Effectiveness Study

Gwinnett County Project No.: F-0781-01

Pleasant Hill Road DDI

Gwinnett County, Georgia

Prepared For:
Georgia Department of Transportation

W&A Project No. 12-718

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1. INTRODUCTION

PLEASANT HILL ROAD DDI EFFECTIVENESS STUDY

Wolverton & Associates, Inc. as a consultant, under contract with Midasco, recently completed a project to develop coordinated signal timing plans along Pleasant Hill Road in conjunction with the Diverging Diamond Interchange (DDI) project.

Improved signal timing and coordination in conjunction with a signalized intersection project offers one of the most cost-effective and quickly implementable ways to reduce congestion and improve traffic flow. Recognizing that, the Gwinnett County Department of Transportation (GCDOT) and the Gwinnett Place CID have commissioned this project to develop and implement improved signal timing plans at the Pleasant Hill Road DDI. Wolverton & Associates, Inc. (W&A) was selected by Midasco to develop new timing plans for the upgraded signals in this project.

This report compares the travel time and delay along Pleasant Hill Road for the four (4) signals associated with this project prior to and after implementation of the new signal timings. Reductions of delay and travel time are documented to quantify the magnitude of the improvement in service. A benefit/cost analysis was conducted to quantify the improvements of the new timing plans.

The four (4) intersections included in the project, seen in Table 1, are part of an existing forty-five (45) intersection area-wide signal system along Pleasant Hill Road, Club Drive, Satellite Boulevard and Steve Reynolds Boulevard. W&A currently maintains the integrity of the existing signal timings and time clock synchronization for all forty-five (45) signalized intersections for the Gwinnett Place CID and Gwinnett County DOT. Figure 1 shows the existing area-wide signal system highlighting the four (4) intersections included in the Pleasant Hill Road DDI. During implementation, and if necessary, adjustments were made upstream on Pleasant Hill Road to Satellite Boulevard, and downstream to Club Drive.

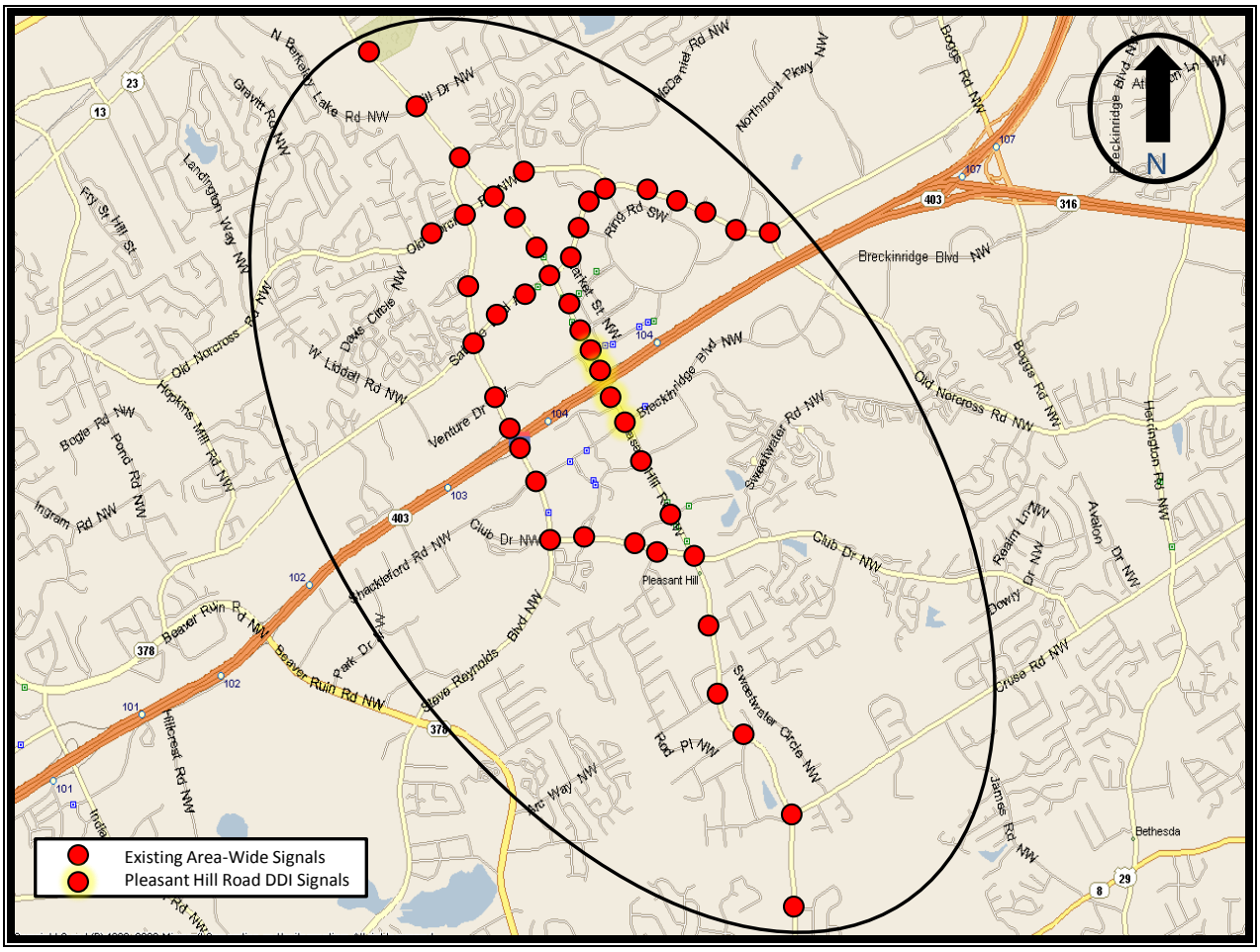
This Effectiveness Study is divided into the following sections:

1. Introduction
2. Before and After Study
3. Recommendations

Table 1 – Project Signalized Intersections

No.	Intersection	Maintaining Agency
1	Pleasant Hill Road @ Venture Drive	Gwinnett County
2	Pleasant Hill Road @ I-85 Southbound Ramp	Gwinnett County
3	Pleasant Hill Road @ I-85 Northbound Ramp	Gwinnett County
4	Pleasant Hill Road @ Shackleford Road/Breckenridge Blvd	Gwinnett County

Figure 1 – Project Vicinity Map



The existing Time of Day (TOD) schedule and cycle lengths for the forty-five (45) signal system were also applied to the Pleasant Hill Road DDI signals. This is so the traffic would flow to and from the DDI during any particular timing plan throughout the day. Splits were adjusted as needed for the DDI signals to accommodate the unique movements.

2. BEFORE AND AFTER STUDY

PLEASANT HILL ROAD DDI EFFECTIVENESS STUDY

In order to determine the effectiveness of the new signal timing plans, travel time studies were conducted on Pleasant Hill Road between Club Drive and Satellite Boulevard, to evaluate and document the results of the timing plan development and the process of fine-tuning. This section presents the results of the "before" and "after" studies that were conducted. The travel time studies, utilizing the *GeoStats*, were conducted by W&A staff on typical weekdays during the AM, MD, and PM peak time periods of the day. All field studies were conducted on non-holiday weekdays, in order to observe typical, repeatable traffic patterns. The "before" studies were conducted on November 29, 2012 and the "after" studies were conducted on August 20, 2013. The AM Peak studies were conducted between 7:00 a.m. and 9:00 a.m., Mid-Day Peak studies were conducted between 11:00 a.m. and 1:00 p.m., and PM Peak studies were conducted between 4:00 p.m. and 6:00 p.m.

Travel Time and Delay Studies

Table 2 shows a summarization of the "before" and "after" travel time study data for the northbound direction on Pleasant Hill Road through the DDI during the two-hour AM Peak Period. A comparison of the AM Peak Period "before" and "after" study results shows that after implementation of the new signal timings, average travel time increased 51.4 seconds (21%), average trip running speed decreased 3.4 mph (17%), average delay at intersections increased 42.6 seconds (39%) and the average number of stops increased 0.5 (24%). The reason for the decline in results is largely due in part to the signal timings necessary to accommodate the southbound right-turn traffic off of I-85 on to Pleasant Hill Road as it relates to the upstream signals. After discussions with Gwinnet County DOT and GDOT, it was requested the southbound right-turn ramp split time be increased to reduce the queue lengths on the southbound I-85 off ramp. Therefore, the Pleasant Hill Road northbound split was reduced, thus increasing delay and travel time. Before construction of the DDI, the southbound right turn movement was free flowing, but now is signalized with a right turn on red restriction. This intersection is operating optimally; however, not necessarily favorable for the travel run during the AM Peak in the northbound direction.

Table 2 – AM Peak Period
Pleasant Hill Road DDI – Northbound
Speed and Delay Study Results

	Pleasant Hill DDI AM (NB)		
	Before	**After**	**% Improvement**
Travel Time (sec.)	243.0	293.4	-21%
Trip Speed (mph)	20.3	16.9	-17%
Total Delay (sec.)	108.6	151.2	-39%
Number of Stops	2.1	2.6	-24%

Table 3 shows a summarization of the "before" and "after" travel time study data for the northbound direction on Pleasant Hill Road through the DDI during the two-hour MD Peak Period. A comparison of the MD Peak Period "before" and "after" study results shows that after implementation of the new signal timings at the DDI, average travel time decreased 85.2 seconds (28%), average trip running speed increased 6.2 mph (39%), average delay at intersections decreased 78.6 seconds (48%) and the average number of stops decreased 1.6 (59%).

Table 3 – MD Peak Period
Pleasant Hill Road DDI – Northbound
Speed and Delay Study Results

	Pleasant Hill DDI MD (NB)		
	Before	**After**	**% Improvement**
Travel Time (sec.)	307.2	222.0	28%
Trip Speed (mph)	16.2	22.4	39%
Total Delay (sec.)	163.2	84.6	48%
Number of Stops	2.7	1.1	59%

Table 4 shows a summarization of the "before" and "after" travel time study data for the northbound direction on Pleasant Hill Road through the DDI during the two-hour PM Peak Period. A comparison of the PM Peak Period "before" and "after" study results shows that after implementation of the new signal timings at the DDI, average travel time decreased 36.6 seconds (10%), average trip running speed increased 1.2 mph (12%), average delay at intersections decreased 37.2 seconds (17%) and the average number of stops decreased 2.0 (48%).

Table 4 – PM Peak Period
Pleasant Hill Road DDI – Northbound
Speed and Delay Study Results

	Pleasant Hill DDI PM (NB)		
	Before	**After**	**% Improvement**
Travel Time (sec.)	349.2	312.6	10%
Trip Speed (mph)	14.2	15.9	12%
Total Delay (sec.)	216.6	179.4	17%
Number of Stops	4.3	2.3	48%

Table 5 shows a summarization of the "before" and "after" travel time study data for the southbound direction on Pleasant Hill Road through the DDI during the two-hour AM Peak Period. A comparison of the AM Peak Period "before" and "after" study results shows that after implementation of the new signal timings at the DDI, average travel time decreased 55.8 seconds (15%), average trip running speed increased 2.5 mph (18%), average delay at intersections decreased 52.2 seconds (21%) and the average number of stops decreased 0.7 (18%).

Table 5 – AM Peak Period
Pleasant Hill Road DDI – Southbound
Speed and Delay Study Results

	Pleasant Hill DDI AM (SB)		
	Before	**After**	**% Improvement**
Travel Time (sec.)	375.0	319.2	15%
Trip Speed (mph)	13.2	15.7	18%
Total Delay (sec.)	245.4	193.2	21%
Number of Stops	3.7	3.0	18%

Table 6 shows a summarization of the "before" and "after" travel time study data for the southbound direction on Pleasant Hill Road through the DDI during the two-hour MD Peak Period. A comparison of the MD Peak Period "before" and "after" study results shows that after implementation of the new signal timings at the DDI, average travel time decreased 16.8 seconds (7%), average trip running speed increased 1.7 mph (8%), average delay at intersections decreased 9.6 seconds (10%) and the average number of stops increased 0.3 (21%).

Table 6 – MD Peak Period
Pleasant Hill Road DDI – Southbound
Speed and Delay Study Results

	Pleasant Hill DDI MD (SB)		
	Before	**After**	**% Improvement**
Travel Time (sec.)	240.6	223.8	7%
Trip Speed (mph)	20.5	22.2	8%
Total Delay (sec.)	100.2	90.6	10%
Number of Stops	1.6	1.9	-18%

Table 7 shows a summarization of the "before" and "after" travel time study data for the southbound direction on Pleasant Hill Road through the DDI during the two-hour PM Peak Period. A comparison of the PM Peak Period "before" and "after" study results shows that after implementation of the new signal timings at the DDI, average travel time decreased 19.2 seconds (6%), average trip running speed increased 1.1 mph (7%), average delay at intersections decreased 15.6 seconds (8%) and the average number of stops increased 0.5 (17%).

Table 7 – PM Peak Period
Pleasant Hill Road DDI – Southbound
Speed and Delay Study Results

	Pleasant Hill DDI PM (SB)		
	Before	**After**	**% Improvement**
Travel Time (sec.)	322.2	303.0	6%
Trip Speed (mph)	15.3	16.4	7%
Total Delay (sec.)	183.6	168.0	8%
Number of Stops	3.1	2.6	17%

Environmental Pollution Emissions

Atmospheric pollutants are emitted from vehicles when they are stopped or idling. Carbon monoxide, oxides of nitrogen, and volatile oxygen compounds (hydrocarbons) are three types of vehicle emissions that are regulated by federal law. New signal timing can reduce these pollutants by reducing the number of stops vehicles make and having vehicles travel at a constant speed. The following summary shows a comparison of the "before" and "after" emissions for both directions for this project.

Table 8 is comprised of the northbound and southbound directions along Pleasant Hill Road during the AM Peak Period emission study data. Comparing the AM Peak "before" and "after" study results reveals that implementation of the new signal timings for the Pleasant Hill Road DDI resulted in a 10% increase in carbon monoxide, 10% increase in oxides of nitrogen and a 11% increase in volatile oxygen.

Table 8 – AM Peak Period Emissions
Pleasant Hill Road DDI
Environmental Pollution Emissions

	Pleasant Hill DDI (AM)		
	Before	**After**	**% Improvement**
CO Emissions (kg/hr)	11.7932	12.9883	-10%
NOx Emissions (kg/hr)	1.4645	1.6120	-10%
VOC Emissions (kg/hr)	2.0446	2.2746	-11%

Table 9 is comprised of the northbound and southbound directions along Pleasant Hill Road during the MD Peak Period emission study data. Comparing the MD Peak "before" and "after" study results reveals that implementation of the new signal timings for the Pleasant Hill Road DDI resulted in a 24% reduction in carbon monoxide, 22% reduction in oxides of nitrogen and a 28% reduction in volatile oxygen.

Table 9 – MD Peak Period Emissions
Pleasant Hill Road DDI
Environmental Pollution Emissions

	Pleasant Hill DDI (MD)		
	Before	**After**	**% Improvement**
CO Emissions (kg/hr)	6.8996	5.2484	24%
NOx Emissions (kg/hr)	0.8688	0.6788	22%
VOC Emissions (kg/hr)	1.1861	0.8579	28%

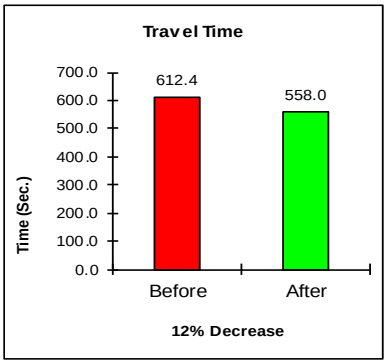
Table 10 is comprised of the northbound and southbound directions along Pleasant Hill Road during the PM Peak Period emission study data. Comparing the PM Peak "before" and "after" study results reveals that implementation of the new timing plans for the Pleasant Hill Road DDI resulted in a 7% reduction in carbon monoxide, 8% reduction in oxides of nitrogen and a 6% reduction in volatile oxygen.

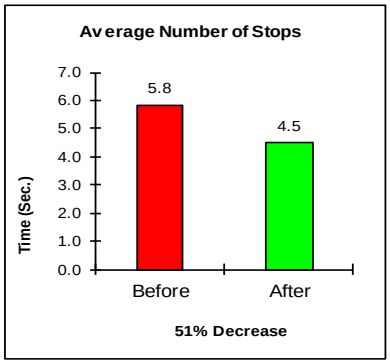
Table 10 – PM Peak Period Emissions
Pleasant Hill Road DDI
Environmental Pollution Emissions

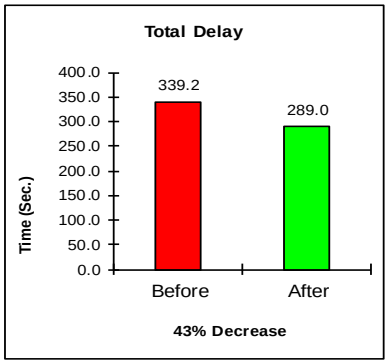
	Pleasant Hill DDI (PM)		
	Before	**After**	**% Improvement**
CO Emissions (kg/hr)	17.4811	16.3135	7%
NOx Emissions (kg/hr)	2.1465	1.9761	8%
VOC Emissions (kg/hr)	3.1098	2.9119	6%

Before and After Study Summary

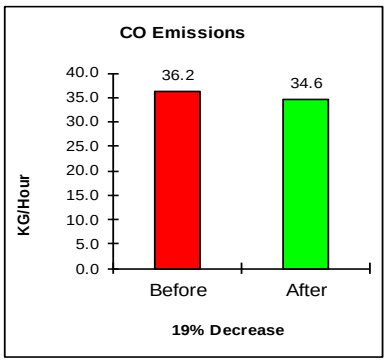
The following summary shows a comparison of the "before" and "after" average trip speed, travel time, number of stops, and delay recorded for the study. Details of each travel time run are shown in the Appendix. The following charts show the improvements for both directions of travel during all three (3) time periods:

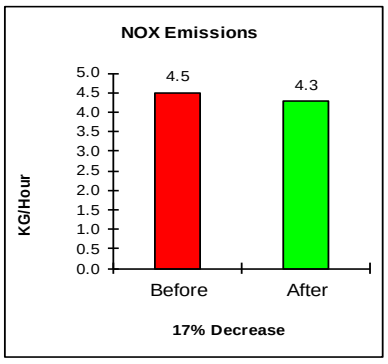


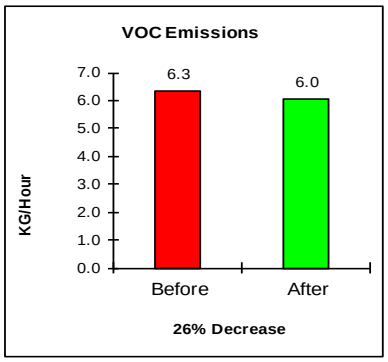




Carbon monoxide, oxides of nitrogen and hydrocarbon compounds are three (3) types of vehicle emissions that are regulated by Federal law. The following charts show the change in vehicle emissions for both directions combined during the weekday AM, MD and PM Peak Periods:







Delay incurs direct costs upon motorists in the form of increased fuel consumption and the value of their time wasted while waiting in traffic. Motorists using the signal system during the three (3) peak periods will save 15,600 hours and 9,360 gallons of gasoline each year because of improved traffic flow due to the new timing plans. Conservatively assuming a vehicle occupancy rate of 1.2, $12.00 per hour for the value of motorist's time and $3.50 per gallon for gasoline, annual savings to motorists in the signal system will be $224,640 in the form of reduced delay and $32,760 due to reduced fuel consumption, for a total annual savings of $257,400.

Benefit/Cost Analysis

An analysis of the benefit/cost ratio is an important measure of the effectiveness of a project. It provides a method of comparing the project cost to the benefits received by the motoring public. A benefit/cost ratio was obtained for the Pleasant Hill DDI by dividing the annual benefit to motorists (in the form of reduced delay and fuel consumption) by the equivalent annual project cost. A ratio value of 1 or greater indicates that annual benefits equal or exceed annual costs.

The annual benefit to motorists, in the form of reduced delay and fuel consumption, for the Pleasant Hill DDI is $257,400. The equivalent annual cost of developing and implementing timing plans for the four (4) signals ranged from $13,706 at 4 percent interest to $14,497 at 8 percent interest. Table 11 illustrates the benefit/cost ratios at interest rates of 4 percent to 8 percent.

Table 11
Pleasant Hill DDI
Benefit/Cost Analysis

Rate	Annual Cost	Delay	Consumption	Savings	Ratio
4%	$13,706	$224,640	$32,760	$257,400	18.8
5%	$13,902	$224,640	$32,760	$257,400	18.5
6%	$14,099	$224,640	$32,760	$257,400	18.3
7%	$14,298	$224,640	$32,760	$257,400	18.0
8%	$14,497	$224,640	$32,760	$257,400	17.8

The improved timing plans for the Pleasant Hill Road DDI has benefit/cost ratios ranging from 18.8 to 1 to 17.8 to 1. Expressed in another way, the new timing plans for the Pleasant Hill Road DDI pays for itself every 3 weeks. Other non-cost benefits include lower driver frustration levels on Pleasant Hill Road and potentially, a reduction of accidents. All of the improvements mentioned in the report are for the six hours of weekdays during the AM, MD, and PM Peak periods.

New signal timing plans were also implemented during the off-peak hours and on weekends. The improved signal timing during these times is significant. Unfortunately, the "before" and "after" studies were not conducted during the off-peak time periods, so additional savings could not be quantified for these periods.

3. RECOMMENDATIONS

PLEASANT HILL ROAD DDI EFFECTIVENESS STUDY

Wolverton & Associates recommends that all (45) signals be re-timed to incorporate the DDI in with the entire area wide system; however this has recently taken place under the Metro Signal Timing project. It is also recommended that dual coordination be utilized at both DDI signals so that both main street pedestrian signal indications illuminate during the vehicular phase. Also, it is recommended that ramp meters be turned off so that traffic from the on-ramps does not queue onto Pleasant Hill Road during the Peak Periods.

APPENDIX

TRAVEL RUN DATA

Pleasant Hill DDI Trave Run Route

Scenario	Time Period	Route	Compass Direction	Avg Speed	Avg Travel Time	Avg # Stops	Avg Congested Time	VOC	CO	NOX
After Runs	AM	Pleasant Hill Road (SB)	SE	15.67	5.32	3	3.22	0.43915	2.41846	0.28591
After Runs	AM	Pleasant Hill Road (NB)	NW	16.93	4.89	2.62	2.52	0.33664	1.95012	0.24649
After Runs	MD	Pleasant Hill Road (SB)	SE	22.19	3.73	1.9	1.51	0.22882	1.39675	0.18022
After Runs	MD	Pleasant Hill Road (NB)	NW	22.41	3.7	1.1	1.41	0.2227	1.36557	0.17704
After Runs	PM	Pleasant Hill Road (SB)	SE	16.39	5.05	2.6	2.8	0.3733	2.11755	0.2609
After Runs	PM	Pleasant Hill Road (NB)	NW	15.9	5.21	2.25	2.99	0.42865	2.35592	0.27773
Before Runs	AM	Pleasant Hill Road (SB)	SE	13.24	6.25	3.67	4.09	0.58134	3.08726	0.35036
Before Runs	AM	Pleasant Hill Road (NB)	NW	20.29	4.05	2.11	1.81	0.24429	1.49215	0.19562
Before Runs	MD	Pleasant Hill Road (SB)	SE	20.48	4.01	1.57	1.67	0.24786	1.4976	0.19396
Before Runs	MD	Pleasant Hill Road (NB)	NW	16.17	5.12	2.71	2.72	0.37639	2.13379	0.26328
Before Runs	PM	Pleasant Hill Road (SB)	SE	15.31	5.37	3.14	3.06	0.39175	2.22826	0.27748
Before Runs	PM	Pleasant Hill Road (NB)	NW	14.22	5.82	4.29	3.61	0.46986	2.59567	0.31197