FY 2016 Local Safety & CMAQ Project Development
County Route 621

Pacific Ave (MP 4.06) to
Rio Grande Ave/New Jersey Route 47 (MP 5.30)

Wildwood Crest Boro and Wildwood City,
Cape May County, NJ

Final Report

Prepared for:
South Jersey Transportation Planning Organization

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Executive Summary

Traffic signal optimization has been shown to be a cost effective method to improve traffic operations by reducing vehicular delays, queuing, the number of vehicle stops, travel times, and emissions. There are two main project objectives: (1) provide signal optimization of the CR 621 corridor using existing signal equipment, and (2) identify the need for improvements (signal, pedestrian, etc) and analyze the potential operational benefits with the identified improvements. The approximately 1.25 mile corridor is comprised of 12 signalized intersections on an urban minor arterial.

Data collection occurred in July and August 2015 and included turning movement counts, travel time runs, automatic traffic recorder data, field inventory and field observations. Calibration of the existing conditions for the AM, PM, and SAT peak hours was completed using Synchro 8.

Optimization included Time-Of-Day (TOD) plan development, proposed network zones/partitioning, and signal timing changes to cycle length, splits and offsets. Optimization was completed using existing signal equipment and also with mitigation improvement measures to analyze the potential operational benefits from improvements such as sidestreet vehicle detection, pedestrian push buttons, and pedestrian signal heads.

The traffic analysis shows that conventional signal optimization without equipment upgrades will provide operational benefits when compared to the No Build condition, but optimization with equipment upgrades provided significant improvements to LOS, travel time, network delay and emissions results. The following results were determined when comparing the No Build and Optimized-Mitigation 1 conditions:

- Travel Time improved by 13-20%,
- Stops per Vehicle decreased by up to 35%,
- Overall Network Delay decreased by 13-33%, and
- Emissions (HC, CO, NOx) decreased by 4-15%.

The main reason for the substantial improvement is that the majority of the intersections function as pre-timed either because they do not have detection or because the detection is either disconnected or inoperable. Installation of image detection should be considered at each intersection as a means to optimize vehicular movements.

In addition to image detection, coordination needs to be provided and maintained. GPS clocks should be considered since that would allow for coordination without the difficulties experienced by a hard wired interconnect project. Also, pedestrian push buttons and countdown signal heads should be installed. Lastly, it was noted in the intersection assessment that many of the controllers were older and are considered obsolete and should be replaced.

In addition to evaluating the intersections along CR 621 for potential operational improvements through signal equipment upgrades, the intersections were reviewed for MUTCD/physical status and overall condition. A ranking system was established for each intersection and this intersection assessment provides a means for prioritizing intersections and sections of the corridor.

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1. Project Purpose

Traffic signal optimization has been shown to be a cost effective method to improve traffic operations by reducing vehicular delays, queuing, the number of vehicle stops, travel times, and emissions. These reductions help decrease the risk of crashes including fatalities and serious injuries along the route. Through the use of computerized traffic models, it is possible to quantify the potential improvement that optimized timings will have to these various measures of effectiveness (MOE's) for an existing signalized arterial or network. The improvement to these MOE's serve as the basis for optimization strategies with an emphasis on improving arterial travel time, reducing the number of stops, and reducing overall network-wide delay.

2. Project Objectives

There are two main project objectives: (1) provide signal optimization of the CR 629 corridor using existing signal equipment, and (2) identify the need for improvements (signal, pedestrian, etc) and analyze the potential operational benefits with the identified improvements.

3. Background

The County Route 621 corridor (south to north) begins at Pacific Avenue (MP 4.06) in Wildwood Crest Boro and terminates at Rio Grande Ave/NJ Route 47 (MP 5.30) in Wildwood City. The approximately 1.25 mile corridor is comprised of 12 signalized intersections on an urban minor arterial.

The CR 621 corridor cross-section within the project limits is variable. Proceeding from south to north, the corridor starts as a two-lane cross-section between New Jersey Ave and Pacific Ave, becomes a five-lane cross-section with left turn lanes from New Jersey Ave to Cresse Ave, and finishes up as a four-lane cross-section through NJ Route 47.

The posted speed limit is 25 mph through the entire corridor. County Route 621 generally parallels the shoreline through the study area, except at the south end of the project corridor, where it turns perpendicular to the beach between New Jersey Ave and Pacific Ave. The corridor provides access to the Wildwood Beach shore points and connects Wildwood to the Garden State Parkway via NJ Route 47.

The Route CR 621 corridor is mainly commercial development directly along the route with residences behind the businesses and hotels, accessing Route CR 621 at various signalized and un-signalized points throughout the project area. ***Figure 1*** shows a map of the project area.

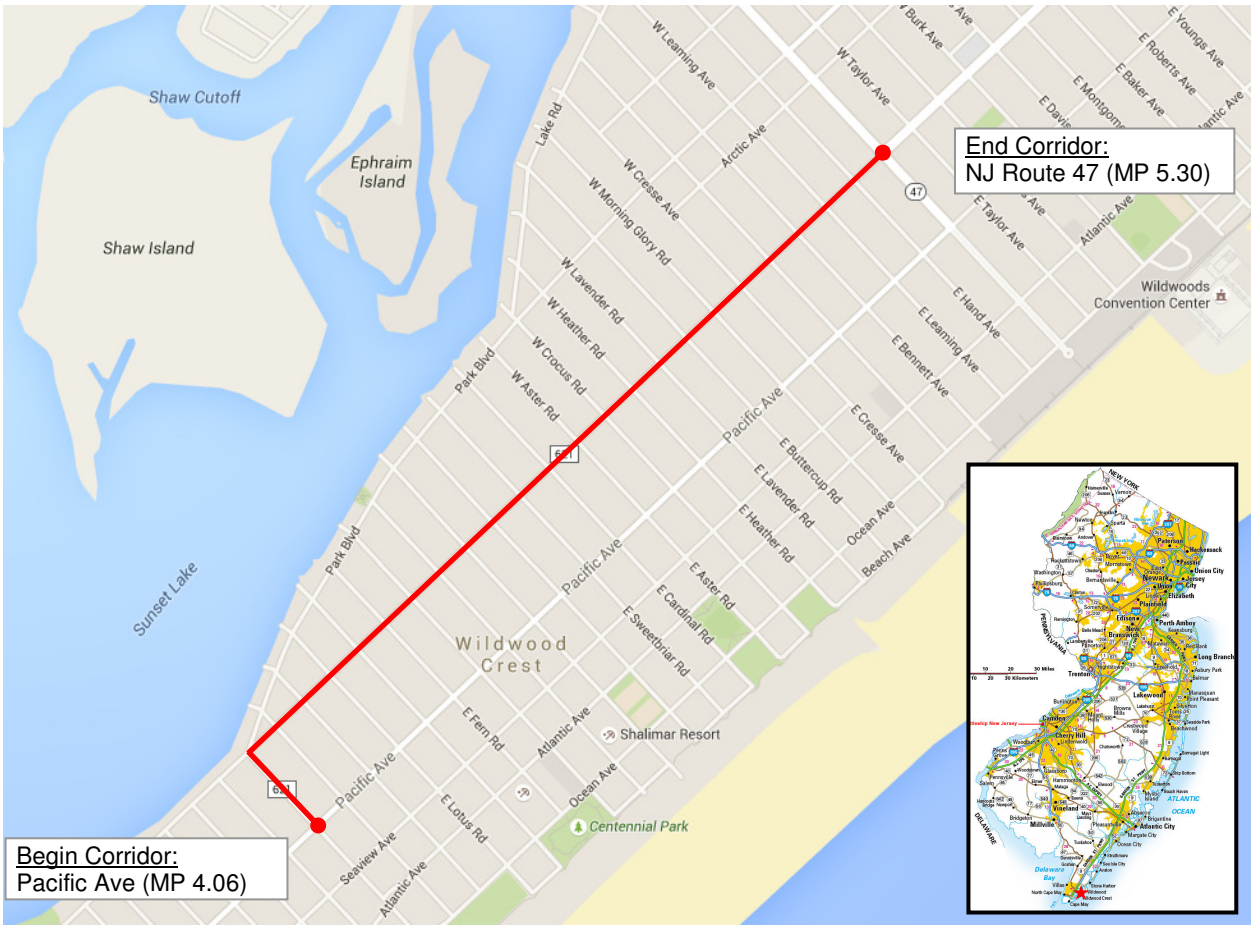


Figure 1: Map of the Project Area

4. Data Collection

The following data was collected during the data collection effort in July 2015:

- Turning movement counts (TMCs)
- GPS-Based Travel Time Data
- Automatic traffic recorders (ATRs)
- Field Inventory (including Red Line signal plans and timing directives)
- Field Observations

4.1. Turning Movement Counts

Table 1 shows the intersections that were counted for AM, PM, and Saturday peak periods, including count days and section peak hours.

Table 1: TMC Data Collection Intersections

Int ID	Intersecting Street	MP	Count Days	Peak Hours	
				Weekday	Weekend
1	Pacific Ave	4.06	Thursday, 7/16 & Saturday, 7/18	AM: 10:00 - 11:00 PM: 5:00 - 6:00	SAT: 11:45 - 12:45
2	Rambler Rd/Park Blvd	4.19			
3	Palm Rd	4.37			
4	Rosemary Rd	4.52			
5	Sweet Briar Rd	4.66			
6	Cardinal Rd	4.71			
7	Aster Rd	4.76			
8	Heather Rd	4.86			
9	Cresse Ave	5.05			SAT: 9:45 - 10:45
10	Hildreth Ave	5.10			
11	Hand Ave	5.25			
12	Rio Grande Ave/ RT 47	5.30			

Intersection ID numbers were assigned in accordance with the identification provided by SJTPO. The ID numbers begin at the southern end of the corridor. Count day sections and section peak zones were developed based on anticipated zones for signal coordination purposes.

Turning movement counts (TMC) included passenger cars, light trucks, heavy vehicles and pedestrians. The TMCs were conducted using cameras to collect video that could then be processed to generate count reports. Count periods included the following: AM peak (7:00-11:00 AM), PM (2:00-6:00 PM), and SAT (8:00 AM-4:00 PM), where the count periods were based on automatic traffic recorder (ATR) data from the NJDOT Traffic Monitoring System Program. Section peak hours were developed for the corridor and were based on intersection 15-minute counts that generated the largest total number of vehicles per section. ***Table 1*** shows the section peak hours.

Appendix A contains the TMC section peak hour analysis and volume figures for all three peak periods.

4.2. Travel Time Data

Travel time and delay studies were performed using the method of GPS-based unit and laptop enabled with Tru-Traffic software. This method provides output data that can be used during the Existing Conditions calibration process. The GPS based travel time runs provide detailed travel time and delay data between intersections which is critical during the calibration process.

Travel time and delay studies were performed on Thursday, July 16 and Saturday, July 18, 2015. A minimum of five travel time runs in both directions along CR 621 were completed. The software provides travel time and delay reports, speed-distance profiles and time-space trajectories graphs. The field collected travel time and delay study data along with a travel time summary table are included in ***Appendix A***.

The travel time results in ***Table 2*** are an average of all completed travel time runs. The travel time results indicate that the AM peak period is the lightest of the three study periods, with PM and Saturday peak periods having significantly higher travel times southbound and slightly higher travel times northbound. The PM peak period has the highest southbound travel times of the three study periods, while the Saturday peak period has the highest northbound travel times. Travel time and delay reports are included in ***Appendix A***.

Table 2: GPS-Based Travel Time Comparison by Peak

Direction		Travel Time (minutes)			
		Free Flow	**AM**	**PM**	**SAT**
Southbound	Travel Time	4.0	5.5	6.3	6.1
	% increase to FF	-	39%	59%	55%
Northbound	Travel Time	4.3	5.3	5.7	5.9
	% increase to FF	-	25%	34%	40%

Free flow speed is included in ***Table 2*** and is based on the fastest overall run performed during data collection. Travel time for each peak is compared to the free flow travel time and shown as a percent increase. Percent increases range from 25 to 59 percent with the larger increases during the PM and Saturday peak periods.

4.3. Automatic traffic recorders (ATRs)

In addition to providing daily traffic volumes, the ATR data is used to help identify the peak traffic hours and time-of-day plan hours. The ATRs were installed on Wednesday, July 15 and removed on Friday, July 17, 2015. ATRs were installed near the intersections of New Jersey Ave/Ramble Road and New Jersey Ave/Rio Grande Ave.

The average ATR data was graphed for each location, and ***Figure 2*** shows a sample ATR graph for ATR #1 near Ramble Road/Park Blvd. ***Appendix A*** contains applicable ATR data and ATR graphs for weekday daily volumes.

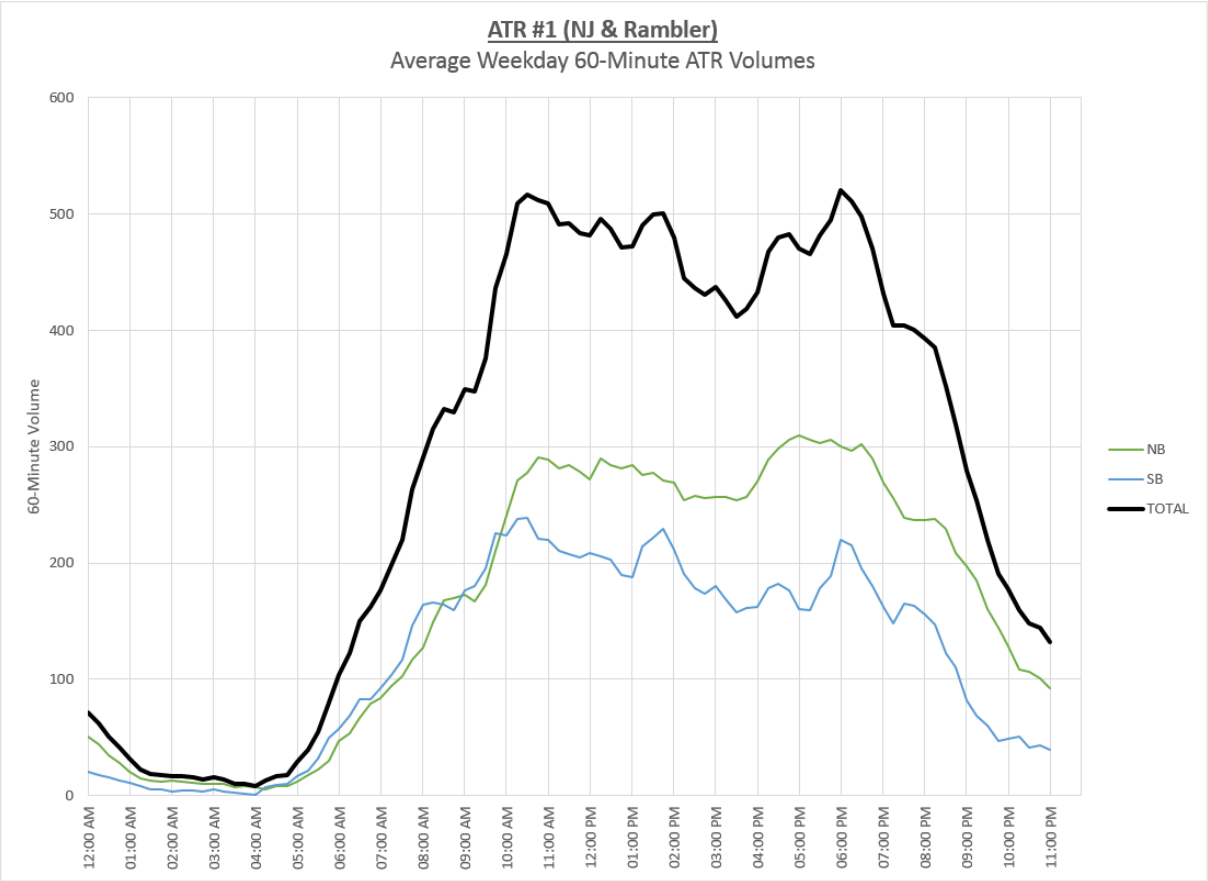


Figure 2: Example ATR Graph

4.4. Field Inventory

A field inventory was completed during July and August 2015 and included "Red Line" traffic signal plans and field signal timings at each intersection. Red Lining signal plans and field signal timings provide a mark-up of differences between what is on the provided plans/directives and what is actually in the field. Intersection sketches were developed for locations that did not have an existing signal plan and included the following intersections: Sweet Briar Road, Cardinal Road and Aster Road. ***Appendix B*** contains all applicable field inventory items.

A traffic signal equipment inventory and photo log was completed by Traffic Products at each intersection and included manufacturer information, condition and equipment options on items including controllers, cabinets, power panels, battery backups, pedestrian push buttons, signal interconnect, controller timing plans, and vehicle detection. Field signal equipment inventory sheets and photo logs for each intersection are included in ***Appendix B***.

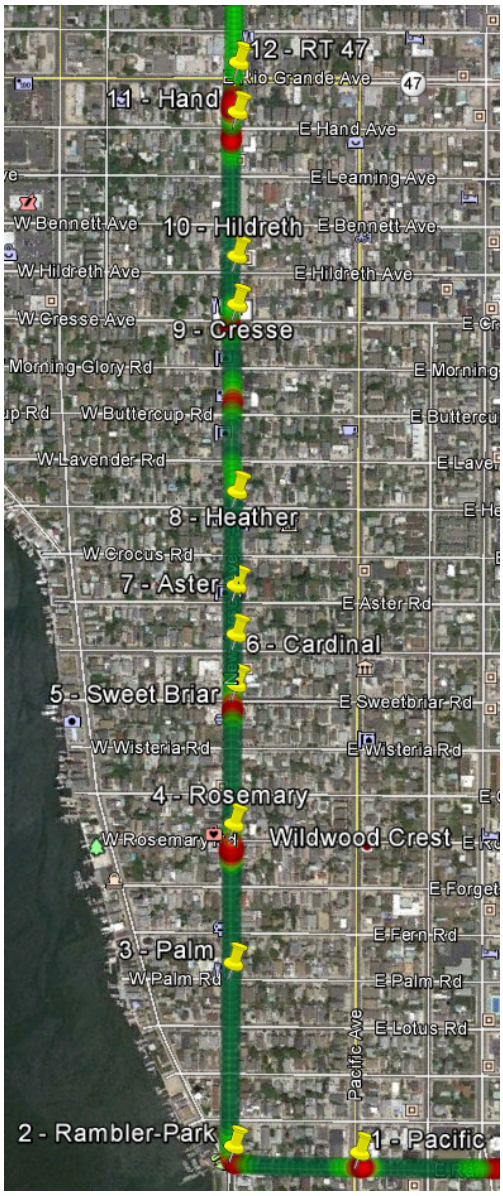
Additional intersection data, to be incorporated into a web-based interactive map, was collected by Rodriguez Consulting and included ramps, crosswalks, signal poles, mounted signs, mast arms, luminaires, signal controllers, and vehicle detection. The website for the web-based map including field inventory data is: http://arcg.is/1EFkBl2. GIS database schema and dictionary, database model diagram design, are other applicable information to the web-based map are included in ***Appendix B***.

4.5. Field Observations

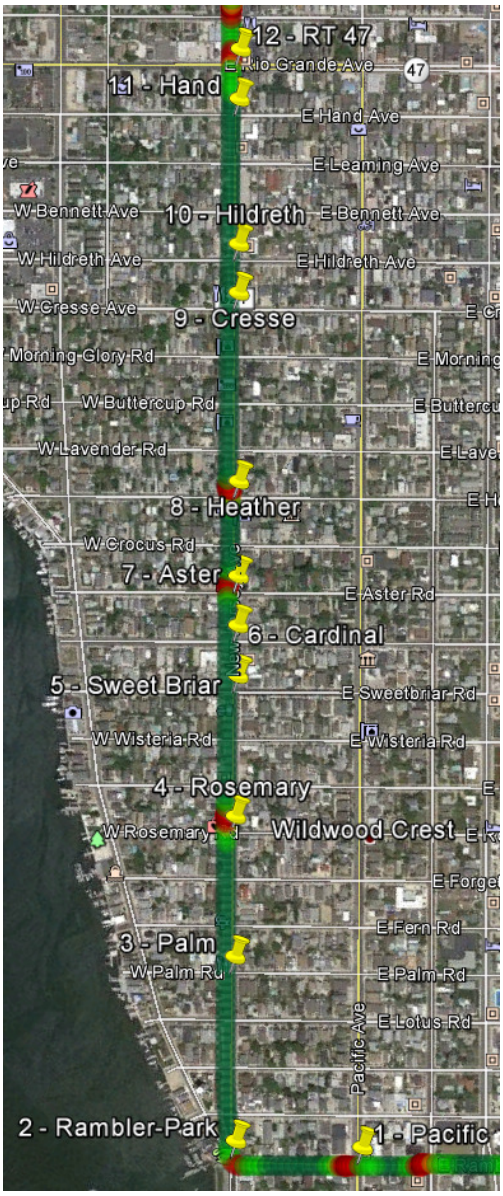
During the data collection effort general field observations were made throughout the study area. The following is a description of field conditions by peak period, and included in each period description is a screenshot of a GPS-based field travel time run converted to *.kmz file format and graphically shown in Google Earth.

AM Field Observations

In general the AM peak period was lighter than the PM and Saturday peak periods. There was no significant queuing along the corridor, though observations during the travel time runs indicated that pedestrians, bicyclists and pre-timed signals would impede vehicular travel.



AM Peak
NB Pacific Ave to NJ Rt 47

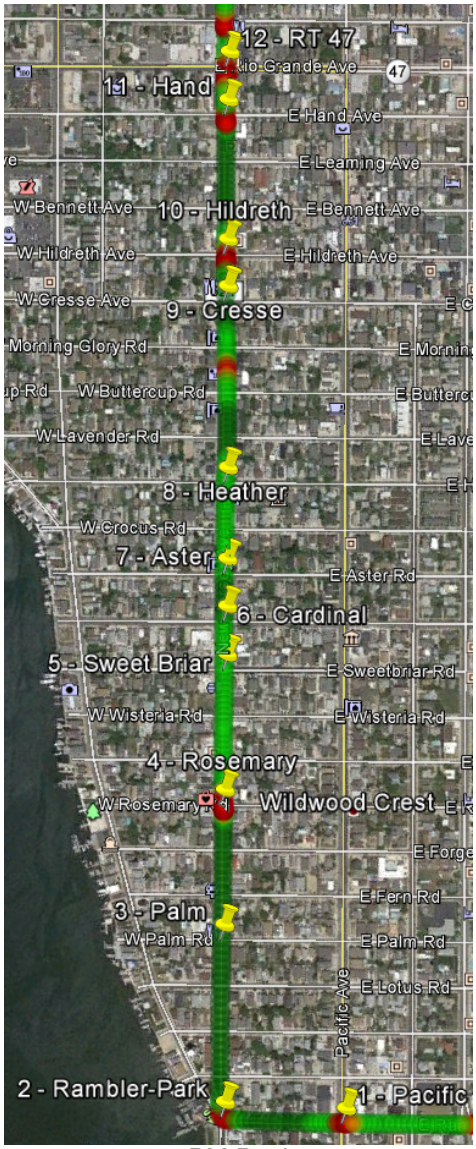


AM Peak
SB NJ Rt 47 to Pacific Ave

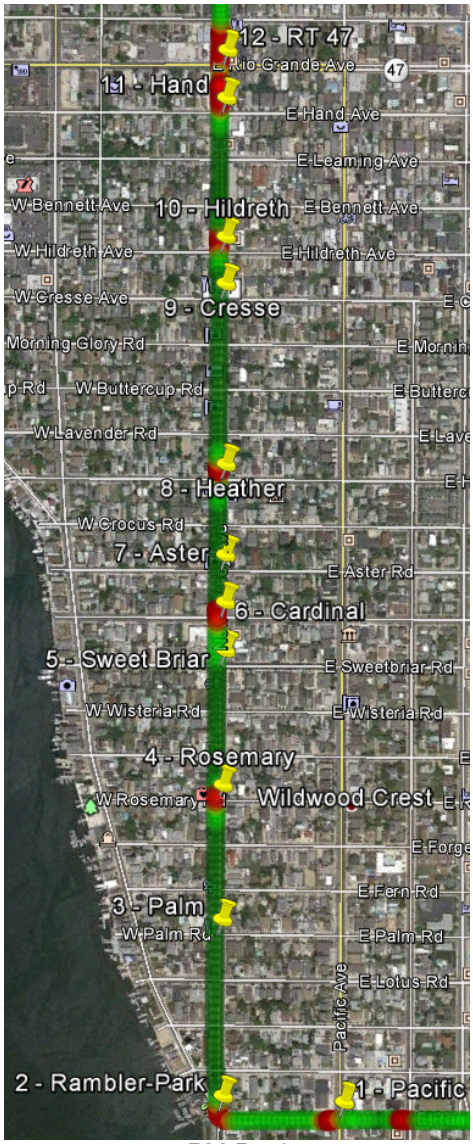
**See next page for description and legend for green, yellow, red "bubbles"*

PM Field Observations

In general the PM period had higher volumes than the AM peak and comparable to the SAT peak. There was minor queuing noted on New Jersey Ave near Rio Grande Ave/Route 47.



PM Peak
NB Pacific Ave to NJ Rt 47



PM Peak
SB NJ Rt 47 to Pacific Ave

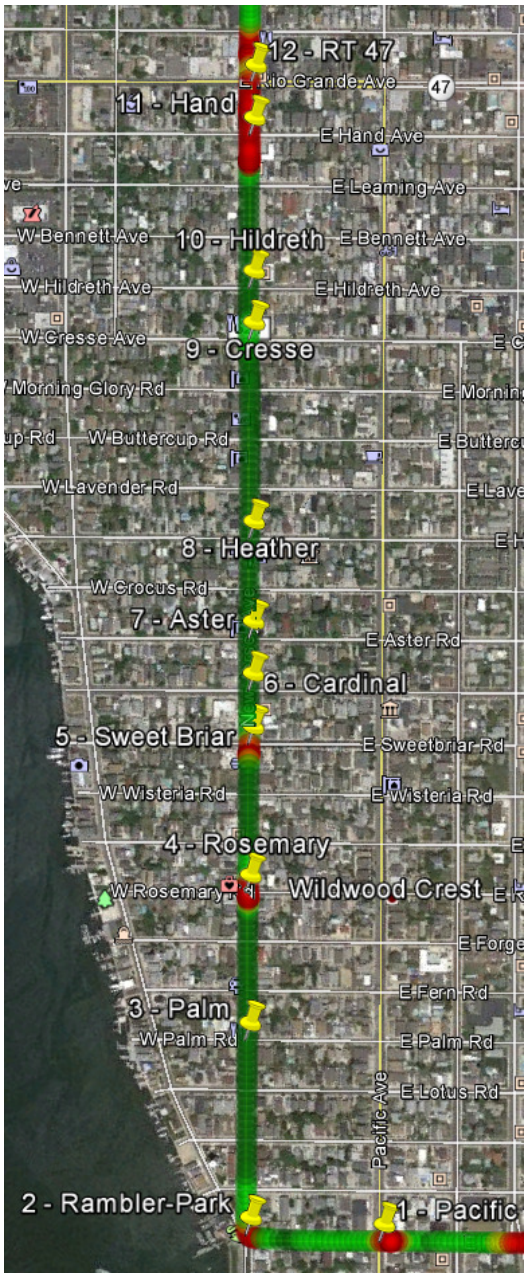
The following figures show Tru-Traffic GPS travel time runs within Google Earth with each colored "bubble" representing each second of the travel time run. Each bubble shows the travel time run name, type, peak period, date, time and speed. Bubble designations are shown on the right.

As Percentage of Posted Speed Limit

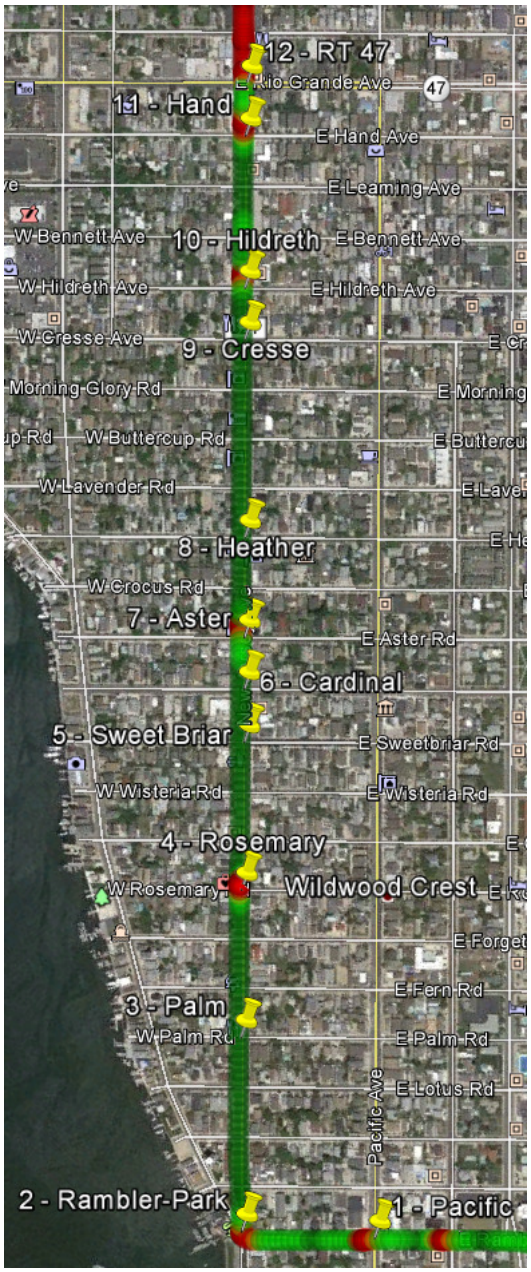
- *≥ 90%*
- *66 to 89%*
- *33 to 66%*
- *< 33 %*

Saturday Field Observations

The Saturday period had more volume on CR 621 as compared to the AM period, though it was still not significant. There was notable queuing on New Jersey Ave near Rio Grande Ave/Route 47. Field notes during the travel time runs indicated that queuing did not clear each cycle on New Jersey Ave southbound at Rio Grande Ave/NJ RT 47, which appeared to be due to poor coordination between the signals and significant pedestrian activity in the area.



SAT Peak
NB Pacific Ave to NJ Rt 47



SAT Peak
SB NJ Rt 47 to Pacific Ave

5. Existing Conditions Analysis

5.1. Existing Conditions Model Calibration

The operational analysis was performed utilizing Synchro 8 and its simulation component SimTraffic. The base Synchro model for each peak period is setup with proper input data including geometric information, signal phasing and timing, volume information, pedestrian timings, truck percentage and peak hour factors. The initial model provides output data including travel time, average delay per vehicle, and total network delay to facilitate the calibration process. Each of the three peak periods, AM, PM, and Saturday, were modeled using section peak hours as shown in ***Table 1***.

Calibration is an iterative process where differences between field and model data are identified and resolved based on further investigation of the field data. Specific model parameters have an impact and can generate a more realistic driver behavior including lane alignment through an intersection, turning speeds, lane change distances, headway factors and entering blocked intersections. Adjustment of these parameters helps bridge the gap between field and model data to enable model calibration.

Federal Highway Administrations' Guidelines for Applying Traffic Microsimulation Modeling Software are followed for calibration of models with the following key calibration targets:

- Travel Times, Model Versus Observed — Within 15% for > 85% of cases
- Vehicles Processed, Model Versus Observed — Within 5% for > 85% of cases
- Visual Audits — Visually Acceptable Queuing

Synchro base models for the three (3) peak periods were setup with the turning movement count (TMC) data from the November 2014 data collection effort.

5.2. Existing Conditions Results

Table 3 shows the travel time results comparing field travel time data and the Synchro output.

Table 3: Existing Conditions Travel Time Results

Travel Time Run	AM Peak Hour (minutes)			PM Peak Hour (minutes)		
	Field*	Model	△	Field*	Model	△
Southbound	4.9	5.6	14%	5.7	6.0	5%
Northbound	5.0	5.7	13%	5.1	5.7	12%
Travel Time Run	SAT Peak Hour (minutes)					
	Field*	Model	△			
Southbound	5.6	6.3	12%			
Northbound	5.4	6.0	11%			

* Values are based on a partial network from Pacific Ave (#1) to Rio Grande Ave/RT 47 (#12) to match up with the Synchro 8 travel time unit locations. These Field values will not match the complete runs from Table 2 in this report.

Table 3 results show that travel time runs are within 15% of field travel times, which is the FHWA calibration guideline for travel times. ***Table 4*** shows the Existing AM, PM, and Saturday peak hour Level of Service (LOS) and delay results for the CR 621 mainline approaches along the corridor.

Table 4: Existing Conditions Mainline Approach LOS and Delay Results

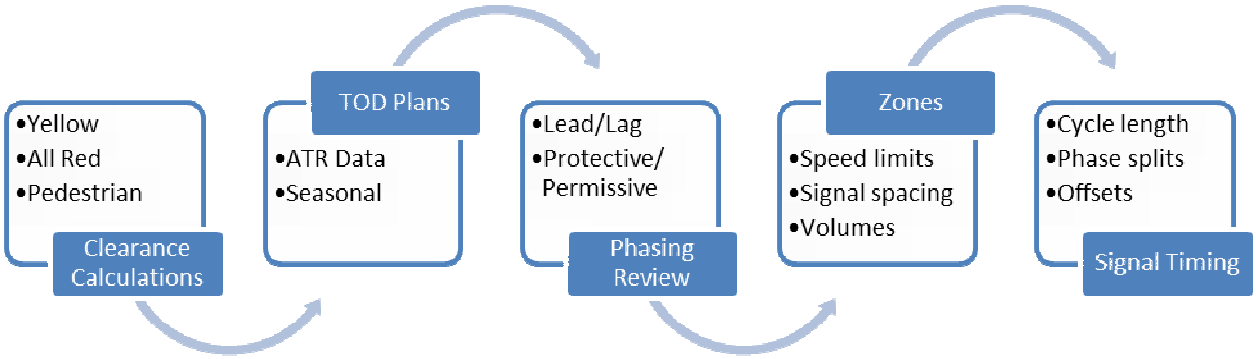
Int ID	Intersection	AM Peak Hour		PM Peak Hour		SAT Peak Hour	
		NB	SB	NB	SB	NB	SB
1	Pacific Ave (NB-EB)*	A (7)	B (15)	A (7)	B (16)	A (7)	B (15)
2	Park Blvd (WB-SB)*	C (34)	B (12)	C (33)	B (11)	A (9)	A (10)
3	Palm Rd	A (1)	A (1)	A (1)	A (1)	A (4)	A (4)
4	Rosemary Rd	A (8)	A (7)	A (8)	A (7)	A (8)	A (7)
5	Sweet Briar Rd	A (8)	A (3)	A (8)	A (4)	A (10)	A (4)
6	Cardinal Rd	A (4)	A (5)	A (4)	A (3)	A (5)	A (5)
7	Aster Rd	A (3)	A (8)	A (4)	A (8)	A (4)	A (9)
8	Heather Rd	A (8)	B (10)	A (8)	A (9)	A (7)	B (10)
9	Cresse Ave	A (9)	A (4)	A (10)	A (5)	B (13)	B (11)
10	Hildreth Ave	A (6)	A (5)	A (6)	A (5)	A (8)	A (5)
11	Hand Ave	A (7)	B (12)	A (8)	B (13)	B (10)	B (16)
12	NJ Route 47	C (22)	A (4)	C (26)	C (32)	C (25)	C (33)

*Corridor mainline "turns the corner" at the New Jersey Ave/Ramble Rd/Park Blvd intersection.

Table 6 results show that mainline approaches operate at LOS C or better in all of the peak hours. Complete results including all sidestreet approaches are located in ***Appendix C***.

6. Optimization

Traffic signal optimization is the process of collecting data, re-timing signals and developing timing directives for coordinated traffic signal systems to maximize efficiency, resulting in reduced vehicle stops, delays and travel times. The process for optimization is as follows:



6.1. Clearance Interval Calculations

Optimized Synchro models and any timing directives developed will include yellow change and red clearance intervals, and pedestrian intervals that conform to the 2009 Manual on Uniform Traffic Control Devices (MUTCD), the Institute of Transportation Engineers (ITE) "Traffic Control Devices Handbook", and "Manual of Traffic Signal Design" guidance. All calculations are included in ***Appendix D***.

6.2. Network Zones

The existing corridor does not contain coordination between signals. Urban analyzed the existing corridor to determine optimal zones for arterial platoon progression. Proposed zones are generally based on traffic volumes, traffic patterns, roadway characteristics, speed limits, signal spacing, Synchro's Partition Network optimization feature, and engineering judgment. For this project corridor, generally signal spacing and engineering judgement were utilized due to the low speed limits, and closely spaced intersections. The proposed zones are shown in ***Figure 3***.

Existing Zone	Int ID	Intersection	Speed Limit	MP	Distance to Downstream Int (mi)	Synchro Partition Network		Proposed Zone	
						Rarely	Sometimes	ID	Comments
None	1	Pacific Ave	25	4.06	0.13	A	A	*	*
	2	Rambler Rd/Park Blvd		4.19	0.18	A	A	A	
	3	Palm Rd		4.37	0.15	A	A		
	4	Rosemary Rd		4.52	0.14	A	A		
	5	Sweet Briar Rd		4.66	0.05	A	A		
	6	Cardinal Rd		4.71	0.05	A	A		
	7	Aster Rd		4.76	0.10	A	A		
	8	Heather Rd		4.86	0.19	A	A		See Below
	9	Cresse Ave		5.05	0.05	A	A	B	See Below
	10	Hildreth Ave		5.10	0.15	A	A		
	11	Hand Ave		5.25	0.05	A	A		
	12	Rio Grande Ave (NJ 47)		5.30	-	A	A		

Notes:

* Pacific Ave/Ramble Road is coordinated along Pacific Ave to the Rio Grande (RT 47)/Pacific Ave intersection

Reasons for Zones:

Cross-section changes from four to five lanes between Heather Rd and Cresse Ave
There is a significant volume change and peak hour between Heather Rd and Cresse Ave on Saturdays
As noted in TOD Schedule table, Zone A can have a lower cycle length than Zone B due to pedestrian minimums.

Figure 3: Proposed Zones

The first intersection *#1* Pacific Ave is coordinated along Pacific Ave; therefore, it is assumed no changes will be implemented at this intersection as the rest of the Pacific Ave corridor is not in the project area. Zone A begins at *#2* Ramble Rd/Park Blvd and terminates at *#9* Cresse Ave. The zone break between *#8* Heather Rd and *#9* Cresse Ave is due to the several reasons noted in ***Figure 3***.

6.3. Time-Of-Day Plans

The corridor signals generally run a pre-timed 70 second cycle all day. One exception to this is Palm Rd, which has a separate timing plan for when there is pedestrian actuation, and although the cycle length remains at 70 seconds, the splits are variable due to sidestreet detection. Another exception is at Rambler Rd/Park Blvd, which operates with sidestreet video detection and a variable cycle length.

Due to the generally low volumes and the mostly pre-timed signal operation, in order to provide coordination, the proposed cycle lengths were controlled by pedestrian minimum times. Selected TOD plans were developed as shown in ***Table 5***.

Table 5: Proposed Time-of-Day (TOD) Plans

Zone	Int.	Plan	Cycle (sec)	Time of Day	Day of Week	Description
*	1	All Times	70	-	-	Coord. along Pacific
A	2-8	All Times	65	-	-	
B	9-12	All Times	70	-	-	

It should be noted that the New Jersey Ave/Taylor Ave intersection is approximately 200 feet north of the New Jersey Ave/Rio Grande Ave intersection. If any proposed signal timings are implemented at Rio Grande Ave, a cooridnated plan with appropriate offsets should be developed and implemented at Taylor Ave due to the extremely close proximity of these two signalized intersections.

6.4. No Build Model

Prior to developing the optimized signal timings, a No Build modeled was created and analyzed for all three (3) peak hours. The No Build model includes any changes to clearance calculations and pedestrian intervals. The No Build results are compared to the Optimized results for an “apples to apples” comparison.

6.5. Signal Timings

Optimizing the signal timings for a corridor is a combination of cycle length, phase splits, and offsets.

Cycle Length

Optimal cycle length is determined for each zone and each TOD plan based on a combination of Synchro, pedestrian interval minimums and engineering judgement methodologies. Synchro’s cycle length optimization method incrementally analyzes cycle lengths using multiple performance measures including total vehicle delay, queue delay, stops per vehicle and other factors. Pedestrian interval minimums are utilized for this corridor due to the low traffic volumes, high pedestrian volumes, and pre-timed signal operations. ***Table 5*** shows the cycle length selected for each zone within the project corridor.

Phase Splits

After the cycle lengths are selected the next step is to determine appropriate phase splits for each intersection. This is an iterative process that compares existing Synchro results with proposed results in an effort to maximize arterial green time without significantly degrading sidestreet LOS. When a cycle length changes from existing (i.e., 90 to 80 seconds) the first step is to adjust splits to make the Optimized model approaches have a similar g/C (green time to cycle length) ratio compared to the Existing model. From this point adjustments are made based on intersection needs such as more times for sidestreet or mainline approaches, satisfying pedestrian minimums and adjusting splits for left turn movements. Generally, several iterations of

each model (for each TOD plan) are processed until there is an optimal balance of arterial and sidestreet LOS and average vehicular delay.

Offsets
After the phase splits for each intersection are determined, coordination offsets are developed using a combination of the Synchro programs 'Network Offset' optimization feature and engineering judgement. Determining the optimal offset is an iterative processing comparing optimized offsets Synchro and visually verifying the offsets in the SimTraffic program, Synchro's microscopic simulation companion program.

6.6. Optimization Results

The first step in the optimization process for this project is to optimize signal timings without any mitigation improvements such as sidestreet vehicular detection or pedestrian push buttons. The existing signal equipment and time-based coordination between intersections are assumed for this section of optimization results.

The same methodology from the Existing Conditions analysis was used for the Optimized analysis, including operational analysis of measures of effectiveness such as LOS and average vehicle delay, travel time, and network-wide impacts. ***Table 6*** shows a comparison of travel time results from Synchro between No Build Conditions and Optimized for the three peak models analyzed.

Table 6: No Build Conditions and Optimized Travel Time Results

Travel Time Run	AM Peak Hour (minutes)			PM Peak Hour (minutes)		
	No Build	Optimized	△	No Build	Optimized	△
Southbound	5.8	5.5	-5%	6.2	5.6	-10%
Northbound	5.7	5.2	-9%	5.7	5.3	-8%
Travel Time Run	SAT Peak Hour (minutes)					
	No Build	Optimized	△			
Southbound	6.5	5.4	-16%			
Northbound	5.9	5.4	-9%			

Table 6 shows 5-16% decrease in travel time for all three time periods. Complete LOS results are included in ***Appendix E***.

In addition to travel time and LOS results, network measures of effectiveness (MOE) such as stops per vehicle, total delay, fuel efficiency, and emissions were also determined. ***Tables 7 and 8*** shows the network-wide and emission MOE comparison between No-Build and Optimized conditions for all three peaks analyzed in Synchro.

Table 7: No-Build Conditions and Optimized Network-Wide MOE									
Peak Hour	Stops/Vehicle			Total Network Delay (hr)			Fuel Efficiency (mpg)		
	No-Build	Opt.	△	No-Build	Opt.	△	No-Build	Opt.	△
AM	0.47	0.42	-11%	24	22	-8%	13.4	14.0	4%
PM	0.48	0.42	-13%	30	25	-17%	12.8	13.6	6%
SAT	0.49	0.40	-18%	48	37	-23%	12.4	13.7	10%

Table 7 shows significant network-wide improvements including up to an 18 percent reduction in stops per vehicle, 8 to 23 percent reduction in overall network delay, and 4 to 10 percent improvement in fuel efficiency.

Table 8: No-Build Conditions and Optimized Network-Wide Emissions									
Peak Hour	HC (g)			CO (g)			NOx (g)		
	No-Build	Opt.	△	No-Build	Opt.	△	No-Build	Opt.	△
AM	1,350	1,290	-4%	5,810	5,570	-4%	1,130	1,080	-4%
PM	1,470	1,380	-6%	6,350	5,960	-6%	1,240	1,160	-6%
SAT	2,210	2,010	-9%	9,540	8,670	-9%	1,860	1,690	-9%

Network-wide emissions results from the Synchro models are shown in ***Table 8***. The emissions results show network-wide improvements of 4-9% in Hydrocarbons (HC), Carbon Monoxide (CO), and Nitrogen Oxide (NOx) when comparing the No Build and Optimized conditions.

6.7. Optimization-Mitigation 1 Results

A part of the second project objective is to optimize signal timings with assumed signal equipment upgrades to quantify the benefits these upgrades will provide to LOS, travel time, network delay and emissions. The signal equipment upgrades at most intersections included detection for all non-mainline (i.e., New Jersey Avenue) movements, pedestrian push buttons and countdown signal heads, and GPS clocks for signal coordination. These improvements and subsequent signal timing optimization discussion and results are denoted as “Mitigation 1” or “Mit 1.”

The same methodology from the Existing Conditions analysis was used for the Optimized analysis, including operational analysis of measures of effectiveness such as LOS and average vehicle delay, travel time, and network-wide impacts. ***Table 9*** shows a comparison of travel time results from Synchro between No Build Conditions and Optimized-Mitigation 1 for the three peak models analyzed.

Table 9: No Build Conditions and Optimized-Mitigation 1 Travel Time Results						
Travel Time Run	AM Peak Hour (minutes)			PM Peak Hour (minutes)		
	No Build	Opt-Mit 1	△	No Build	Opt-Mit 1	△
Southbound	5.8	5.0	-13%	6.2	4.9	-20%
Northbound	5.7	4.9	-13%	5.7	4.9	-14%
Travel Time Run	SAT Peak Hour (minutes)					
	No Build	Opt-Mit 1	△			
Southbound	6.5	5.3	-19%			
Northbound	5.9	5.0	-17%			

Table 9 shows 13-20% decrease in travel time for all three time periods. The 13-20% improvement with the addition of equipment upgrades for Mit-1 compares to only 5-16% improvement with optimization alone. Complete LOS results are included in ***Appendix E***.

In addition to travel time and LOS results, network measures of effectiveness (MOE) such as stops per vehicle, total delay, fuel efficiency, and emissions were also determined. ***Tables 10 and 11*** shows the network-wide and emission MOE comparison between No-Build and Optimized conditions for all three peaks analyzed in Synchro.

Table 10: No-Build Conditions and Optimized-Mitigation 1 Network-Wide MOE									
Peak Hour	Stops/Vehicle			Total Network Delay (hr)			Fuel Efficiency (mpg)		
	No-Build	Opt-Mit 1	△	No-Build	Opt-Mit 1	△	No-Build	Opt-Mit 1	△
AM	0.47	0.38	-19%	24	21	-13%	13.4	14.4	7%
PM	0.48	0.35	-27%	30	22	-27%	12.8	14.4	13%
SAT	0.49	0.32	-35%	48	32	-33%	12.4	14.6	18%

Table 10 shows significant network-wide improvements including up to a 35 percent reduction in stops per vehicle, 13 to 33 percent reduction in overall network delay, and 7 to 18 percent improvement in fuel efficiency. The addition of equipment upgrades for Mit-1 provided significant improvements in network-wide results compared to the optimized results.

Table 11: No-Build Conditions and Optimized-Mitigation 1 Emissions									
Peak Hour	HC (g)			CO (g)			NOx (g)		
	No-Build	Opt-Mit 1	△	No-Build	Opt-Mit 1	△	No-Build	Opt-Mit 1	△
AM	1,350	1,300	-4%	5,810	5,590	-4%	1,130	1,090	-4%
PM	1,470	1,340	-9%	6,350	5,790	-9%	1,240	1,130	-9%
SAT	2,210	1,880	-15%	9,540	8,110	-15%	1,860	1,580	-15%

Network-wide emissions results from the Synchro models are shown in ***Table 11***. The emissions results show network-wide improvements of 4-15% in Hydrocarbons (HC),

Carbon Monoxide (CO), and Nitrogen Oxide (NOx) when comparing the No Build and Optimized conditions. The 4-15% improvement with the addition of equipment upgrades for Mit-1 compares to only 4-9% improvement with optimization alone.

6.8. Optimization-Mitigation 2 Results

An additional scenario was tested including a road diet along New Jersey Ave from Rambler Road/Park Blvd to Heather Road which reduced the existing five lane cross-section down to a three lane cross-section. Complete Synchro 8 results for the SAT peak period, which has the highest traffic volumes, are included in ***Appendix E*** which show extremely minimum impact when comparing Mit 1 and Mit 2 results in the road diet section.

7. Implementation

This report section is pending based on whether the optimized timings are implemented.

8. Intersection Assessment

In addition to evaluating the intersections along CR 621 for potential operational improvements through signal equipment upgrades, the intersections were reviewed for MUTCD/physical status and overall condition. A ranking system was established for each intersection and the summary is included in ***Appendix F***. For the purpose of this exercise a score of 10 is considered the best and 1 is the lowest score. There is a summary for each intersection noting the deficiencies as well as the mitigation strategies employed.

Operational scores were based on intersection functionality including detection, timings/offsets, and coordination between closely spaced intersections, as well as a metric driven Synchro analysis.

MUTCD/Physical scores are based on field data and equipment including presence and condition of crosswalks, ramps, signal heads, controller, cabinet, and pedestrian features such as push buttons and pedestrian countdown signal heads.

The scores were adjusted based on pedestrian activity that was collected during the data collection effort at each location. For example, areas that had little to no pedestrian activity could benefit from some improvements (push buttons, pedestrian signals, etc.) but not as much as those in the downtown section of the corridor.

9. Conclusions and Recommendations

The traffic analysis shows that conventional signal optimization without equipment upgrades will provide operational benefits when compared to the No Build condition, but optimization with equipment upgrades provided significant improvements to LOS, travel

time, network delay and emissions results. The following results were determined when comparing the No Build and Optimized-Mitigation 1 conditions:

- Travel Time improved by 13-20%,
- Stops per Vehicle decreased by up to 35%,
- Overall Network Delay decreased by 13-33%, and
- Emissions (HC, CO, NOx) decreased by 4-15%.

The main reason for the substantial improvement is that the majority of the intersections function as pre-timed either because they do not have detection or because the detection is either disconnected or inoperable. Installation of image detection should be considered at each intersection as a means to optimize vehicular movements.

In addition to image detection, coordination needs to be provided and maintained. GPS clocks should be considered since that would allow for coordination without the difficulties experienced by a hard wired interconnect project. Also, pedestrian push buttons and countdown signal heads should be installed. Lastly, it was noted in the intersection assessment that many of the controllers were older and are considered obsolete and should be replaced.

The intersection assessment provides a means for prioritizing intersections and sections of the corridor.