	19

Intersection: 5: W. O'Reilly St/E. O'Reilly St & Broadway

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	LTR	LTR
Maximum Queue (ft)	265	281	144	102
Average Queue (ft)	116	103	53	41
95th Queue (ft)	218	210	106	80
Link Distance (ft)	622	894	502	490
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 6: Broadway & Foxhall Ave

Movement	EB	EB	WB	SB
Directions Served	L	T	TR	LR
Maximum Queue (ft)	88	180	157	74
Average Queue (ft)	25	60	54	34
95th Queue (ft)	67	143	128	65
Link Distance (ft)		894	592	487
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)	20			
Storage Blk Time (%)	7	11		
Queuing Penalty (veh)	24	5		

Intersection: 7: W. Chester St/E. Chester St & Broadway

Movement	EB	EB	WB	WB	NB	SB
Directions Served	L	TR	LT	R	LTR	LTR
Maximum Queue (ft)	47	242	206	110	128	208
Average Queue (ft)	9	108	81	28	55	98
95th Queue (ft)	35	201	155	71	99	176
Link Distance (ft)		592	464		436	478
Upstream Blk Time (%)			0			
Queuing Penalty (veh)			0			
Storage Bay Dist (ft)	210			130		
Storage Blk Time (%)		1	1	0		
Queuing Penalty (veh)		0	1	0		

Network Summary

Network wide Queuing Penalty: 232

1: Liberty St/Elmendorf St & Broadway Performance by approach

Approach	EB	WB	SB	All
Denied Delay (hr)	0.2	0.0	0.0	0.2
Denied Del/Veh (s)	1.1	0.0	0.1	0.5
Total Delay (hr)	2.8	4.9	0.9	8.7
Total Del/Veh (s)	13.4	23.6	42.5	19.7
Stop Delay (hr)	1.7	3.1	0.9	5.7
Stop Del/Veh (s)	8.1	14.8	40.4	12.9
Total Stops	327	457	69	853
Stop/Veh	0.43	0.61	0.86	0.54
Travel Dist (mi)	137.2	128.0	10.5	275.8
Travel Time (hr)	8.6	10.2	1.4	20.2
Avg Speed (mph)	16	13	8	14
Fuel Used (gal)	4.9	5.3	0.5	10.7
Fuel Eff. (mpg)	28.1	24.1	19.2	25.7
HC Emissions (g)	49	52	6	108
CO Emissions (g)	1088	1172	151	2412
NOx Emissions (g)	159	176	17	353

2: Henry St/O'Neil St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.1	0.1
Denied Del/Veh (s)	0.0	0.0	1.0	1.3	0.2
Total Delay (hr)	3.4	4.6	1.0	1.5	10.4
Total Del/Veh (s)	17.1	22.2	23.1	35.7	21.4
Stop Delay (hr)	1.9	2.9	0.9	1.4	7.1
Stop Del/Veh (s)	9.8	13.9	20.9	33.2	14.6
Total Stops	325	423	78	128	954
Stop/Veh	0.46	0.57	0.50	0.84	0.54
Travel Dist (mi)	120.9	88.5	6.4	24.3	240.0
Travel Time (hr)	8.3	8.2	1.3	2.6	20.4
Avg Speed (mph)	15	11	5	10	12
Fuel Used (gal)	4.4	4.1	0.4	1.1	10.0
Fuel Eff. (mpg)	27.2	21.6	15.6	22.1	23.9
HC Emissions (g)	37	39	3	8	88
CO Emissions (g)	865	888	76	224	2053
NOx Emissions (g)	130	130	8	26	293

3: Cedar St /Cornell St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.1	0.0	0.8	1.0
Denied Del/Veh (s)	0.1	0.7	0.2	12.4	1.8
Total Delay (hr)	5.2	8.0	5.2	14.0	32.4
Total Del/Veh (s)	25.0	37.7	72.4	217.6	58.3
Stop Delay (hr)	3.5	5.7	5.0	13.9	28.1
Stop Del/Veh (s)	16.7	27.1	69.3	215.6	50.5
Total Stops	491	582	230	209	1512
Stop/Veh	0.66	0.76	0.89	0.90	0.76
Travel Dist (mi)	88.9	150.7	63.4	29.0	332.0
Travel Time (hr)	9.0	14.5	7.9	16.0	47.4
Avg Speed (mph)	10	10	8	2	7
Fuel Used (gal)	4.3	7.0	3.0	4.3	18.6
Fuel Eff. (mpg)	20.8	21.6	21.1	6.7	17.9
HC Emissions (g)	32	60	12	17	121
CO Emissions (g)	811	1481	394	542	3228
NOx Emissions (g)	115	203	43	39	400

4: Pine Grove Ave./Grand St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.2	0.3	0.5
Denied Del/Veh (s)	0.0	0.0	3.4	3.0	0.9
Total Delay (hr)	5.6	4.5	5.0	2.0	17.1
Total Del/Veh (s)	24.0	38.0	94.6	20.8	34.1
Stop Delay (hr)	4.3	3.7	4.9	1.7	14.6
Stop Del/Veh (s)	18.4	31.6	92.3	18.1	29.2
Total Stops	520	368	189	280	1357
Stop/Veh	0.61	0.87	0.99	0.82	0.75
Travel Dist (mi)	170.3	55.4	16.8	22.3	264.7
Travel Time (hr)	12.8	6.8	5.9	3.3	28.8
Avg Speed (mph)	13	8	3	7	9
Fuel Used (gal)	7.0	2.9	1.8	1.3	13.0
Fuel Eff. (mpg)	24.3	19.0	9.3	16.9	20.3
HC Emissions (g)	50	28	10	9	96
CO Emissions (g)	1413	677	334	302	2727
NOx Emissions (g)	198	87	31	32	348

5: W. O'Reilly St/E. O'Reilly St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.0	0.0	0.2	0.2	0.0
Total Delay (hr)	1.7	1.5	0.6	0.5	4.2
Total Del/Veh (s)	12.5	13.8	15.8	14.5	13.5
Stop Delay (hr)	1.0	1.0	0.5	0.4	2.9
Stop Del/Veh (s)	7.3	9.6	13.8	12.6	9.4
Total Stops	246	199	92	90	627
Stop/Veh	0.50	0.52	0.73	0.73	0.56
Travel Dist (mi)	66.0	68.0	12.1	11.3	157.3
Travel Time (hr)	4.4	4.3	1.1	1.0	10.7
Avg Speed (mph)	15	16	11	11	15
Fuel Used (gal)	2.7	2.5	0.5	0.5	6.1
Fuel Eff. (mpg)	24.9	27.0	24.2	25.0	25.7
HC Emissions (g)	24	23	4	3	55
CO Emissions (g)	631	554	128	108	1421
NOx Emissions (g)	89	80	14	12	196

6: Broadway & Foxhall Ave Performance by approach

Approach	EB	WB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.0	0.0	0.2	0.0
Total Delay (hr)	1.4	0.7	0.6	2.7
Total Del/Veh (s)	10.0	6.6	15.5	9.5
Stop Delay (hr)	0.7	0.4	0.5	1.6
Stop Del/Veh (s)	4.8	3.4	13.6	5.5
Total Stops	196	113	110	419
Stop/Veh	0.38	0.30	0.79	0.41
Travel Dist (mi)	91.3	45.9	12.9	150.1
Travel Time (hr)	5.2	2.6	1.2	9.0
Avg Speed (mph)	18	18	11	17
Fuel Used (gal)	3.4	1.9	0.5	5.8
Fuel Eff. (mpg)	26.9	24.4	23.8	25.8
HC Emissions (g)	28	21	3	51
CO Emissions (g)	689	541	111	1342
NOx Emissions (g)	106	76	11	193

7: W. Chester St/E. Chester St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.1	0.0	0.0	0.1
Denied Del/Veh (s)	0.0	0.5	0.2	0.3	0.2
Total Delay (hr)	1.8	2.4	0.4	1.4	6.0
Total Del/Veh (s)	11.3	20.6	12.7	20.4	15.9
Stop Delay (hr)	1.2	2.0	0.4	1.2	4.7
Stop Del/Veh (s)	7.4	16.9	11.0	17.7	12.5
Total Stops	286	313	82	197	878
Stop/Veh	0.50	0.75	0.67	0.81	0.65
Travel Dist (mi)	69.1	36.3	10.0	22.2	137.6
Travel Time (hr)	4.6	3.9	0.9	2.4	11.8
Avg Speed (mph)	15	9	12	10	12
Fuel Used (gal)	2.8	1.7	0.4	1.0	5.9
Fuel Eff. (mpg)	24.9	21.0	24.7	21.5	23.2
HC Emissions (g)	19	14	2	7	41
CO Emissions (g)	568	425	91	239	1322
NOx Emissions (g)	80	47	9	25	161

Total Network Performance

Denied Delay (hr)	1.9
Denied Del/Veh (s)	2.0
Total Delay (hr)	82.7
Total Del/Veh (s)	85.6
Stop Delay (hr)	64.8
Stop Del/Veh (s)	67.1
Total Stops	6600
Stop/Veh	1.90
Travel Dist (mi)	1989.0
Travel Time (hr)	167.8
Avg Speed (mph)	12
Fuel Used (gal)	88.0
Fuel Eff. (mpg)	22.6
HC Emissions (g)	750
CO Emissions (g)	20139
NOx Emissions (g)	2652

Arterial Level of Service: EB Broadway

Cross Street	Node	Delay (s/veh)	Travel time (s)	Dist (mi)	Arterial Speed
Henry St	2	16.1	41.1	0.2	15
Cedar St	3	21.3	38.8	0.1	11
Pine Grove Ave.	4	15.2	44.5	0.2	17
W. O'Reilly St	5	12.9	32.6	0.1	15
Foxhall Ave	6	9.7	35.7	0.2	18
W. Chester St	7	11.2	28.9	0.1	15
Total		86.5	221.6	0.9	15

Arterial Level of Service: WB Broadway

Cross Street	Node	Delay (s/veh)	Travel time (s)	Dist (mi)	Arterial Speed
Foxhall Ave	6	7.2	24.6	0.1	18
E. O'Reilly St	5	13.7	39.4	0.2	17
Grand St	4	38.2	57.2	0.1	8
Cornell St	3	34.8	64.9	0.2	12
O'Neil St	2	22.0	39.4	0.1	11
Elmendorf St	1	22.9	47.8	0.2	13
Total		138.7	273.4	0.9	12

Intersection: 1: Liberty St/Elmendorf St & Broadway

Movement	EB	EB	WB	WB	SB
Directions Served	L	TR	L	TR	LTR
Maximum Queue (ft)	124	444	84	579	126
Average Queue (ft)	42	152	39	263	56
95th Queue (ft)	95	341	85	514	108
Link Distance (ft)		965		842	701
Upstream Blk Time (%)		0		0	
Queuing Penalty (veh)		0		0	
Storage Bay Dist (ft)	50		60		
Storage Blk Time (%)	9	17	5	26	
Queuing Penalty (veh)	61	10	31	16	

Intersection: 2: Henry St/O'Neil St & Broadway

Movement	EB	EB	WB	WB	NB	NB	SB	SB
Directions Served	L	TR	L	TR	L	T	L	TR
Maximum Queue (ft)	104	436	124	522	71	111	111	156
Average Queue (ft)	26	202	22	264	31	41	32	63
95th Queue (ft)	75	379	76	493	68	90	78	126
Link Distance (ft)		842		565		252		841
Upstream Blk Time (%)				0				
Queuing Penalty (veh)				2				
Storage Bay Dist (ft)	90		100		50		75	
Storage Blk Time (%)	0	18	0	24	10	10	2	7
Queuing Penalty (veh)	1	4	1	6	5	4	2	3

Intersection: 3: Cedar St /Cornell St & Broadway

Movement	EB	EB	WB	WB	NB	SB
Directions Served	L	TR	L	TR	LTR	LTR
Maximum Queue (ft)	89	534	220	649	500	663
Average Queue (ft)	34	257	87	360	201	406
95th Queue (ft)	83	478	218	695	443	751
Link Distance (ft)		565		1001	1310	699
Upstream Blk Time (%)		1		0		13
Queuing Penalty (veh)		4		1		0
Storage Bay Dist (ft)	65		120			
Storage Blk Time (%)	4	27	4	33		
Queuing Penalty (veh)	31	10	26	20		

Intersection: 4: Pine Grove Ave./Grand St & Broadway

Movement	EB	EB	WB	WB	NB	NB	SB	SB
Directions Served	L	TR	L	TR	LT	R	LT	R
Maximum Queue (ft)	300	365	100	403	324	182	251	71
Average Queue (ft)	163	159	18	198	162	35	115	65
95th Queue (ft)	273	301	68	361	349	142	217	83
Link Distance (ft)		1001		622	465		344	
Upstream Blk Time (%)				0	4		0	
Queuing Penalty (veh)				0	0		0	
Storage Bay Dist (ft)	225		50			150		45
Storage Blk Time (%)	5	2	0	45	26		15	26
Queuing Penalty (veh)	26	6	2	10	8		40	18

Intersection: 5: W. O'Reilly St/E. O'Reilly St & Broadway

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	LTR	LTR
Maximum Queue (ft)	311	270	116	124
Average Queue (ft)	144	111	50	54
95th Queue (ft)	264	210	93	100
Link Distance (ft)	622	894	502	490
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 6: Broadway & Foxhall Ave

Movement	EB	EB	WB	SB
Directions Served	L	T	TR	LR
Maximum Queue (ft)	46	248	204	120
Average Queue (ft)	22	105	73	55
95th Queue (ft)	50	211	158	95
Link Distance (ft)		894	591	487
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)	20			
Storage Blk Time (%)	9	17		
Queuing Penalty (veh)	42	7		

Intersection: 7: W. Chester St/E. Chester St & Broadway

Movement	EB	EB	WB	WB	NB	SB
Directions Served	L	TR	LT	R	LTR	LTR
Maximum Queue (ft)	68	258	313	72	104	192
Average Queue (ft)	28	131	145	4	48	92
95th Queue (ft)	62	223	258	41	86	162
Link Distance (ft)		591	464		436	478
Upstream Blk Time (%)						
Queuing Penalty (veh)						
Storage Bay Dist (ft)	210			130		
Storage Blk Time (%)		1	15			
Queuing Penalty (veh)		1	1			

Network Summary

Network wide Queuing Penalty: 399

APPENDIX C-3

2018 Build Condition
with Interconnected Coordinated Traffic Signals

1: Liberty St/Elmendorf St & Broadway Performance by approach

Approach	EB	WB	SB	All
Denied Delay (hr)	0.2	0.0	0.0	0.2
Denied Del/Veh (s)	1.0	0.0	0.2	0.5
Total Delay (hr)	2.6	1.7	0.9	5.1
Total Del/Veh (s)	12.4	9.0	48.0	12.5
Stop Delay (hr)	1.4	0.9	0.9	3.1
Stop Del/Veh (s)	6.6	4.9	46.1	7.7
Total Stops	292	148	60	500
Stop/Veh	0.40	0.22	0.88	0.34
Travel Dist (mi)	134.6	113.2	9.1	256.9
Travel Time (hr)	8.2	6.3	1.3	15.8
Avg Speed (mph)	17	18	7	16
Fuel Used (gal)	4.6	4.0	0.5	9.2
Fuel Eff. (mpg)	28.9	28.0	18.5	28.0
HC Emissions (g)	96	83	6	184
CO Emissions (g)	1742	1559	136	3437
NOx Emissions (g)	261	244	16	521

2: Henry St/O'Neil St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.1
Denied Del/Veh (s)	0.1	0.2	1.6	0.8	0.3
Total Delay (hr)	3.5	1.9	0.9	1.0	7.3
Total Del/Veh (s)	17.5	10.1	31.6	45.7	16.7
Stop Delay (hr)	2.2	0.9	0.9	0.9	4.9
Stop Del/Veh (s)	10.8	4.9	29.6	43.6	11.2
Total Stops	326	143	59	66	594
Stop/Veh	0.45	0.21	0.56	0.86	0.38
Travel Dist (mi)	123.5	78.9	4.4	12.4	219.2
Travel Time (hr)	8.6	5.1	1.2	1.5	16.4
Avg Speed (mph)	14	15	4	8	13
Fuel Used (gal)	4.7	3.2	0.3	0.6	8.8
Fuel Eff. (mpg)	26.2	24.7	13.5	20.6	24.8
HC Emissions (g)	80	56	6	12	154
CO Emissions (g)	1510	1065	105	225	2906
NOx Emissions (g)	236	166	10	28	440

3: Cedar St /Cornell St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.0	0.0	0.2	0.2	0.1
Total Delay (hr)	4.3	4.4	2.1	1.9	12.8
Total Del/Veh (s)	23.2	23.6	34.3	47.8	26.9
Stop Delay (hr)	3.1	2.9	1.9	1.8	9.7
Stop Del/Veh (s)	16.7	15.4	31.8	44.9	20.5
Total Stops	376	371	176	128	1051
Stop/Veh	0.56	0.55	0.81	0.88	0.62
Travel Dist (mi)	80.3	132.5	53.2	19.2	285.1
Travel Time (hr)	7.7	10.0	4.3	2.8	24.7
Avg Speed (mph)	10	13	12	7	12
Fuel Used (gal)	3.7	5.6	2.0	1.1	12.3
Fuel Eff. (mpg)	21.5	23.8	26.7	18.2	23.1
HC Emissions (g)	57	78	24	14	173
CO Emissions (g)	1112	1657	495	310	3575
NOx Emissions (g)	165	243	65	36	510

4: Pine Grove Ave./Grand St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.2	0.3
Denied Del/Veh (s)	0.2	0.0	0.6	2.9	0.7
Total Delay (hr)	5.8	4.5	2.3	1.9	14.5
Total Del/Veh (s)	25.3	38.5	58.8	24.2	31.3
Stop Delay (hr)	4.1	3.8	2.2	1.7	11.8
Stop Del/Veh (s)	17.9	32.5	56.2	21.7	25.4
Total Stops	465	319	132	202	1118
Stop/Veh	0.57	0.76	0.94	0.71	0.67
Travel Dist (mi)	160.2	54.6	12.5	18.6	246.0
Travel Time (hr)	12.6	6.8	2.9	3.0	25.2
Avg Speed (mph)	13	8	4	7	10
Fuel Used (gal)	6.5	2.8	1.0	1.1	11.4
Fuel Eff. (mpg)	24.7	19.3	12.8	16.4	21.5
HC Emissions (g)	103	37	7	16	164
CO Emissions (g)	2106	796	229	391	3523
NOx Emissions (g)	300	103	23	44	470

5: W. O'Reilly St/E. O'Reilly St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.0	0.1	0.2	0.2	0.1
Total Delay (hr)	1.5	1.1	0.6	0.3	3.5
Total Del/Veh (s)	12.8	9.8	16.3	13.7	12.2
Stop Delay (hr)	0.9	0.7	0.5	0.3	2.4
Stop Del/Veh (s)	7.6	5.8	14.2	11.9	8.1
Total Stops	212	145	101	57	515
Stop/Veh	0.50	0.36	0.74	0.70	0.49
Travel Dist (mi)	57.5	70.8	12.8	7.6	148.7
Travel Time (hr)	3.9	4.0	1.2	0.6	9.7
Avg Speed (mph)	15	18	11	12	15
Fuel Used (gal)	2.4	2.5	0.5	0.3	5.7
Fuel Eff. (mpg)	24.3	28.0	23.8	25.8	26.0
HC Emissions (g)	44	40	5	2	90
CO Emissions (g)	927	810	141	62	1940
NOx Emissions (g)	134	120	16	7	277

6: Broadway & Foxhall Ave Performance by approach

Approach	EB	WB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.0	0.0	0.2	0.0
Total Delay (hr)	0.6	0.6	0.2	1.5
Total Del/Veh (s)	5.3	6.4	10.8	6.2
Stop Delay (hr)	0.2	0.4	0.2	0.8
Stop Del/Veh (s)	1.3	3.9	9.8	3.1
Total Stops	66	118	55	239
Stop/Veh	0.15	0.32	0.75	0.27
Travel Dist (mi)	75.9	44.1	6.9	126.9
Travel Time (hr)	3.7	2.5	0.5	6.8
Avg Speed (mph)	20	18	13	19
Fuel Used (gal)	2.8	1.7	0.2	4.8
Fuel Eff. (mpg)	26.9	25.6	28.5	26.5
HC Emissions (g)	49	28	3	81
CO Emissions (g)	993	611	72	1676
NOx Emissions (g)	159	89	9	257

7: W. Chester St/E. Chester St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.1	0.0	0.0	0.2
Denied Del/Veh (s)	0.0	1.1	0.2	0.3	0.5
Total Delay (hr)	1.0	0.8	0.5	1.6	3.8
Total Del/Veh (s)	8.5	7.4	13.6	22.0	11.6
Stop Delay (hr)	0.7	0.6	0.4	1.3	3.1
Stop Del/Veh (s)	6.2	5.2	11.7	19.0	9.2
Total Stops	140	191	93	203	627
Stop/Veh	0.34	0.48	0.71	0.80	0.52
Travel Dist (mi)	49.5	35.0	10.8	23.4	118.7
Travel Time (hr)	3.0	2.4	1.0	2.6	8.9
Avg Speed (mph)	17	15	11	9	14
Fuel Used (gal)	1.8	1.4	0.4	1.1	4.7
Fuel Eff. (mpg)	27.6	25.9	24.4	20.9	25.2
HC Emissions (g)	35	20	8	18	80
CO Emissions (g)	674	483	171	421	1750
NOx Emissions (g)	99	62	21	49	231

Total Network Performance

Denied Delay (hr)	0.8
Denied Del/Veh (s)	1.0
Total Delay (hr)	49.4
Total Del/Veh (s)	58.3
Stop Delay (hr)	35.8
Stop Del/Veh (s)	42.3
Total Stops	4644
Stop/Veh	1.52
Travel Dist (mi)	1766.0
Travel Time (hr)	124.1
Avg Speed (mph)	14
Fuel Used (gal)	71.9
Fuel Eff. (mpg)	24.6
HC Emissions (g)	1249
CO Emissions (g)	26114
NOx Emissions (g)	3692

Arterial Level of Service: EB Broadway

Cross Street	Node	Delay (s/veh)	Travel time (s)	Dist (mi)	Arterial Speed
Henry St	2	15.6	40.4	0.2	15
Cedar St	3	20.0	37.4	0.1	12
Pine Grove Ave.	4	15.7	44.0	0.2	17
W. O'Reilly St	5	13.3	33.0	0.1	15
Foxhall Ave	6	4.5	29.9	0.2	22
W. Chester St	7	8.4	25.8	0.1	17
Total		77.5	210.5	0.9	16

Arterial Level of Service: WB Broadway

Cross Street	Node	Delay (s/veh)	Travel time (s)	Dist (mi)	Arterial Speed
Foxhall Ave	6	7.2	24.7	0.1	18
E. O'Reilly St	5	9.3	34.7	0.2	19
Grand St	4	37.8	56.6	0.1	9
Cornell St	3	25.2	53.7	0.2	14
O'Neil St	2	8.7	26.0	0.1	17
Elmendorf St	1	6.2	30.9	0.2	20
Total		94.3	226.7	0.9	15

Intersection: 1: Liberty St/Elmendorf St & Broadway

Movement	EB	EB	WB	WB	SB
Directions Served	L	TR	L	TR	LTR
Maximum Queue (ft)	104	541	115	229	129
Average Queue (ft)	18	181	34	86	54
95th Queue (ft)	64	403	82	182	107
Link Distance (ft)		965		842	701
Upstream Blk Time (%)		0			
Queuing Penalty (veh)		0			
Storage Bay Dist (ft)	50		60		
Storage Blk Time (%)	2	17	4	11	
Queuing Penalty (veh)	13	4	23	6	

Intersection: 2: Henry St/O'Neil St & Broadway

Movement	EB	EB	WB	WB	NB	NB	SB	SB
Directions Served	L	TR	L	TR	L	T	L	TR
Maximum Queue (ft)	157	495	86	382	93	94	51	129
Average Queue (ft)	49	217	16	105	39	25	11	47
95th Queue (ft)	124	407	54	262	82	70	37	103
Link Distance (ft)		842		565		252		841
Upstream Blk Time (%)				0				
Queuing Penalty (veh)				0				
Storage Bay Dist (ft)	90		100		50		75	
Storage Blk Time (%)	2	19	0	8	16	7	0	5
Queuing Penalty (veh)	11	6	0	2	4	3	0	1

Intersection: 3: Cedar St /Cornell St & Broadway

Movement	EB	EB	WB	WB	NB	SB
Directions Served	L	TR	L	TR	LTR	LTR
Maximum Queue (ft)	139	488	194	526	248	250
Average Queue (ft)	41	244	40	256	113	103
95th Queue (ft)	108	401	136	481	210	198
Link Distance (ft)		565		1001	1310	699
Upstream Blk Time (%)		0				
Queuing Penalty (veh)		0				
Storage Bay Dist (ft)	65		120			
Storage Blk Time (%)	4	29	1	21		
Queuing Penalty (veh)	26	11	8	7		

Intersection: 4: Pine Grove Ave./Grand St & Broadway

Movement	EB	EB	WB	WB	NB	NB	SB	SB
Directions Served	L	TR	L	TR	LT	R	LT	R
Maximum Queue (ft)	295	514	120	457	225	75	243	120
Average Queue (ft)	154	219	22	209	95	7	88	84
95th Queue (ft)	280	405	83	386	186	36	195	136
Link Distance (ft)		1001		622	465		344	
Upstream Blk Time (%)				0				
Queuing Penalty (veh)				1				
Storage Bay Dist (ft)	225		50			150		45
Storage Blk Time (%)	3	5	3	45	6		18	28
Queuing Penalty (veh)	18	12	12	11	1		40	21

Intersection: 5: W. O'Reilly St/E. O'Reilly St & Broadway

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	LTR	LTR
Maximum Queue (ft)	272	235	128	94
Average Queue (ft)	122	83	57	40
95th Queue (ft)	239	188	104	77
Link Distance (ft)	622	894	502	490
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 6: Broadway & Foxhall Ave

Movement	EB	EB	WB	SB
Directions Served	L	T	TR	LR
Maximum Queue (ft)	61	102	163	86
Average Queue (ft)	18	35	74	33
95th Queue (ft)	49	80	137	69
Link Distance (ft)		894	592	487
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)	20			
Storage Blk Time (%)	4	7		
Queuing Penalty (veh)	16	3		

Intersection: 7: W. Chester St/E. Chester St & Broadway

Movement	EB	EB	WB	WB	NB	SB
Directions Served	L	TR	LT	R	LTR	LTR
Maximum Queue (ft)	47	191	155	79	124	218
Average Queue (ft)	10	101	80	27	54	103
95th Queue (ft)	35	174	139	61	101	187
Link Distance (ft)		592	464		436	478
Upstream Blk Time (%)						
Queuing Penalty (veh)						
Storage Bay Dist (ft)	210			130		
Storage Blk Time (%)		0	1			
Queuing Penalty (veh)		0	1			

Network Summary

Network wide Queuing Penalty: 259

1: Liberty St/Elmendorf St & Broadway Performance by approach

Approach	EB	WB	SB	All
Denied Delay (hr)	0.2	0.0	0.0	0.2
Denied Del/Veh (s)	1.1	0.0	0.1	0.5
Total Delay (hr)	2.9	2.6	1.1	6.6
Total Del/Veh (s)	14.2	12.4	46.6	15.0
Stop Delay (hr)	1.9	1.4	1.0	4.3
Stop Del/Veh (s)	8.9	6.7	44.4	9.7
Total Stops	325	223	69	617
Stop/Veh	0.44	0.30	0.84	0.39
Travel Dist (mi)	135.6	129.9	10.6	276.1
Travel Time (hr)	8.7	7.9	1.5	18.1
Avg Speed (mph)	16	16	7	15
Fuel Used (gal)	4.9	4.7	0.6	10.2
Fuel Eff. (mpg)	28.0	27.4	18.5	27.2
HC Emissions (g)	46	44	7	98
CO Emissions (g)	1046	1038	166	2250
NOx Emissions (g)	152	156	19	327

2: Henry St/O'Neil St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.1	0.1
Denied Del/Veh (s)	0.0	0.0	1.1	1.2	0.2
Total Delay (hr)	3.1	2.2	1.3	1.9	8.5
Total Del/Veh (s)	15.9	10.8	29.0	46.3	17.6
Stop Delay (hr)	1.9	1.1	1.2	1.8	6.1
Stop Del/Veh (s)	10.0	5.5	26.7	43.6	12.5
Total Stops	288	165	84	133	670
Stop/Veh	0.41	0.22	0.53	0.88	0.38
Travel Dist (mi)	119.7	88.6	6.4	24.1	238.8
Travel Time (hr)	8.0	5.9	1.6	3.0	18.5
Avg Speed (mph)	15	15	4	8	13
Fuel Used (gal)	4.4	3.7	0.5	1.2	9.9
Fuel Eff. (mpg)	27.0	23.7	13.3	20.0	24.2
HC Emissions (g)	34	36	2	9	82
CO Emissions (g)	821	825	77	248	1971
NOx Emissions (g)	125	130	8	27	289

3: Cedar St /Cornell St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.1	0.0	0.0	0.2
Denied Del/Veh (s)	0.2	0.6	0.3	0.3	0.4
Total Delay (hr)	6.3	10.6	2.8	4.0	23.7
Total Del/Veh (s)	30.6	49.6	39.7	62.1	42.8
Stop Delay (hr)	4.5	8.0	2.6	3.8	18.8
Stop Del/Veh (s)	21.8	37.3	36.9	58.3	33.9
Total Stops	497	684	213	211	1605
Stop/Veh	0.67	0.89	0.84	0.91	0.80
Travel Dist (mi)	87.6	151.0	62.9	30.6	332.1
Travel Time (hr)	10.0	17.1	5.5	5.3	37.9
Avg Speed (mph)	9	9	12	6	9
Fuel Used (gal)	4.4	7.5	2.4	1.9	16.3
Fuel Eff. (mpg)	19.8	20.1	25.7	16.2	20.4
HC Emissions (g)	26	59	11	9	105
CO Emissions (g)	717	1481	339	323	2860
NOx Emissions (g)	98	197	40	31	367

4: Pine Grove Ave./Grand St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.3	0.3
Denied Del/Veh (s)	0.0	0.0	0.9	3.0	0.7
Total Delay (hr)	7.2	5.2	3.3	2.2	17.9
Total Del/Veh (s)	30.8	43.8	61.6	23.3	35.7
Stop Delay (hr)	5.6	4.3	3.1	2.0	15.0
Stop Del/Veh (s)	23.8	36.5	58.8	20.4	29.9
Total Stops	536	344	183	264	1327
Stop/Veh	0.64	0.80	0.95	0.77	0.73
Travel Dist (mi)	168.8	56.5	17.1	22.4	264.8
Travel Time (hr)	14.3	7.6	4.1	3.6	29.5
Avg Speed (mph)	12	7	4	7	9
Fuel Used (gal)	7.3	3.1	1.4	1.4	13.1
Fuel Eff. (mpg)	23.1	18.5	12.3	16.2	20.2
HC Emissions (g)	44	25	8	8	85
CO Emissions (g)	1332	636	294	301	2563
NOx Emissions (g)	182	79	28	31	320

5: W. O'Reilly St/E. O'Reilly St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.0	0.0	0.2	0.2	0.0
Total Delay (hr)	1.7	1.1	0.6	0.5	3.9
Total Del/Veh (s)	12.0	10.4	16.5	14.8	12.3
Stop Delay (hr)	1.0	0.7	0.5	0.4	2.7
Stop Del/Veh (s)	7.0	6.7	14.5	13.0	8.4
Total Stops	224	147	97	91	559
Stop/Veh	0.45	0.37	0.75	0.74	0.49
Travel Dist (mi)	66.3	70.0	12.5	11.4	160.1
Travel Time (hr)	4.4	4.0	1.1	1.0	10.5
Avg Speed (mph)	15	17	11	11	15
Fuel Used (gal)	2.7	2.5	0.5	0.5	6.2
Fuel Eff. (mpg)	24.1	27.8	24.4	24.7	25.6
HC Emissions (g)	21	21	4	3	50
CO Emissions (g)	595	536	123	107	1360
NOx Emissions (g)	86	77	13	12	188

6: Broadway & Foxhall Ave Performance by approach

Approach	EB	WB	SB	All
Denied Delay (hr)	0.0	0.0	0.0	0.0
Denied Del/Veh (s)	0.0	0.0	0.2	0.0
Total Delay (hr)	0.9	0.8	0.7	2.4
Total Del/Veh (s)	6.7	7.7	16.6	8.4
Stop Delay (hr)	0.3	0.5	0.6	1.3
Stop Del/Veh (s)	1.9	4.7	14.7	4.7
Total Stops	107	143	105	355
Stop/Veh	0.21	0.37	0.74	0.34
Travel Dist (mi)	91.1	46.0	13.0	150.1
Travel Time (hr)	4.7	2.7	1.2	8.6
Avg Speed (mph)	20	17	11	17
Fuel Used (gal)	3.3	1.9	0.5	5.7
Fuel Eff. (mpg)	27.9	24.2	23.7	26.3
HC Emissions (g)	23	16	5	44
CO Emissions (g)	623	461	138	1223
NOx Emissions (g)	95	64	15	173

7: W. Chester St/E. Chester St & Broadway Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.1	0.0	0.0	0.1
Denied Del/Veh (s)	0.0	0.5	0.2	0.3	0.2
Total Delay (hr)	1.5	2.5	0.5	1.4	6.0
Total Del/Veh (s)	9.6	21.8	15.1	20.7	15.9
Stop Delay (hr)	1.0	2.1	0.5	1.2	4.8
Stop Del/Veh (s)	6.6	18.3	13.2	17.9	12.9
Total Stops	223	309	90	204	826
Stop/Veh	0.39	0.75	0.73	0.81	0.61
Travel Dist (mi)	69.1	36.2	10.1	22.8	138.2
Travel Time (hr)	4.4	4.1	1.0	2.4	11.8
Avg Speed (mph)	16	9	11	9	12
Fuel Used (gal)	2.7	1.8	0.4	1.1	6.0
Fuel Eff. (mpg)	25.4	20.6	23.5	21.4	23.1
HC Emissions (g)	18	12	3	7	39
CO Emissions (g)	551	390	99	254	1294
NOx Emissions (g)	77	43	10	26	156

Total Network Performance

Denied Delay (hr)	1.0
Denied Del/Veh (s)	1.0
Total Delay (hr)	70.2
Total Del/Veh (s)	72.5
Stop Delay (hr)	53.2
Stop Del/Veh (s)	54.9
Total Stops	5959
Stop/Veh	1.71
Travel Dist (mi)	1997.7
Travel Time (hr)	154.7
Avg Speed (mph)	13
Fuel Used (gal)	85.0
Fuel Eff. (mpg)	23.5
HC Emissions (g)	681
CO Emissions (g)	18924
NOx Emissions (g)	2489

Arterial Level of Service: EB Broadway

Cross Street	Node	Delay (s/veh)	Travel time (s)	Dist (mi)	Arterial Speed
Henry St	2	15.0	39.8	0.2	16
Cedar St	3	26.6	44.0	0.1	10
Pine Grove Ave.	4	16.8	45.9	0.2	16
W. O'Reilly St	5	12.1	31.7	0.1	15
Foxhall Ave	6	5.9	32.0	0.2	20
W. Chester St	7	9.6	27.2	0.1	16
Total		86.0	220.6	0.9	15

Arterial Level of Service: WB Broadway

Cross Street	Node	Delay (s/veh)	Travel time (s)	Dist (mi)	Arterial Speed
Foxhall Ave	6	8.6	26.1	0.1	17
E. O'Reilly St	5	9.5	35.2	0.2	19
Grand St	4	42.2	61.4	0.1	8
Cornell St	3	42.0	70.9	0.2	11
O'Neil St	2	9.1	26.6	0.1	17
Elmendorf St	1	9.9	35.0	0.2	18
Total		121.3	255.1	0.9	13

Intersection: 1: Liberty St/Elmendorf St & Broadway

Movement	EB	EB	WB	WB	SB
Directions Served	L	TR	L	TR	LTR
Maximum Queue (ft)	124	520	84	355	128
Average Queue (ft)	50	154	32	132	61
95th Queue (ft)	110	332	72	293	113
Link Distance (ft)		965		842	701
Upstream Blk Time (%)		0			
Queuing Penalty (veh)		0			
Storage Bay Dist (ft)	50		60		
Storage Blk Time (%)	13	17	2	18	
Queuing Penalty (veh)	91	10	12	11	

Intersection: 2: Henry St/O'Neil St & Broadway

Movement	EB	EB	WB	WB	NB	NB	SB	SB
Directions Served	L	TR	L	TR	L	T	L	TR
Maximum Queue (ft)	102	400	103	318	72	127	124	165
Average Queue (ft)	25	204	17	115	32	46	35	74
95th Queue (ft)	70	352	58	218	71	105	85	141
Link Distance (ft)		842		565		252		841
Upstream Blk Time (%)				0				
Queuing Penalty (veh)				0				
Storage Bay Dist (ft)	90		100		50		75	
Storage Blk Time (%)	0	19		11	13	16	2	13
Queuing Penalty (veh)	0	4		3	7	6	3	6

Intersection: 3: Cedar St /Cornell St & Broadway

Movement	EB	EB	WB	WB	NB	SB
Directions Served	L	TR	L	TR	LTR	LTR
Maximum Queue (ft)	86	570	220	819	294	351
Average Queue (ft)	33	287	97	450	138	174
95th Queue (ft)	78	458	228	892	244	297
Link Distance (ft)		565		1001	1310	699
Upstream Blk Time (%)		1		1		
Queuing Penalty (veh)		6		4		
Storage Bay Dist (ft)	65		120			
Storage Blk Time (%)	6	35	6	34		
Queuing Penalty (veh)	42	13	42	21		

Intersection: 4: Pine Grove Ave./Grand St & Broadway

Movement	EB	EB	WB	WB	NB	NB	SB	SB
Directions Served	L	TR	L	TR	LT	R	LT	R
Maximum Queue (ft)	361	491	91	476	276	183	307	72
Average Queue (ft)	193	224	16	224	129	32	134	65
95th Queue (ft)	328	406	63	415	236	131	249	79
Link Distance (ft)		1001		622	465		344	
Upstream Blk Time (%)				0			0	
Queuing Penalty (veh)				0			0	
Storage Bay Dist (ft)	225		50			150		45
Storage Blk Time (%)	9	6	0	47	14		18	27
Queuing Penalty (veh)	50	16	2	10	4		47	19

Intersection: 5: W. O'Reilly St/E. O'Reilly St & Broadway

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	LTR	LTR
Maximum Queue (ft)	298	253	128	114
Average Queue (ft)	149	84	51	50
95th Queue (ft)	262	183	98	93
Link Distance (ft)	622	894	502	490
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 6: Broadway & Foxhall Ave

Movement	EB	EB	WB	SB
Directions Served	L	T	TR	LR
Maximum Queue (ft)	46	164	198	135
Average Queue (ft)	18	59	86	59
95th Queue (ft)	46	130	160	110
Link Distance (ft)		894	591	487
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)	20			
Storage Blk Time (%)	5	11		
Queuing Penalty (veh)	22	5		

Intersection: 7: W. Chester St/E. Chester St & Broadway

Movement	EB	EB	WB	WB	NB	SB
Directions Served	L	TR	LT	R	LTR	LTR
Maximum Queue (ft)	86	219	360	105	109	199
Average Queue (ft)	25	109	148	6	53	94
95th Queue (ft)	65	186	298	54	94	164
Link Distance (ft)		591	464		436	478
Upstream Blk Time (%)			0			
Queuing Penalty (veh)			0			
Storage Bay Dist (ft)	210			130		
Storage Blk Time (%)		0	16			
Queuing Penalty (veh)		0	1			

Network Summary

Network wide Queuing Penalty: 457

APPENDIX D

Signal Timing Plan Programming Charts

CONTROLLER TIMING CHART								
LOCAL PROGRAMMING	**PHASE**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Minimum Green		20		10	7	20		
Extension		3		3	3	3		
Yellow Clearance		4		4	4	4		
All Red Clearance		4		1	1	4		
Max. Green I		35		25	8	35		
Max. Green II		70		51	9	70		
Walk		7		7	-	7		
Flashing Don't Walk		10		15	-	10		
Recall		MAX		MIN	NONE	MAX		
Memory		-		-	-	-		

COORDINATION DATA CHART								
CYCLE	**SPLIT**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle 1 - 120 Seconds (AM)		64		56	14	50		
Cycle 2 - 120 Seconds (PM)		78		28	14	78		

TIME OF DAY PLAN	
TIME	**CYCLE**
06:00 - 12:00	1
12:00 - 22:00	2
22:00 - 06:00	FREE (MAX I)

CYCLE	**OFFSET***
Cycle 1 - 120 Seconds (AM)	64
Cycle 2 - 120 Seconds (PM)	112

* Ref. End of Broadway Green Interval.

CONTROLLER TIMING CHART								
LOCAL PROGRAMMING	**PHASE**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Minimum Green		20		10	7	20		10
Extension		3		3	3	3		3
Yellow Clearance		4		4	4	4		4
All Red Clearance		5		1	1	5		1
Max. Green I		35		25	8	35		25
Max. Green II		62		45	9	62		45
Walk		7		7	-	7		7
Flashing Don't Walk		14		14	-	14		14
Recall		MAX		MIN	NONE	MAX		MIN
Memory		-		-	-	-		-

COORDINATION DATA CHART								
CYCLE	**SPLIT**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle 1 - 120 Seconds (AM)		70		50	14	56		50
Cycle 2 - 120 Seconds (PM)		71		35	14	71		35

TIME OF DAY PLAN	
TIME	**CYCLE**
06:00 - 12:00	1
12:00 - 22:00	2
22:00 - 06:00	FREE (MAX I)

CYCLE	**OFFSET***
Cycle 1 - 120 Seconds (AM)	40
Cycle 2 - 120 Seconds (PM)	88

* Ref. End of Broadway Green Interval.

CONTROLLER TIMING CHART								
LOCAL PROGRAMMING	**PHASE**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Minimum Green		20		10	7	20		10
Extension		3		3	3	3		3
Yellow Clearance		4		4	4	4		4
All Red Clearance		4		1	1	4		1
Max. Green I		35		25	8	35		25
Max. Green II		54		45	9	54		45
Walk		7		7	-	7		7
Flashing Don't Walk		25		15	-	15		15
Recall		MAX		MIN	NONE	MAX		MIN
Memory		-		-	-	-		-

COORDINATION DATA CHART								
CYCLE	**SPLIT**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle 1 - 120 Seconds (AM)		70		50	14	56		50
Cycle 2 - 120 Seconds (PM)		62		44	14	62		44

TIME OF DAY PLAN	
TIME	**CYCLE**
06:00 - 12:00	1
12:00 - 22:00	2
22:00 - 06:00	FREE (MAX I)

CYCLE	**OFFSET***
Cycle 1 - 120 Seconds (AM)	24
Cycle 2 - 120 Seconds (PM)	72

* Ref. End of Broadway Green Interval.

CONTROLLER TIMING CHART								
LOCAL PROGRAMMING	**PHASE**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Minimum Green	7	25		12				
Extension	3	3		3				
Yellow Clearance	4	4		4				
All Red Clearance	1	5		2				
Max. Green I	20	40		35				
Max. Green II	21	43		40				
Walk	-	7		7				
Flashing Don't Walk	-	18		14				
Recall	MIN	MAX		MIN				
Memory		-		-				

COORDINATION DATA CHART								
CYCLE	**SPLIT**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle 1 - 120 Seconds (AM)	26	52		42				
Cycle 2 - 120 Seconds (PM)	26	48		46				

TIME OF DAY PLAN	
TIME	**CYCLE**
06:00 - 12:00	1
12:00 - 22:00	2
22:00 - 06:00	FREE (MAX I)

CYCLE	**OFFSET***
Cycle 1 - 120 Seconds (AM)	67
Cycle 2 - 120 Seconds (PM)	0

* Ref. End of Broadway Green Interval.

CONTROLLER TIMING CHART								
LOCAL PROGRAMMING	**PHASE**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Minimum Green		20		10		20		10
Extension		3		3		3		3
Yellow Clearance		4		4		4		4
All Red Clearance		1		1		1		1
Max. Green I		32		18		32		18
Max. Green II		32		18		32		18
Walk		7		7		7		7
Flashing Don't Walk		10		10		10		10
Recall		MAX		MIN		MAX		MIN
Memory		-		-		-		-

COORDINATION DATA CHART								
CYCLE	**SPLIT**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle 1 - 120 Seconds (AM)		37		23		37		23
Cycle 2 - 120 Seconds (PM)		37		23		37		23

TIME OF DAY PLAN	
TIME	**CYCLE**
06:00 - 12:00	1
12:00 - 22:00	2
22:00 - 06:00	FREE (MAX I)

CYCLE	**OFFSET***
Cycle 1 - 120 Seconds (AM)	0
Cycle 2 - 120 Seconds (PM)	40

* Ref. End of Broadway Green Interval.

CONTROLLER TIMING CHART								
LOCAL PROGRAMMING	**PHASE**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Minimum Green		20		10		20		
Extension		3		3		3		
Yellow Clearance		4		4		4		
All Red Clearance		1		1		1		
Max. Green I		30		20		30		
Max. Green II		30		20		30		
Walk		7		7		7		
Flashing Don't Walk		10		12		10		
Recall		MAX		MIN		MAX		
Memory		-		-		-		

COORDINATION DATA CHART								
CYCLE	**SPLIT**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle 1 - 120 Seconds (AM)		35		25		35		
Cycle 2 - 120 Seconds (PM)		35		25		35		

TIME OF DAY PLAN	
TIME	**CYCLE**
06:00 - 12:00	1
12:00 - 22:00	2
22:00 - 06:00	FREE (MAX I)

CYCLE	**OFFSET***
Cycle 1 - 120 Seconds (AM)	32
Cycle 2 - 120 Seconds (PM)	16

* Ref. End of Broadway Green Interval.

CONTROLLER TIMING CHART								
LOCAL PROGRAMMING	**PHASE**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Minimum Green		20		10		20		10
Extension		3		3		3		3
Yellow Clearance		4		4		4		4
All Red Clearance		1		1		1		1
Max. Green I		30		21		30		21
Max. Green II		30		21		30		21
Walk		7		7		7		7
Flashing Don't Walk		10		12		10		12
Recall		MAX		MIN		MAX		MIN
Memory		-		-		-		-

COORDINATION DATA CHART								
CYCLE	**SPLIT**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cycle 1 - 120 Seconds (AM)		34		26		34		26
Cycle 2 - 120 Seconds (PM)		35		25		35		25

TIME OF DAY PLAN	
TIME	**CYCLE**
06:00 - 12:00	1
12:00 - 22:00	2
22:00 - 06:00	FREE (MAX I)

CYCLE	**OFFSET***
Cycle 1 - 120 Seconds (AM)	32
Cycle 2 - 120 Seconds (PM)	16

* Ref. End of Broadway Green Interval.

GPI Greenman-Pedersen, Inc.

Engineering and Construction Services

Teamwork | Quality | Commitment