

Traffic Impact Study for the Quiet Waters Preserve

City of Annapolis, Maryland



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TABLE OF CONTENTS

	Page
Executive Summary and Introduction	1
Proposed Development	7
Study Area	8
<i>Site Accessibility</i>	8
<i>Area Land Uses</i>	9
<i>Planned Roadway Projects</i>	9
Existing Conditions Analysis	10
<i>Existing Roadway Characteristics</i>	10
<i>Pedestrian and Bicycle</i>	11
<i>Transit Services</i>	11
<i>Existing Traffic Count Data</i>	11
<i>Capacity/Level-of-Service Analysis</i>	12
Future Traffic Volumes without Development	13
<i>Regional Traffic Growth</i>	13
<i>Local Traffic Growth</i>	13
<i>Capacity/Level-of-Service Analysis</i>	14
Site-Generated Traffic	15
<i>Trip Generation Characteristics</i>	15
<i>Trip Distribution and Assignment</i>	15
Future With-Development Traffic Conditions	17
<i>Site Layout</i>	17
<i>Capacity/Level-of-Service Analysis</i>	17
<i>Forest Drive and Hilltop Lane</i>	18
<i>Forest Drive and Spa Road</i>	18
<i>Forest Drive and Gemini Drive</i>	18
<i>Forest Drive and Youngs Farm Road/School Access</i>	19
<i>Forest Drive and Tyler Avenue</i>	19
<i>Forest Drive and Annapolis Neck Road/Martha Court</i>	19
<i>Forest Drive and Bay Bridge Avenue/Hillsmere Drive</i>	20
<i>Forest Drive Corridor</i>	21
<i>Queues</i>	21
Potential Connection to Quiet Waters Farm Road	22
Conclusions and Recommendations	24

LIST OF TABLES

Number		Page
1	Existing Roadway Characteristics	9
2	Vehicular Trip Generation	14

LIST OF FIGURES

Number	
1	Site Location Map
2	Preliminary Land Development Site Plan
3	2011 Existing Peak Hour Traffic Volumes
4	2011 Existing Levels of Service
5	2016 Future Peak Hour Traffic Volumes without Development
6	2016 Future Levels of Service without Development
7	“New” Trip Distribution
8	“New” Trip Assignment
9	2016 Future Peak Hour Traffic Volumes with Development
10	2016 Future Levels of Service with Development

LIST OF APPENDICES

- APPENDIX A** - Level of Service and Queue Matrix Tables
- APPENDIX B** - Study Area Intersection Sketches,
Photographs and Signal Permit Plans
- APPENDIX C** - Automatic Traffic Recorder Counts
- APPENDIX D** - Manual Turning Movement Count Data
- APPENDIX E** - HCM Methodology
- APPENDIX F** - 2011 Existing
Capacity/Level-of-Service Analysis Worksheets
- APPENDIX G** - Other Developments
Trip Generation/Trip Distribution/Trip Assignment
- APPENDIX H** - 2016 Future without Development
Capacity/Level-of-Service Analysis Worksheets
- APPENDIX I** - 2012 Future with Development
(Base and Improvements) Capacity/Level-of-Service Analysis
Worksheets
- APPENDIX J** - Signal Warrant Analysis
Forest Drive and Annapolis Neck Drive/Martha Court
- APPENDIX K** - Potential Connection to Quiet Waters Farm Road

Executive Summary and Introduction

As requested by the City of Annapolis, McMahon Associates, Inc. has completed this Traffic Impact Study for the proposed Quiet Waters Preserve residential development that will be located on the south side of Annapolis Neck Road in the City of Annapolis, Anne Arundel County, Maryland. According to the sketch plan prepared by LPDA, Inc. for the site, dated January 5, 2011, the proposed residential development will consist of 86 single-family homes and 72 townhomes on a 40-acre site. The proposed residential development will result in a new residential street system that will tie into the south side of Annapolis Neck Road via two new intersections, respectively located approximately 575 feet and 1,375 feet east of Annapolis Neck Road's intersection with Forest Drive. Annapolis Neck Road will serve as the primary link to/from the new residential area and the main roadway in the area, Forest Drive.

The primary purpose of this traffic assessment is to evaluate the existing and anticipated future build-out year (2016) operating conditions with development of the site on the surrounding roadway network. The approved scope of this traffic impact study was developed based upon guidance from the City of Annapolis and generally follows the City Code Section 22.21.010 "Traffic Impact Analyses" and the corresponding "Policies and Guidelines for Traffic Impact Analysis for Proposed Development in the City of Annapolis." This traffic impact study includes an evaluation of the typical weekday morning, weekday afternoon, and Saturday midday commuter peak hours for existing (2011) and future (2016) conditions without and with development of the site at each of the following study intersections, as well as along the Forest Drive corridor within the limits of the study area:

- Forest Drive and Hilltop Lane,
- Forest Drive and Spa Road,
- Forest Drive and Gemini Drive,
- Forest Drive and Youngs Farm Road/School Access,
- Forest Drive and Tyler Avenue,
- Forest Drive and Annapolis Neck Road/Martha Court, and
- Forest Drive and Bay Ridge Avenue/Hillsmere Drive.

The evaluation of traffic conditions associated with the proposed residential development reveals the following findings and conclusions:

- **Planned Roadway Improvements** – There are currently no plans to improve any of the study area roadways or intersections by the City, State, or other area developers that would have a significant effect on area traffic operations. It should however be noted that a recent improvement project was constructed by the County along the northwestern section of Forest Drive, which resulted in additional travel lanes at the intersection of Hilltop Lane including dual left-turn lanes into Hilltop Lane and an additional travel lane along Forest Drive in the northbound direction of travel.
- **Future Traffic Volumes without Development** – To account for regional traffic growth, the existing traffic volumes were increased by an annual traffic growth rate of 1.00 percent per year or a total of 5.10 percent (compounded) to obtain the future base year (2016) without-

development peak hour traffic volumes. Although the City's guidelines call for a 4.00 percent annual traffic growth rate, the growth rate was reduced to better represent current traffic growth in the area given the effects of the economy on development in recent years, based upon guidance from Anne Arundel County. In addition, the projected traffic from six other proposed area developments have also been accounted for in the future traffic projections.

- **Trip Generation** – The trip generation for the site was based upon data compiled from numerous studies contained in the Institute of Transportation Engineers (ITE) publication, *Trip Generation, 8th Edition*. It is anticipated that the proposed residential development will generate approximately 1,388 total trips (inbound and outbound) on a typical weekday with approximately 110 total trips (inbound and outbound) trips generated during the weekday morning peak hour and approximately 138 total trips (inbound and outbound) generated during the weekday afternoon peak hour. In addition, the site is anticipated to generate approximately 1,606 total trips (inbound and outbound) on a typical Saturday with approximately 150 total trips (inbound and outbound) generated during the midday peak hour.
- **Site Accesses** – A new residential street system will be provided, connecting to Annapolis Neck Road, which will result in two new street intersections located along the south side of Annapolis Neck Road approximately 575 feet and 1,375 feet east of Forest Drive. Between these two intersecting streets, the applicant is proposing to widen Annapolis Neck Road to provide for on-street parking. As a result, it is recommended that the entire length of Annapolis Neck Road, from its intersection with Forest Drive to the southeastern limits of the site frontage, be milled and overlaid to provide a new roadway surface. In addition, according to the site plans, the applicant will also be providing a new sidewalk system along the south side of Annapolis Neck Road along the site frontage. As there is an existing sidewalk system along Forest Drive, it is also recommended that the applicant investigate the potential to extend the sidewalk to Forest Drive or provide for a connection to the sidewalk system located along Forest Drive, if feasible, to improve the connectivity of the property.

In general, the new residential streets are being designed to provide a minimum roadway width of 24 feet (curbed), which may need to be increased if on-street parking is to be permitted as proposed along Annapolis Neck Road and Bonny Way. If on-street parking is provided along the other residential streets to increase parking of the units, then the roadway width will need to be increased by 8 to 16 feet, depending on if the parking is provided on one-side (8 feet) or both sides (16 feet) of the residential streets.

- **Area Transit Services** – Annapolis Transit currently provides two bus stops along Forest Drive at the intersections of Tyler Avenue and Thom Drive for two transit routes (brown and purple). It is recommended that the applicant contact the local transit agency to discuss providing a bus stop at the intersection of Annapolis Neck Road.
- **Capacity/Level-of-Service Analysis** – The peak hour traffic volumes were analyzed to determine existing and future operating conditions (both without and with the proposed residential development) in accordance with the standard techniques contained in the current *Highway Capacity Manual*. Based upon the completed analysis, all of the study area intersections will operate at acceptable levels of service overall (LOS D or better) during all three peak hours

under existing and future without- and with-development conditions., with the exception of the intersections of Forest Drive with Spa Road, Martha Court/Annapolis Neck Road, and Bay Ridge Avenue/Hillsmere Drive. The following is a summary of the operations at the other intersections where mitigation measures and/or improvements from other development projects may be necessary:

- **Forest Drive and Spa Road** – This signalized intersection does operate at acceptable conditions overall (LOS D or better) during the weekday afternoon and Saturday midday peak hours; however, during the weekday morning peak hour, the intersection operates at capacity conditions overall (LOS E) under without- and with-development conditions. As this intersection will be influenced by the Crystal Spring development project, which is located on the south side of Forest Drive between Spa Road and Hilltop Road, it is recommended that any improvements to this intersection be completed in conjunction with that project as the Quite Waters Preserve results in a minimal increase in traffic volumes at the Spa Road intersection from without- to with-development conditions (less than two percent). With the increase in traffic from Crystal Spring, it may be necessary to widen the eastbound approach of Spa Road to provide dual left-turn lanes and a shared through/right-turn lane. If additional improvements are necessary, then it may be beneficial to widen the northbound approach of Forest Drive to provide an additional travel lane, which would be tied into the recent widening done at the Hilltop Lane intersection.
- **Forest Drive and Tyler Avenue** – Although the overall delay at this intersection will remain at acceptable levels (LOS B) with development of the site, it may be necessary to modify the signal timings during the weekday morning peak hour to mitigate the delay associated with the southbound left-turn movement along Forest Drive.
- **Forest Drive and Annapolis Neck Road/Martha Court** – The Annapolis Neck Road and Martha Court approaches are currently stop-controlled, and as a result, the Annapolis Neck Road approach operates with delay (LOS F) during all three peak hours under existing and without-development conditions. With development of the site, the levels of delay will increase excessively along Annapolis Neck Road, as the number of available gaps will decrease as traffic volumes increase along Forest Drive. To provide for safe and efficient access to the Forest Drive corridor via this intersection, the following three alternatives are being investigated and reviewed by the City and Anne Arundel County. The preferred alternative will be selected based upon further review/analysis as indicated below, as well as collaboration between the City and Anne Arundel County:
 - **Alternative 1**– is to install a traffic control signal. With development of the site, the intersection will meet the Four-Hour Warrant for the installation of a traffic control signal. As discussed with the County, there is limited space available along the Annapolis Neck Road approach to Forest Drive prior to the intersection of Annapolis Neck Road with an existing cemetery access. As a result, when designed, the detectors and signal equipment may need to be located at the Annapolis Neck Road and cemetery access to allow for adequate queuing approaching Forest Drive, and to allow for continued access to Forest Drive from both Annapolis Neck Road and the cemetery. The layout of this intersection would need to be similar to Route 178 and Crownsville Road.

With the installation of the signal, there will be gaps provided along Forest Drive that will allow for traffic to safely exit onto Forest Drive from either Annapolis Neck Road/cemetery or Martha Court; however, depending upon the layout of the signal equipment, these approaches may need to be split phased.

An added benefit of the traffic control signal is the potential reduction in vehicle speeds along Forest Drive between in this section between Tyler Avenue and Hillsmere Drive, which is located at the midpoint between these two existing signalized intersections that are approximately 4,000 feet apart. In addition, the signal also has the potential to create additional gaps in the Forest Drive traffic for other stop-controlled access driveways or intersecting streets in this section of the corridor.

If installed, the signal would need to be coordinated with the adjacent signals along Forest Drive, and as the County is planning on installing an Adaptive Signal Control system along the corridor, the equipment would need to meet County standards. At this time, further evaluation of the operations of this signal is recommended by the County to determine the optimal layout and design of the signal equipment, the phasing and timings necessary to accommodate all approach legs to Forest Drive, and the potential impacts to the Forest Drive, particularly at the adjacent signalized intersections.

- **Alternative 2** – is to revise the Forest Drive median to provide a center two-way left-turn lane, provide improvements to enhance the sight distance for vehicles exiting Annapolis Neck Road, and to widen Annapolis Neck Road to provide a shared left/through lane and a separate right-turn lane. While this option will not result in a modification to traffic flow along Forest Drive, there will continue to be delays (over three minutes) for vehicles exiting Annapolis Neck Road to travel north on Forest Drive. In addition, although the posted speed is 40 miles per hour along Forest Drive, the 85th percentile speed in this section has been documented at 55 and 50 miles per hour for the northbound and southbound directions, respectively, since this intersection is located at the mid-point between the Tyler Avenue and Hillsmere Drive signalized intersections that are located approximately 4,000 feet apart. Vehicle speeds will not be impacted by this option. Additionally, as traffic volumes continue to grow across the region, the number of available gaps for traffic to safely access Forest Drive from Annapolis Neck Road will decrease as the Forest Drive volumes increase. As a result, this alternative does not adequately address the safety concerns associated with Annapolis Neck Road accessing Forest Drive, nor does it provide for efficient operations.
- **Alternative 3** – is to provide a new connection that will link Annapolis Neck Road to Quiet Waters Farm Preserve, which would allow traffic to access Forest Drive via the Hillsmere Drive signalized intersection. Under this option, the Annapolis Neck Road approach to Forest Drive would also need to be channelized to restrict all left-turn and through egress movements, which would be re-routed to the Hillsmere Drive approach of the Forest Drive signalized intersection. Additionally, widening would also need to occur along Annapolis Neck Road to the west of the site, which is not controlled by the applicant, in order to provide a consistent cross-section. And as there is a heavy right-turn movement from Forest Drive to Hillsmere Drive, the potential implications of cut-

through traffic would also need to be addressed. If this option is pursued, then the County has requested further evaluation to determine the impacts to the Hillsmere Drive/Quiet Waters Farm intersection, as well as to determine the mitigation improvements that will be necessary at the Forest Drive/Hillsmere Drive intersection, which already operates with delay along the Hillsmere Drive approach.

- ***Forest Drive and Bay Ridge Avenue/Hillsmere Drive*** – Although this intersection does operate with delay (LOS F) conditions during the weekday morning peak hour, the incremental increase in the delay from without- to with-development conditions is less than two seconds overall. As a result, no mitigation measures are recommended for this intersection in conjunction with this development if access is provided via Annapolis Neck Road only.
- ***Corridor Operations*** – A review of the anticipated arterial levels of service along the Forest Drive corridor from Hilltop Lane to Bay Ridge Avenue/Hillsmere Drive was also completed. Under existing and without-development conditions, the overall arterial level of service along Forest Drive is at acceptable conditions (LOS C or better) during all three peak hours. With the development of the site and installation of the proposed signal at Forest Drive and Annapolis Neck Road, the incremental increase in travel times along both directions of travel is relatively low (less than 7 percent) compared to without-development conditions during the three peak hours. As a result, the Forest Drive corridor would continue to operate at the same acceptable conditions overall as under without-development of the site. As requested by the County, the corridor operations would need to be further evaluated to determine if additional modifications to the intersection offsets and/or timings would be required if the traffic signal is installed at the intersection of Forest Drive and Annapolis Neck Road to reduce the potential increase in area travel times. A supplemental corridor analysis was performed, which has been attached.
- **Recommendations** – The following improvements are recommended in conjunction with the proposed residential development:
 - ***Annapolis Neck Road*** – As the applicant is proposing to widen the roadway to provide for on-street parking along the site frontage, it is recommended, at a minimum that the roadway be milled and overlaid along the site frontage to the intersection of Forest Drive. Depending upon the intersection configuration utilized at the Forest Drive intersection, additional improvements to Annapolis Neck Road may be warranted. Further investigation of the three alternatives is required for the County to make a decision regarding the operations of Annapolis Neck Road and Forest Drive.
 - ***Sidewalk System*** – As the applicant is providing a sidewalk system along the south side of Annapolis Neck Road along the site frontage, it is recommended that the applicant investigate feasible alternatives to provide a connection to the existing sidewalk system along Forest Drive.
 - ***Residential Street System*** – The new residential street system should be designed to provide for a minimum roadway width of 24 feet (curbed) with additional width provided

for on-street parking, where it is deemed necessary by the City to accommodate area parking requirements.

- *Forest Drive and Tyler Avenue* – Modify the weekday morning peak hour signal timings to provide for additional time for the southbound left-turn phase along Forest Drive.
- *Transit Services* – Meet with Annapolis Transit to determine if a bus stop can be provided at the intersection of Forest Drive and Annapolis Neck Road.

The traffic analyses contained herein reveals that safe and efficient access can be provided to and from the proposed residential development with one of the three alternatives for the intersection of Forest Drive and Annapolis Neck Road provided. Furthermore, site-generated traffic can be accommodated at the study area intersections. Level-of-service and queue matrix tables have been provided for each study area intersection and for the Forest Drive corridor in **Appendix A**.

Proposed Development

The proposed Quiet Waters Preserve residential development consisting of a total of 158 residential units will be located on a 40-acre site the south side of Annapolis Neck Road in the City of Annapolis, Anne Arundel County, Maryland (see **Figure 1**). According to the sketch plan prepared by LPDA, Inc. for the site, dated January 5, 2011, which was provided to the City by the applicant, the proposed residential development will consist of 86 single-family homes and 72 townhomes, of which 19 townhomes will meet the City's "Moderately-Priced Dwelling Unit" guidelines. **Figure 2** provides an overview of the site plan, while a full-size plan has been provided at the back of this study for reference.

A new residential street system will be provided on the south of Annapolis Neck Road, which will have two new street intersections along Annapolis Neck Road that will be located approximately 575 and 1,375 feet east of Forest Drive. Between these two intersecting streets, the applicant is proposing to widen Annapolis Neck Road to provide for on-street parking. In addition, according to the site plans, the applicant will also be providing a new sidewalk system along the south side of Annapolis Neck Road along the site frontage. According to the site plans, the new residential street system will be designed to provide a 24-foot wide curbed roadway width with minimum intersecting curb radii of 25 feet. The roadway width has been increased along Annapolis Neck Road and Bonny Way to 32 feet to provide for on-street parking along one-side of these two roadways.

Study Area

As previously noted and illustrated in Figure 1, the proposed residential development will be located on the south side of Annapolis Neck Road in the City of Annapolis, Anne Arundel County, Maryland. The existing roadways and intersections in the vicinity of the site, which comprise the study area roadway network, are described in this section.

The following key intersections in the vicinity of the site comprise the study area, which were approved by the City of Annapolis for inclusion in this study. The locations of these “numbered” study intersections are also illustrated in Figure 1.

- 1) Forest Drive and Hilltop Lane (signalized);
- 2) Forest Drive and Spa Road (signalized);
- 3) Forest Drive and Gemini Drive (signalized);
- 4) Forest Drive and Youngs Farm Road/School Access (signalized);
- 5) Forest Drive and Tyler Avenue (signalized);
- 6) Forest Drive and Annapolis Neck Road/Martha Court (stop-controlled); and
- 7) Forest Drive and Bay Ridge Avenue/Hillsmere Drive (signalized).

The study area encompassing these intersections includes approximately 2 miles on Forest Drive, and with the two residential street accesses, about 1,500 feet on Annapolis Neck Road. The physical and operational characteristics of Forest Drive and Annapolis Neck Road, and their cross-streets and intersections are contained in the **Existing Conditions Analysis** section of this study.

Site Accessibility

As the site will be located on the south side of Annapolis Neck Road, primary access to/from the residential development to the main area arterial roadway, Forest Drive, will be provided at the existing intersection between these two streets. As the Annapolis Neck Road approach to Forest Drive is currently stop-controlled, a signal warrant analysis has been completed for the intersection based upon the daily and peak hour traffic count data and the anticipated site traffic for the development. Three alternatives were investigated to improve operations at the Forest Drive and Annapolis Neck Road intersection, which are as follows:

- Install a traffic control signal.
- Revise the median along Forest Drive to provide a center two-way left-turn lane, provide sight distance improvements for egress movements from Annapolis Neck Road to Forest Drive, and widen Annapolis Neck Road to provide a shared left/through-turn lane and a separate right-turn lane.
- Provide a new connection linking Annapolis Neck Road to Quiet Waters Farm Road, which will allow for traffic destined to the north along Forest Drive to utilize the Hillsmere Avenue approach of the Forest Drive signalized intersection.

Area Land Uses

The proposed site land use, as previously discussed, is residential, consisting of 86 single-family homes and 72 townhomes. The existing surrounding area land uses also located off of Forest Drive in the vicinity of Annapolis Neck Road are also primarily residential in nature; although there are a limited number of office and commercial uses located along Forest Drive. At this time, there are six other area development projects planned within the study area that have also been incorporated into the future traffic projections. Details regarding the location and types of development projects (i.e., residential, commercial, etc.) are provided in the **Future Traffic Volumes without Development** section of this study.

Planned Roadway Projects

At this time, there are no planned improvements to any of the intersections located along the Forest Drive corridor that are included within the study area. It should be noted however, that a recent County project, did provide additional turning lanes and travel lanes along Forest Drive to the north that included the intersection of Hilltop Lane. At the intersection of Forest Drive and Hilltop Lane, Forest Drive was widened to provide an additional westbound travel lane, as well as dual left-turn lanes to Hilltop Lane, which was widened to provide two receiving lanes for these movements.

Existing Conditions Analysis

This section provides a more detailed summary of existing conditions within the study area that form the basis for determining the traffic impacts associated with the proposed residential development. A summary of physical roadway characteristics, traffic volumes, as well as the existing capacities/levels-of-service are provided in this section.

Existing Roadway Characteristics

A detailed physical and operational inventory of the seven study intersections, including current signal permit plans, field sketches, and photographs, is provided in **Appendix B**. All study area roadways, including Forest Drive are under local (City) jurisdiction, and with the exception of the intersection of Forest Drive and Annapolis Neck Road/Martha Court, all of the study intersections are signalized. Details of the intersection lane configurations are included in subsequent figures and tables. The overall study area roadway network and characteristics are summarized below in **Table 1**.

Table 1 - Existing Roadway Characteristics

Roadway	Roadway Classification	Travel Lanes (per direction)	Sidewalks	Bicycle Lanes	On-Street Parking	Shoulders	Speed Limit
Forest Drive	Major Arterial	2-3	Yes	No	No	No	40
Hilltop Lane	Minor Arterial	2	Yes	No	No	No	NPSL ⁽¹⁾
Spa Road	Minor Arterial/Collector	1-2	No	No	No	No	30
Gemini Drive	Local	1	Yes	No	No	No	25
Youngs Farm Road	Local	1	Yes	No	No	No	NPSL ⁽¹⁾
Tyler Avenue	Local	1	Yes	No	No	No	25
Annapolis Neck Road	Local	1	No	No	No	No	25
Martha Court	Local	1	No	No	Yes	No	NPSL ⁽¹⁾
Bay Ridge Avenue	Minor Arterial	1	Yes	No	No	No	30
Hillsmere Drive	Collector	2	Yes	No	No	No	30

(1) No posted speed limit.

In general, Forest Drive is the main travel corridor in this area and provides two travel lanes in each direction of travel, with an additional travel lane provided in the westbound direction of travel starting at its intersection with Hilltop Lane. As previously noted, primary access to the residential development will be provided to Forest Drive via Annapolis Neck Road. Annapolis Neck Road is a local, residential street that terminates in a cul-de-sac to the west of the proposed site. However, a pedestrian connection is provided from the cul-de-sac to Quiet Waters Farm Road, which provides access to/from the Quiet Waters Park.

Pedestrian and Bicycle

Table 1 provides a summary of the presence of sidewalks and bicycle lanes along the study area roadways. In addition, pedestrian count data has also been documented as part of the manual turning movement counts completed at the seven study area intersections. According to the counts, pedestrians were observed at the intersections of Forest Drive with Tyler Avenue, Gemini Road, and Spa Road only. Field observations did not indicate any bicycle activity at the study area intersections, which is most likely due to the fact that separate bike lanes are not provided along Forest Drive or the other intersecting roadways.

It is anticipated that pedestrian and bicycle activity will increase as the weather conditions improve, most especially along Hillsmere Drive, which provides access to the Quiet Waters Park via Quiet Waters Farm Road. Also, as previously noted there is an existing pedestrian connection provided to/from the park from the cul-de-sac at the terminus of Annapolis Neck Road, which will allow for access between the park and the proposed residential community.

Transit Services

Annapolis Transit currently provides two bus routes that provide service along Forest Drive, which could potentially be modified to provide a bus stop at the Annapolis Neck Road intersection. Currently, there is a bus shelter provided at the intersection of Forest Drive and Tyler Road on the south side of Forest Drive east of Tyler Road. Bus shelters are also provided on both sides of Forest Drive, to the south of its intersection with Thom Drive.

Existing Traffic Count Data

Daily traffic counts were conducted in February and March 2011 on a typical weekday (Tuesday, Wednesday, or Thursday) to record daily and hourly traffic volumes, vehicle classifications, and roadway speeds. The daily count data is provided in **Appendix C** for the following locations:

- Forest Drive, north of Annapolis Neck Road/Martha Court;
- Annapolis Neck Road, west of Forest Drive; and
- Hillsmere Drive, west of Forest Drive.

On a typical weekday, Forest Drive carries approximately 29,660 vehicles per day (total both directions), of which approximately 13 percent are classified as heavy vehicles. While Forest Drive has a posted speed limit of 40 miles per hour, the 85th percentile travel speeds in both directions of travel (utilized to determine appropriate posted speeds) are well over this speed, at 55 and 50 miles per hour for the northbound and southbound directions, respectively. Annapolis Neck Road, which will be utilized by the proposed development to access Forest Drive, currently carries approximately 350 vehicles per day (total both directions), of which approximately 15 percent are classified as heavy vehicles. The 85th percentile speed along Annapolis Neck Road is 25 miles per hour, which matches the posted speed.

Manual turning movement traffic counts were also conducted in February 2011 during the weekday morning peak period (7:00 AM – 9:00 AM), the weekday afternoon peak period (3:00 PM – 6:00 PM) and the Saturday midday peak period (12:00 PM – 3:00 PM) at the existing study intersections. The results of these traffic counts are tabulated by 15-minute intervals in **Appendix D**. The four highest consecutive 15-minute peak intervals during these traffic count periods constitute the peak hours that are the basis of this traffic analysis.

The resultant peak hour traffic volumes were conservatively balanced (adjusted upwards) between intersections, based upon the presence of other intersecting roadways and driveways located between the study intersections, and are depicted in **Figure 3**. It should be noted that the County has recently completed updated count data along the Forest Drive corridor, and as a result, the Saturday midday peak hour is based upon those counts, which better account for peak/summer activity at the Quiet Waters Park.

Capacity/Level-of-Service Analysis

The existing peak hour traffic volumes, illustrated in Figure 3, were analyzed to determine existing operating conditions, in accordance with the standard techniques contained in the current *Highway Capacity Manual (2000)*. These standard capacity/level-of-service analysis techniques, which calculate total control delay, are more thoroughly described in **Appendix E** for unsignalized and unsignalized intersections, as well the correlation between average total control delays and the respective levels of service (LOS) for each intersection type. According to the City's Ordinance related to Traffic Impact Studies, LOS A through D are considered as constituting acceptable operating conditions, while LOS E represents conditions approaching capacity, and LOS F indicates that traffic volumes have exceeded available capacity.

The results of the capacity/level-of-service analyses are illustrated in **Figure 4** for existing peak hour traffic conditions, and the detailed capacity/level-of-service analysis worksheets are contained in **Appendix F**. According to the analysis, the six signalized intersections all operate at acceptable level-of-service conditions overall (LOS D or better) during all three peak hours with the exception of the intersection of Forest Drive and Bay Ridge Avenue/Hillsmere Drive, which operates at capacity conditions (LOS E) during the weekday morning peak hour.

At the intersection of Forest Drive and Annapolis Neck Road/Martha Court, the stop-controlled approach of Martha Court operates at an acceptable level-of-service (LOS D or better) during all three peak hours. However, the stop-controlled approach of Annapolis Neck Road operates with delay (LOS F) during all three peak hours.

A review of the arterial levels of service along Forest Drive in both directions of travel indicates that the corridor operates at acceptable conditions (LOS C or better) overall during all three peak hours with travel times varying from 244 to 276 seconds in the eastbound direction of travel and from 301 to 308 seconds in the westbound direction of travel.

Future Traffic Volumes without Development

This section presents projected traffic volumes without development of the site for the anticipated future build-out year (2016). The future year without-development traffic volumes were estimated by increasing the existing base (2011) peak hour traffic volumes to account for regional and local traffic growth, as described below. The future without-development traffic volumes for the weekday morning and afternoon peak hours are illustrated in **Figure 5**.

Regional Traffic Growth

To account for regional traffic growth, the existing traffic volumes were increased by an annual traffic growth rate of 1.00 percent. The total background growth rate added to the existing peak hour traffic volumes was 5.10 percent to obtain the future the build-out year (2016) peak hour traffic volumes. While the City traffic impact study guidelines recommend a yearly growth rate of 4 percent per year, given the recent effects of the economy on area developments in recent years, the growth rate was reduced to better represent current and anticipated traffic conditions.

Local Traffic Growth

There are six proposed developments in the vicinity of the study area that have been identified by the City and County for inclusion, as they could impact conditions along the Forest Drive corridor. The other area development projects which are at various points in the development process are as follows:

- Rogers Property – will consist of 38 townhomes on Bembe Beach Road.
- Village Greens – will consist of 109 residential units consisting of a mix of live-work, townhouses, and tri-plex units. This project is located at Skippers Lane and South Cherry Grove Road.
- Rocky Gorge – will consist of 48 residential units consisting of 31 townhomes and 17 single-family homes. It will be located off of Aris T. Allen at Yawl Road.
- Bay Village – will consist of a 13,000 CVS Store, approximately 9,000 square-feet of office space, and a 3,000 square-foot restaurant with 100 seats. This project is located along Bay Ridge Road at Edgewood Road.
- 1503 Forest Drive – will provide 22,680 square feet of commercial space consisting of approximately 18,900 square feet of office space and 3,780 square feet of retail space. This project is located along Forest Drive between Spa Road and Gemini Drive.
- Crystal Spring – is a multi-use development project located on the south side of Forest Drive between Hilltop Lane and Spa Road. The development will consist of a 425 unit continuing care retirement community, 100 townhomes, a hotel/spa with 100 rooms, approximately 156,100 square feet of retail space, and approximately 45,000 square feet of office space.

Details regarding the trip generation characteristics for these sites, as well as the trip distribution and assignment are provided in **Appendix G** along with a map showing the location of these development projects.

Capacity/Level-of-Service Analysis

The future without-development peak hour traffic volumes illustrated in Figure 5 were analyzed to determine future operating conditions without the proposed development, in accordance with the standard techniques contained in the current *Highway Capacity Manual (2000)*. The results of the capacity/level-of-service analyses are illustrated in **Figure 6**, and the detailed capacity/level-of-service analysis worksheets are contained in **Appendix H**.

According to the analysis, four of the six signalized intersections all continue to operate at acceptable level-of-service conditions overall (LOS D or better) during all three peak hours as documented under existing conditions. Forest Drive and Bay Ridge Avenue/Hillsmere Drive, as well as Forest Drive and Spa Road will operate with increased delay overall, LOS E and LOS F, respectively, during the weekday morning peak hour only. However, both intersections will continue to operate at acceptable conditions overall (LOS D or better) during the weekday afternoon and Saturday midday peak hours.

At the intersection of Forest Drive and Annapolis Neck Road/Martha Court, the stop-controlled approach of Martha Court will operate with delay (LOS F) during the weekday afternoon and Saturday midday peak hours. In addition, the stop-controlled approach of Annapolis Neck Road, which currently operates with delay (LOS F) during all three peak hours, will continue to degrade.

A review of the arterial levels of service along Forest Drive in both directions of travel indicates that the corridor will continue to operate at acceptable conditions (LOS C) overall during all three peak hours with travel times varying from 266 to 301 seconds in the eastbound direction of travel and from 317 to 344 seconds in the westbound direction of travel.

Site-Generated Traffic

This section provides a summary of the trip generation characteristics associated with the proposed residential development, as well as its trip distribution and assignment characteristics. Finally, the future with-development volumes are presented.

Trip Generation Characteristics

Traffic volumes generated by the proposed residential development were prepared based on trip generation data compiled from numerous studies contained in the Institute of Transportation Engineers (ITE) publication, *Trip Generation, 8th Edition*, for ITE Land Use Code 210 (Single-Family Detached Housing) and Land Use Code 230 (Residential Condominium/Townhouse). **Table 2** presents the anticipated vehicular trip generation for the proposed residential development, consisting of 86 single-family homes and 72 townhomes.

Table 2 - Vehicular Trip Generation

Description	Size (Units)	Daily		Peak Hours								
				Weekday Morning			Weekday Afternoon			Saturday Midday		
		Weekday	Saturday	In	Out	Total	In	Out	Total	In	Out	Total
Single-Family Homes	86	905	917	18	52	70	58	34	92	46	40	86
<u>Townhomes</u>	<u>72</u>	<u>483</u>	<u>689</u>	<u>7</u>	<u>33</u>	<u>40</u>	<u>31</u>	<u>15</u>	<u>46</u>	<u>34</u>	<u>30</u>	<u>64</u>
Total	158	1,388	1,606	25	85	110	89	49	138	80	70	150

As can be seen, the site is anticipated to generate approximately 1,388 trips per day (inbound and outbound) on a typical weekday with 110 total trips (inbound and outbound) during the weekday morning commuter peak hour and approximately 138 total trips (inbound and outbound) during the weekday afternoon commuter peak hour. On a typical Saturday, the development is anticipated to generate approximately 1,606 trips per day (inbound and outbound) with approximately 150 total trips (inbound and outbound) generated during the peak hour.

Trip Distribution and Assignment

Site-generated traffic will approach and depart the site via different routes depending on factors such as the existing traffic patterns, the locations of major roadways, and the locations of the development's site access. The overall "new" peak hour trip distribution percentages for the anticipated directions of approach and departure are illustrated in **Figure 7**.

Application of the distribution percentages illustrated in Figure 7 for the weekday morning, weekday afternoon and Saturday midday peak hours to the generated peak hour trips contained in Table 2

provides an estimate of the site traffic to be assigned to study area roadways and intersections. The trip assignment is illustrated in **Figure 8**. The site-generated traffic volumes were then added to the future without-development traffic volumes (Figure 5) to result in total future peak hour traffic volumes with development for each peak hour. The resultant 2016 future traffic volumes with development are illustrated in **Figure 9**.

Future With-Development Traffic Conditions

This section presents the operational characteristics within the study area with completion of the proposed residential development. It provides a summary of the capacity/level-of-service conditions at the study area intersections compared to the future base without-development conditions. In addition, a summary of the accident data for the primary intersection serving the site, Forest Drive and Annapolis Neck Road/Martha Court, is provided along with a review of the site plan layout of the proposed residential streets and pedestrian amenities.

Site Layout

A new residential street system will be provided on the south side of Annapolis Neck Road, which will have two new street intersections with Annapolis Neck Road, located approximately 575 feet and 1,375 feet east of Forest Drive, respectively. Between these two intersecting streets, the applicant is proposing to widen Annapolis Neck Road to provide for on-street parking. As a result, it is recommended that the entire length of Annapolis Neck Road, from its intersection with Forest Drive to the southeastern limits of the site frontage, be milled and overlaid to provide a new roadway surface.

In addition, according to the site plans, the applicant will also be providing a new sidewalk system along the south side of Annapolis Neck Road along the site frontage. As there is an existing sidewalk system along Forest Drive, it is also recommended that the applicant investigate feasibility of providing a connection to the Forest Drive sidewalk system either by extending the proposed system to the west along Annapolis Neck Road or through some other type of connection.

According to the site plans, the new residential street system will be designed to provide a 24-foot wide curbed roadway width with minimum intersecting street curb radii of 25 feet. While on-street parking is proposed along Annapolis Neck Road and Bonny Way, it may be beneficial to widen the other proposed residential streets is required by the ordinance to increase the parking supply for the residential units. If on-street parking is provided, then the roadway widths would need to be increased by eight to 16 feet, depending on if the parking is provided on one or both sides of the roads

Capacity/Level-of-Service Analysis

The future with-development peak hour traffic volumes presented in Figure 9 were analyzed to determine future operating conditions with the proposed residential development, in accordance with the standard techniques contained in the current *Highway Capacity Manual (2000)*. The results of the capacity/level-of-service analyses are illustrated in **Figure 10** for the future build-out year (2016) with-development peak hour traffic conditions, and the detailed capacity/level-of-service analysis worksheets are contained in **Appendix I**. The analysis results are summarized below for each study area intersection, which also provides a comparison to the future base without-development level of service conditions.

Forest Drive and Hilltop Lane

This intersection was recently widened to provide an additional westbound travel lane along Forest Drive, as well as dual left-turn lanes to Hilltop Lane, which was also widened to provide two receiving lanes for these movements. Under without- and with-development conditions, the signalized intersection operates at acceptable levels of service (LOS C or better) overall during all three peak hours. As the traffic volumes will increase by less than one percent at this intersection with development of the site and the overall delay will not increase as a result of the Quiet Waters Preserve, no improvements are recommended at this intersection.

Forest Drive and Spa Road

Under without-development conditions, the signalized intersection operates at acceptable levels of service (LOS D or better) overall during the weekday afternoon and Saturday midday peak hours, and at capacity (LOS E) overall during the weekday morning peak hour, which is a drop from the existing level of service (LOS D) during this time period. With-development conditions, overall levels-of-service will remain at the same levels-of-service as noted under without-development conditions with the overall delays increasing by less than three seconds.

No improvements to this intersection are recommended in conjunction with the Quiet Waters Preserve project, which is anticipated to increase traffic volumes at this intersection by less than two percent compared to without-development conditions. However, as the Crystal Spring development will be located on the south side of Forest Drive between Spa Road and Hilltop Lane, its access will be located to the north of the Spa Road intersection. Traffic volumes at the Forest Drive/Spa Road intersection are anticipated to be increased by approximately thirteen percent as a result of the Crystal Spring development. Therefore, any improvements to this intersection to improve any deficient levels of service (LOS E or F) conditions for specific lane groups should be completed as part of the Crystal Spring project. These improvements could include signal timing modifications to provide protected only phasing for the Forest Drive left-turn lanes, widening along the eastbound approach of Spa Road to provide dual left-turn lanes and a separate shared through/right-turn lane, or widening along the northbound approach of Forest Drive to provide an additional travel lane that would be tied into the recent widening at the Hilltop Lane intersection to the north.

Forest Drive and Gemini Drive

Under without- and with-development conditions, the signalized intersection operates at a highly acceptable level-of-service overall (LOS B or better) during all three peak hours. While there is minor delay (LOS E) experienced along the Gemini Road approaches during the weekday morning and weekday afternoon peak hours, this delay is primarily a result of the long cycle length (150 seconds). Given that the increase in traffic at this intersection is minimal with development of the site (less than two percent), no improvements are recommended for this intersection with development of the site.

Forest Drive and Youngs Farm Road/School Access

Under without- and with-development conditions, the signalized intersection operates at a highly acceptable level-of-service overall (LOS A) during all three peak hours. While there is minor delay (LOS E) experienced along the Youngs Farm Road and School Access approaches during the weekday morning and weekday afternoon peak hours, this delay is primarily a result of the long cycle length (150 seconds). Given that the increase in traffic at this intersection is minimal with development of the site (less than two percent), no improvements are recommended for this intersection with development of the site.

Forest Drive and Tyler Avenue

Under without- and with-development conditions, the signalized intersection operates at acceptable levels-of-service overall (LOS B or better) during all three peak hours. As there is a drop in the level of service (LOS E to F) for the southbound left-turn lane along Forest Drive in the weekday morning peak hour, minor timing modifications are recommended during this period only to mitigate to without-development conditions. The minor delay (LOS E) experienced along the Tyler Avenue groups is a function of the long cycle length along the corridor (120 to 150 seconds), so it is not recommended that additional green time be transferred to that phase of the signal, as the site traffic will not increase traffic along those two approaches.

Forest Drive and Annapolis Neck Road/Martha Court

At the intersection of Forest Drive and Annapolis Neck Road/Martha Court, the Annapolis Neck Road and Martha Court approaches are currently stop-controlled. As a result, the Annapolis Neck Road approach does operate with delay (LOS F) during all three peak hours under without-development conditions, while the Martha Court approach operates with delay (LOS F) during the weekday afternoon and Saturday midday peak hours. With development of the site, the levels of delay will increase along both stop-controlled approaches.

A traffic signal warrant analysis was conducted for this intersection based upon the hourly count data from the automatic turning movement counts and the anticipated traffic associated with the proposed development. Copies of the future hourly volume projections and the signal warrant analysis that was performed based on guidelines contained in the Federal Highway Administration's, *Manual on Uniform Traffic Control Devices (MUTCD)* are provided in **Appendix J**. According to the signal warrant analysis, the installation of a traffic control signal is warranted at this location based upon the Four-Hour Warrant for the projected opening year conditions.

As part of this study, the crash history was also reviewed for this intersection. Crash data was reviewed from January 1, 2007 to June 30, 2010, which is the most recent three-year period available. According to the data, there was one rear-end crash along Annapolis Neck Road, involving a car and a school bus, and resulting in property damages only. However, based upon the field view completed at this location, it should be noted that there is a sight distance issue for vehicles exiting Annapolis Neck Road looking to the right, which would impact left-turning vehicles. As a result, the installation of the

signal should also be considered as it will provide for a dedicated time period for vehicles to more safely exit onto Forest Drive.

With the installation of a traffic control signal, the intersection will operate at acceptable conditions overall (LOS A) during all peak hours with adequate gaps provided to allow traffic to safely exit onto Forest Drive from Annapolis Neck Road and Martha Court, which will both operate at acceptable conditions (LOS D or better). If installed, this signal will need to be coordinated with the adjacent signals along Forest Drive, and as requested by the County, a more detailed corridor analysis completed. Additionally, further investigation of the queue operations along the Annapolis Neck Road approach should be investigated to determine the layout and design of the signal equipment as the intersection of Annapolis Neck Road and an existing cemetery is less than 100 feet from the Forest Drive intersection, which limits the ability of vehicles to queue along Annapolis Neck Road.

A second alternative was also investigated that would require the existing median area along Forest Drive to be revised to provide a center two-way left-turn lane. In addition, sight distance improvements would be required to enhance the sight distance for vehicles exiting Annapolis Neck Road to Forest Drive, and Forest Drive would need to be widened to provide a shared left/through lane and a separate right-turn turn. With these improvements provided, the analysis indicates that the Annapolis Neck Road shared left/through lane will continue to operate with delays over three minutes, as there are not enough gaps in the Forest Drive traffic stream to accommodate turns from Annapolis Neck Road. In addition, as previously noted, the 85th percentile travel speed along this section of Forest Drive is at least 10 miles per hour over the posted speed due to the spacing of the adjacent signalized intersections along the corridor, which will continue to pose a safety hazard for vehicles exiting from Annapolis Neck Road.

A third alternative, to provide a connection from Annapolis Neck Road to Quiet Waters Farm Road, is discussed in the next section of the report. The determination of the final alternative for this intersection will be determined through additional analysis and collaboration between the City and County.

Forest Drive and Bay Ridge Avenue/Hillsmere Drive

Under without- and with-development conditions, the signalized intersection operates at acceptable levels of service (LOS D or better) during the weekday afternoon and Saturday midday peak hours; however, during the weekday morning peak hour, the intersection operates with delay (LOS F) overall. As the incremental increase in traffic at this intersection as a result of the development is low (less than one percent) from without- to with-development conditions, the incremental increase in the overall delay from without- to with-development conditions is less than one second per vehicle during all three peak hours. As a result, signal timing modifications would completely mitigate the impact of the development, but since they are minimal, they are not recommended at this location.

A review of the intersection operations does indicate that there are existing deficiencies along the eastbound approach of Hillsmere Drive and the westbound approach of Bay Ridge Avenue, some of this side street delay is directly related to the long green times given to Forest Drive to keep traffic moving efficiently on the corridor, as well as the long cycle lengths. Some time could be transferred

from the Forest Drive corridor to the side street advance lefts to mitigate the developments impacts at this intersection. However, as both of these approaches already provide dual left-turn lanes and a separate shared through/right-turn lane, additional turn lanes are not recommended as the heaviest volumes are the left-turns to Forest Drive. To improve long-term operations at this intersection, additional travel lanes would need to be provided along both approaches of Forest Drive so that green time could be transferred to the side streets. However, given the limited right-of-way at the intersection and the presence of area businesses along the Forest Drive corridor, this may not be possible.

Forest Drive Corridor

A comparison of the travel times and anticipated overall level of service along the Forest Drive corridor was also performed. Under without-development conditions, the anticipated travel time in the eastbound direction of travel ranged from 266 to 301 seconds and in the westbound direction of travel ranges from 317 to 344 seconds during the three peak hours. The corresponding arterial levels of service associated with these travel times are at acceptable levels (LOS C).

With development of the site and installation of the traffic control signal at the intersection of Forest Drive and Annapolis Neck Road, the anticipated travel times along Forest Drive will vary from 281 to 295 seconds in the eastbound direction of travel and from 325 to 370 seconds in the westbound direction of travel during the three peak hours. The incremental increase in the travel time along the corridor is less than seven percent in the eastbound direction of travel and less than five percent in the westbound direction of travel. While the arterial levels of service along the Forest Drive corridor will remain the same as under without-development conditions, further evaluation of the corridor operations will be investigated for this option as requested by the County, if the installation of the traffic control signal at Forest Drive/Annapolis Neck Road is selected as the preferred alternative. A supplemental corridor analysis was completed that indicates that the travel time could potentially be reduced with additional modifications to the intersection offsets.

Queues

As part of the analysis, anticipated queues were documented for existing and future without- and with-development build-out year (2016) periods during the three peak hours. Queue matrix tables are provided in Appendix A. A review of the anticipated queues versus the available storage areas for turning lanes and the spacing between signalized intersections, indicates that the queues with-development of the site can be accommodated within the existing storage lane areas at all of the study area intersections with the exception of the Forest Drive and Bay Ridge Avenue/Hillsmere Drive intersection.

At the intersection of Forest Drive and Bay Ridge Avenue/Hillsmere Drive, the storage area for the southbound right-turn lane along Forest Drive, which is 150 feet, is not adequate to accommodate the anticipated without- and with-development queues. In order to accommodate the queue, the lane would need to be extended an additional 150 feet. All other movements are generally consistent with the conditions without development.

Potential Connection to Quiet Waters Farm Road

As requested, we have evaluated a potential connection of Annapolis Neck Road to Hillsmere Drive as the third alternative for improving access to/from the Forest Drive corridor and Annapolis Neck Road. We believe that this connection makes sense operationally to allow drivers egressing the Annapolis Neck Road community the opportunity to utilize a traffic signal to access Forest Drive without the need for a new traffic signal on Annapolis Neck Road. With this connection, which could either provide for two-way travel, or merely one-way travel away from Annapolis Neck Road, left-turns from Annapolis Neck Road to Forest Drive, a movement with limited sight distance, can be restricted.

While this connection does provide benefit, there are geometric issues that will need to be resolved before determining its feasibility, including whether the Quiet Waters Park will cooperate since any feasible connection would utilize park property. Additionally, design considerations need to be more fully evaluated given the grade differences between Annapolis Neck Road and Quiet Waters Farm Road. Another issue involved in this potential connection is the impact to the Forest Drive intersection with Hillsmere Drive/Bay Ridge Avenue. Any potential connection would impact that signalized intersection with a two-way connection creating more of an impact than the one-way only connection. **Appendix K** includes two schematics illustrating possible connection alternatives. Please note that the intersection of Quiet Waters Farm Road/Hillsmere Drive was not included in the scope of this study; however, the two options presented do have some merit for consideration.

Alternative 1 illustrates a typical T-intersection located approximately 100 feet back from the intersection between Quiet Waters Farm Road/Hillsmere Drive, which will allow for some vehicle stacking on the park approach to Hillsmere Drive before it interferes with the Annapolis Neck Road connection. For this potential connection, the following items would need to be addressed by the applicant:

- Remove the existing cul-de-sac at the end of Annapolis Neck Road and modify the existing trail connection to the park.
- Provide a 24-foot wide roadway connection linking Annapolis Neck Road to Quiet Waters Farm Road that will require re-profiling based on the contours provided on the city's zoning maps. Based on the contours, the area between Annapolis Neck Road and the park access is pretty steep, so some additional measures may be needed to address the grade differential, such as retaining walls, which would increase the project cost. As the existing roadway width along Annapolis Neck Road is only about 18 feet wide, it would also be beneficial to widen the entire length of the road from Forest Drive to Quiet Waters Farm Road to provide a consistent cross-section. Another consideration could involve narrowing this connection to only allow movements from Annapolis Neck Road toward Hillsmere (one-way operations) allowing exiting traffic to take advantage of the existing traffic signal at Forest Drive and Hillsmere Drive to access Forest Drive. Entering traffic could still be accommodated at the Annapolis Neck Road intersection with Forest Drive.
- Provide a minimum 5-foot wide sidewalk connection on the west side of the connector road to link into the park to replace the existing cross-walk located closer to the intersection with Hillsmere Drive.

- With approximately six properties located along Annapolis Neck Road between the site and the connection to the park access, it is recommended that the applicant contact the property owners to discuss installing sidewalks along their frontage to provide a continuous pedestrian connection to the park via Annapolis Neck Road.
- The existing gate along the park access, which is located to the west of the pedestrian crosswalk, should be relocated to the west side of the new road. The opening in the median would allow any vehicles that inadvertently enter the park when it is closed to exit back out onto Hillsmere Drive, while still allowing for access to/from Annapolis Neck Road.
- Further evaluation of the intersection operations at Hillsmere Drive/Quiet Waters Farm Park is required if this alternative is selected as the preferred alternative.
- At the intersection of Forest Drive/Annapolis Neck Road, a channelization island and signage will need to be installed restricting all left-turn egress movements onto Forest Drive. With the removal of the left-turn egress traffic at this location, the installation of a traffic control signal is no longer warranted.
- At the intersection of Forest Drive/Hillsmere Drive/Bay Ridge Drive, signal timings modifications will most likely be required during the morning and afternoon peak hours to accommodate the additional traffic from the site. The addition of the Annapolis Neck Road connection would have a relatively minor impact on its operation, particularly if the connection is provided as an egress only connection. However, as previously noted, there are queuing issues associated with the dual left-turn lanes on the Hillsmere approach. Ultimate improvements to this intersection to improve operations and reduce queues would be to provide additional travel lanes along Forest Drive so that green time could be transferred to the side street phase to reduce delays and queues.

The second alternative shows an 80-foot diameter circle, which is the typical radius utilized for a single lane urban roundabout. Instead of providing a T-intersection where Annapolis Neck Road intersects the park access, a roundabout could be provided. Alternatively, this roundabout could be provided at the existing intersection of Hillsmere Drive and the park access with Annapolis Neck Road forming the fourth leg of that intersection. This option however, would involve the modification of the overall park access to provide the proper alignment to each of the approaches to the roundabout.

Conclusions and Recommendations

In conjunction with the development of the Quiet Waters Preserve, the following roadway and/or intersection improvements are proposed to mitigate the impact of the development and provide for safe and efficient operations of the site:

- *Annapolis Neck Road* – As the applicant is proposing to widen the roadway to provide for on-street parking along the site frontage, it is recommended, at a minimum that the roadway be milled and overlaid along the site frontage to the intersection of Forest Drive. Depending upon the intersection configuration utilized at the Forest Drive intersection, additional improvements to Annapolis Neck Road may be warranted. Further investigation of the three alternatives is required for the County to make a decision regarding the operations of Annapolis Neck Road and Forest Drive.
- *Sidewalk System* – As the applicant is providing a sidewalk system along the south side of Annapolis Neck Road along the site frontage, it is recommended that the applicant investigate feasible alternatives to provide a connection to the existing sidewalk system along Forest Drive.
- *Residential Street System* – The new residential street system should be designed to provide for a minimum roadway width of 24 feet (curbed) with additional width provided for on-street parking, where it is deemed necessary by the City to accommodate area parking requirements.
- *Forest Drive and Tyler Avenue* – Modify the weekday morning peak hour signal timings to provide for additional time for the southbound left-turn phase along Forest Drive.
- *Transit Services* – Meet with Annapolis Transit to determine if a bus stop can be provided at the intersection of Forest Drive and Annapolis Neck Road.

As discussed in the previous section, alternative improvements would be required at the intersections of Forest Drive/Annapolis Neck Road and Forest Drive/Bay Ridge Avenue/Hillsmere Drive if a connection could be provided from Annapolis Neck Road to Quiet Waters Farm Road. Additionally, improvements would also be required along the entire length of Annapolis Neck Road from Forest Drive to the connection to provide a consistent roadway cross-section and to provide for pedestrian access to/from the Quiet Waters Preserve and the park.

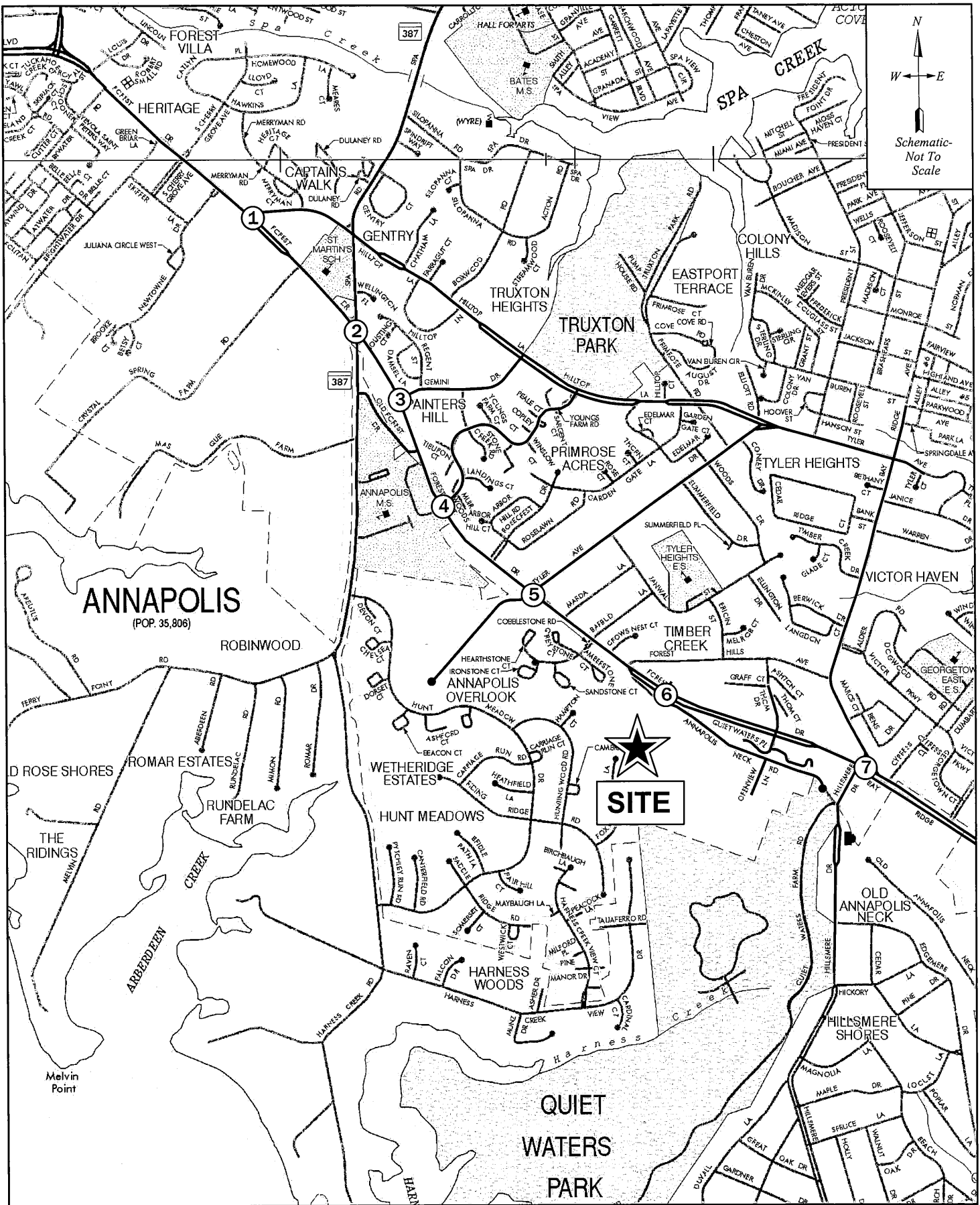
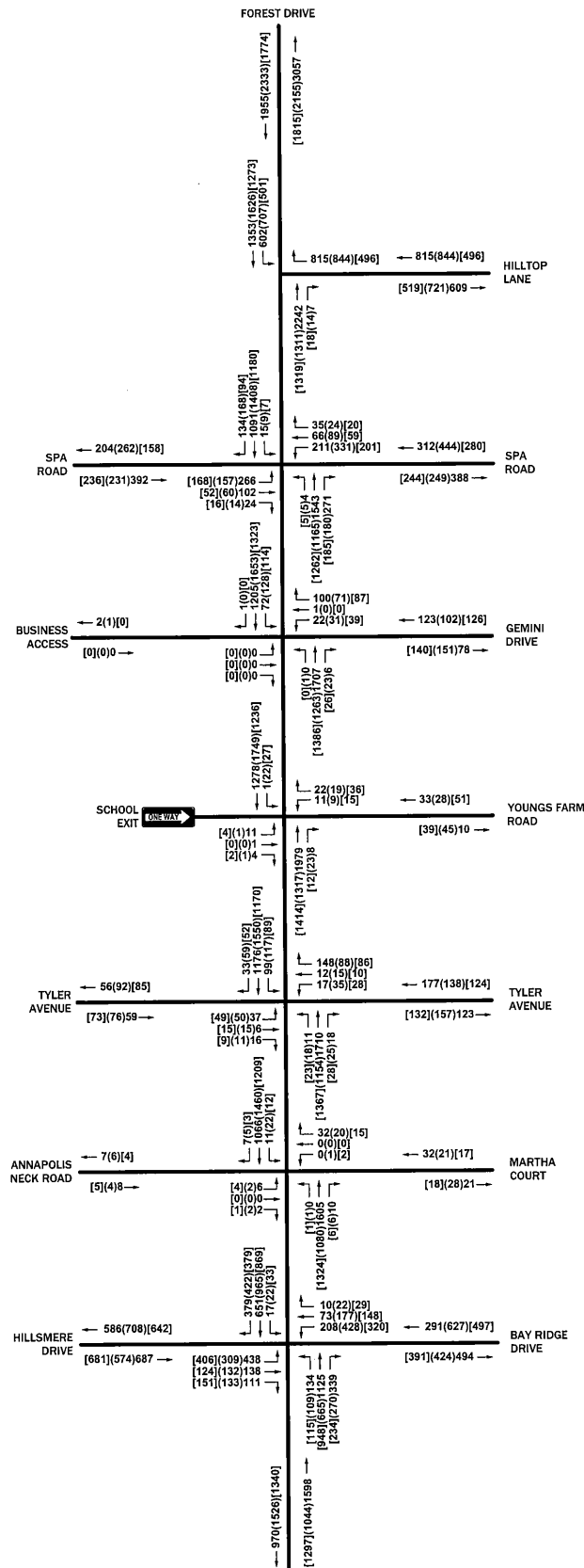
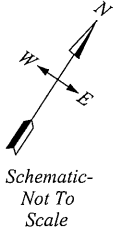


FIGURE 1
 Site Location Map
QUIET WATERS PRESERVE
 CITY OF ANNAPOLIS, MARYLAND

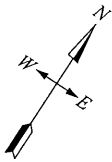




LEGEND:
 10 WEEKDAY MORNING PEAK HOUR
 (10) WEEKDAY AFTERNOON PEAK HOUR
 [10] SATURDAY MIDDAY PEAK HOUR

FIGURE 3
 2011 Existing Peak Hour Traffic Volumes
QUIET WATERS PRESERVE
 CITY OF ANNAPOLIS, MARYLAND





Schematic
Not To
Scale

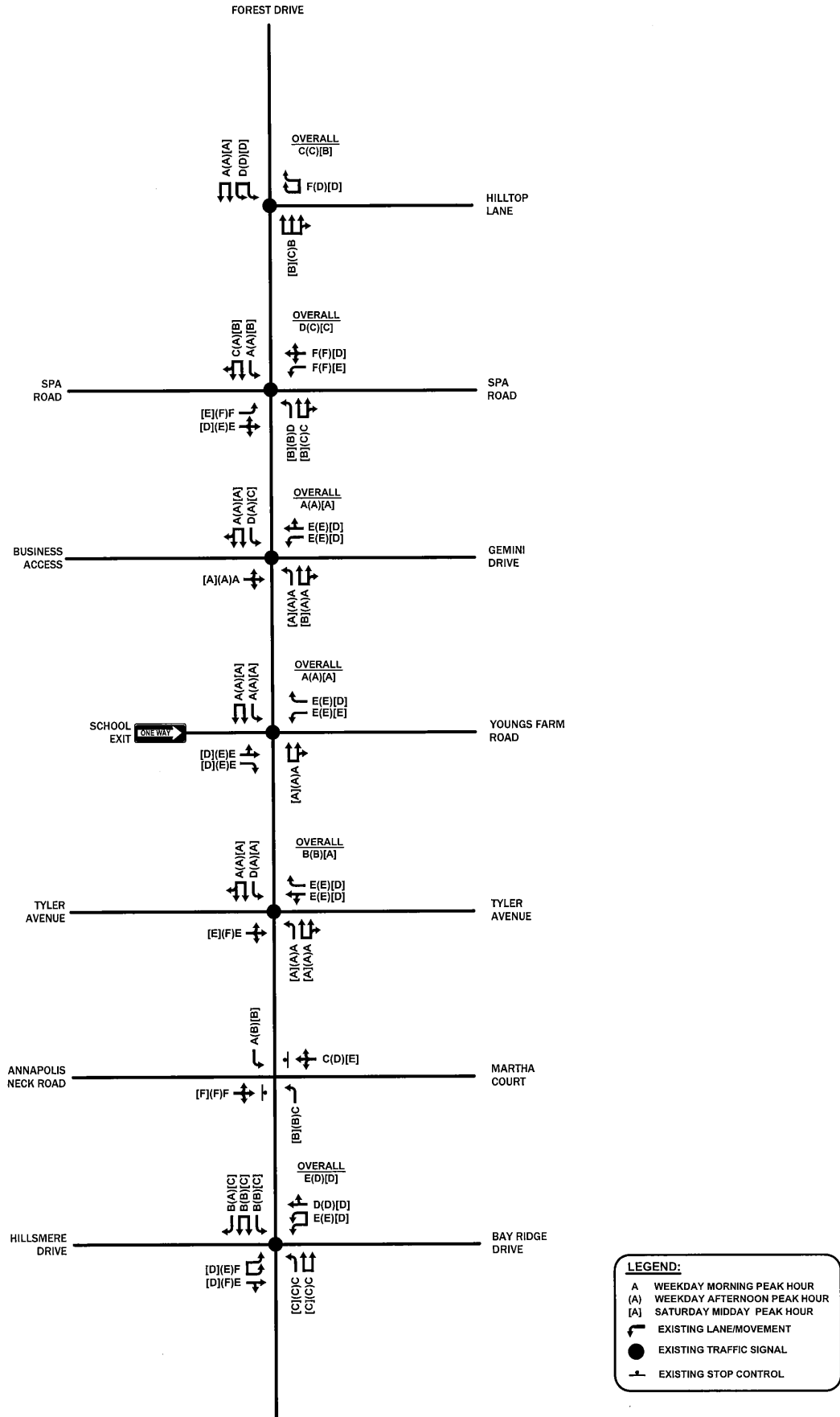


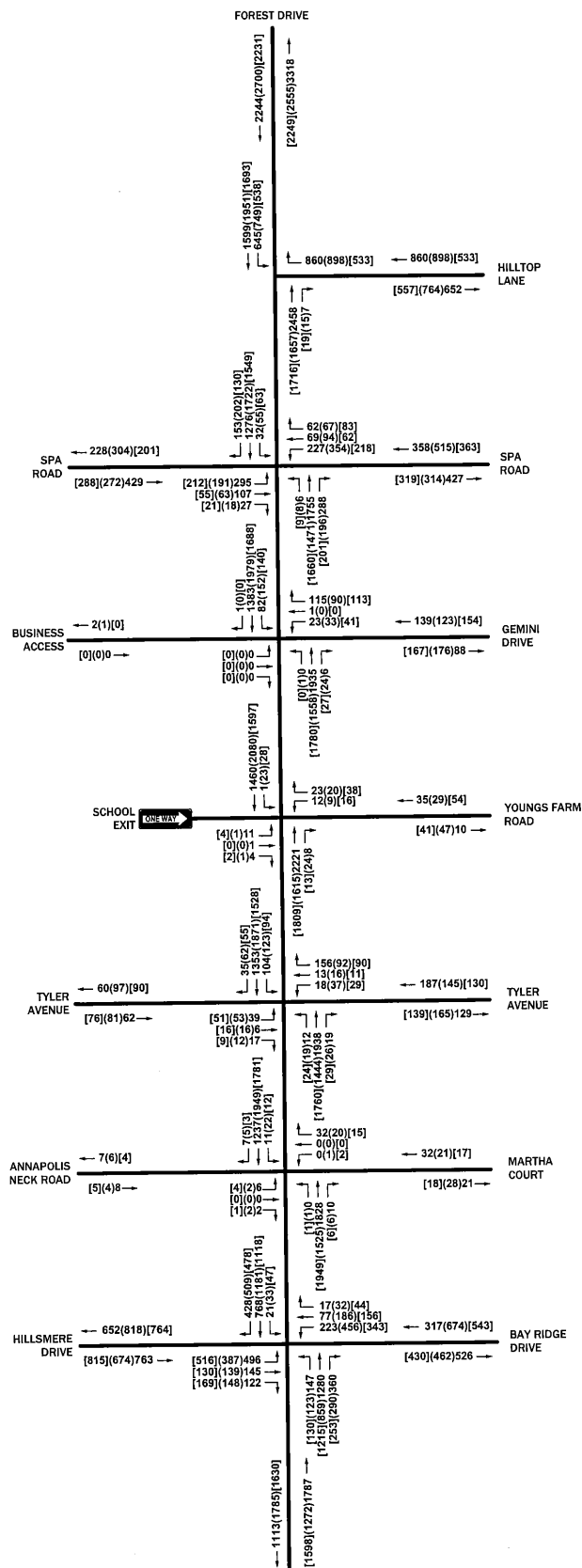
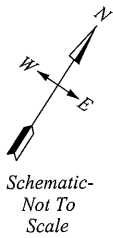
FIGURE 4

2011 Existing Levels of Service

QUIET WATERS PRESERVE

CITY OF ANNAPOLIS, MARYLAND



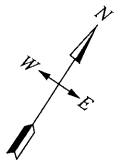


LEGEND:
 10 WEEKDAY MORNING PEAK HOUR
 (10) WEEKDAY AFTERNOON PEAK HOUR
 (10) SATURDAY MIDDAY PEAK HOUR

FIGURE 5
 2016 Future Peak Hour Traffic Volumes without Development

QUIET WATERS PRESERVE
 CITY OF ANNAPOLIS, MARYLAND





Schematic-
Not To
Scale

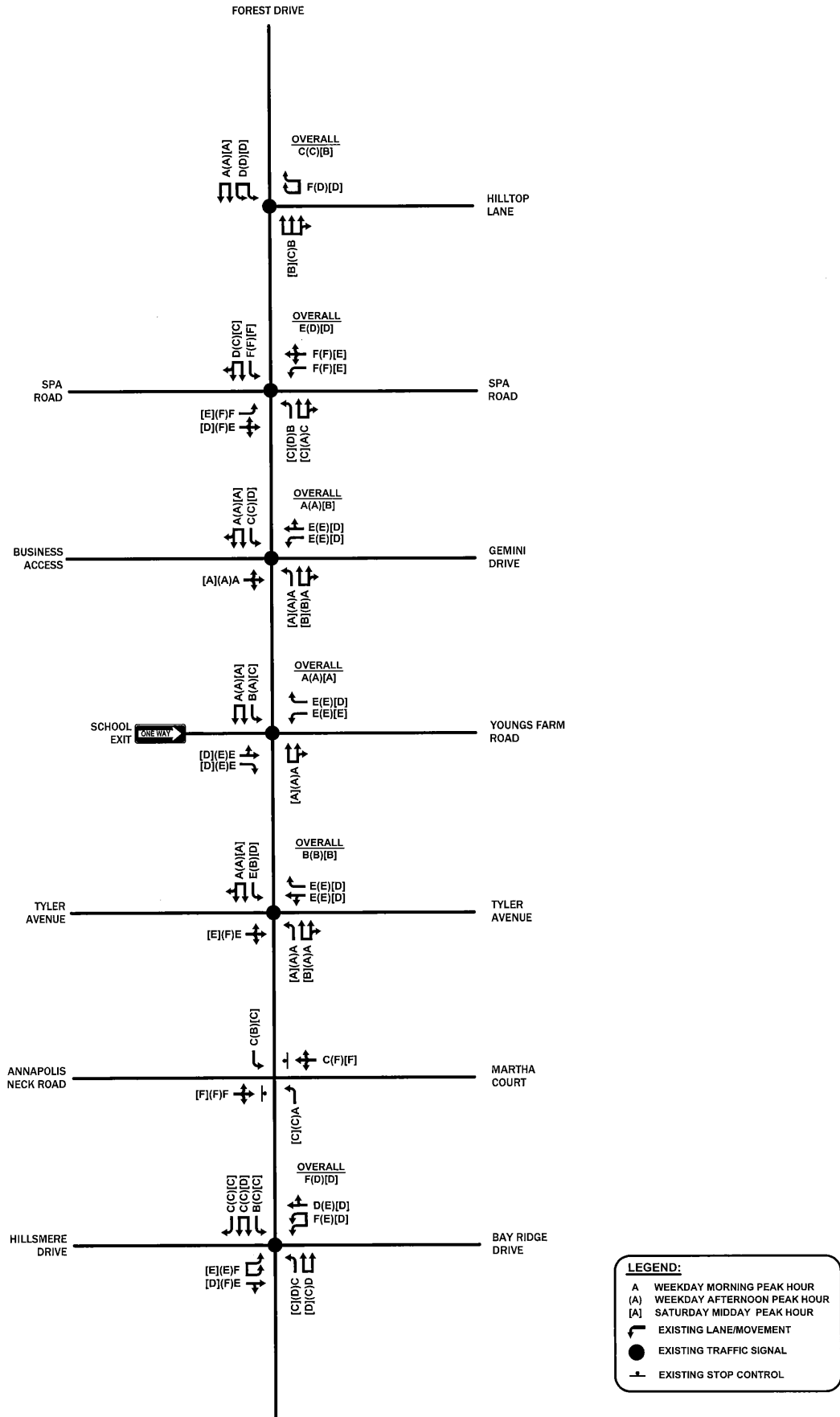
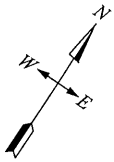


FIGURE 6
2016 Future Levels of Service without Development
QUIET WATERS PRESERVE
CITY OF ANNAPOLIS, MARYLAND





Schematic-
Not To
Scale

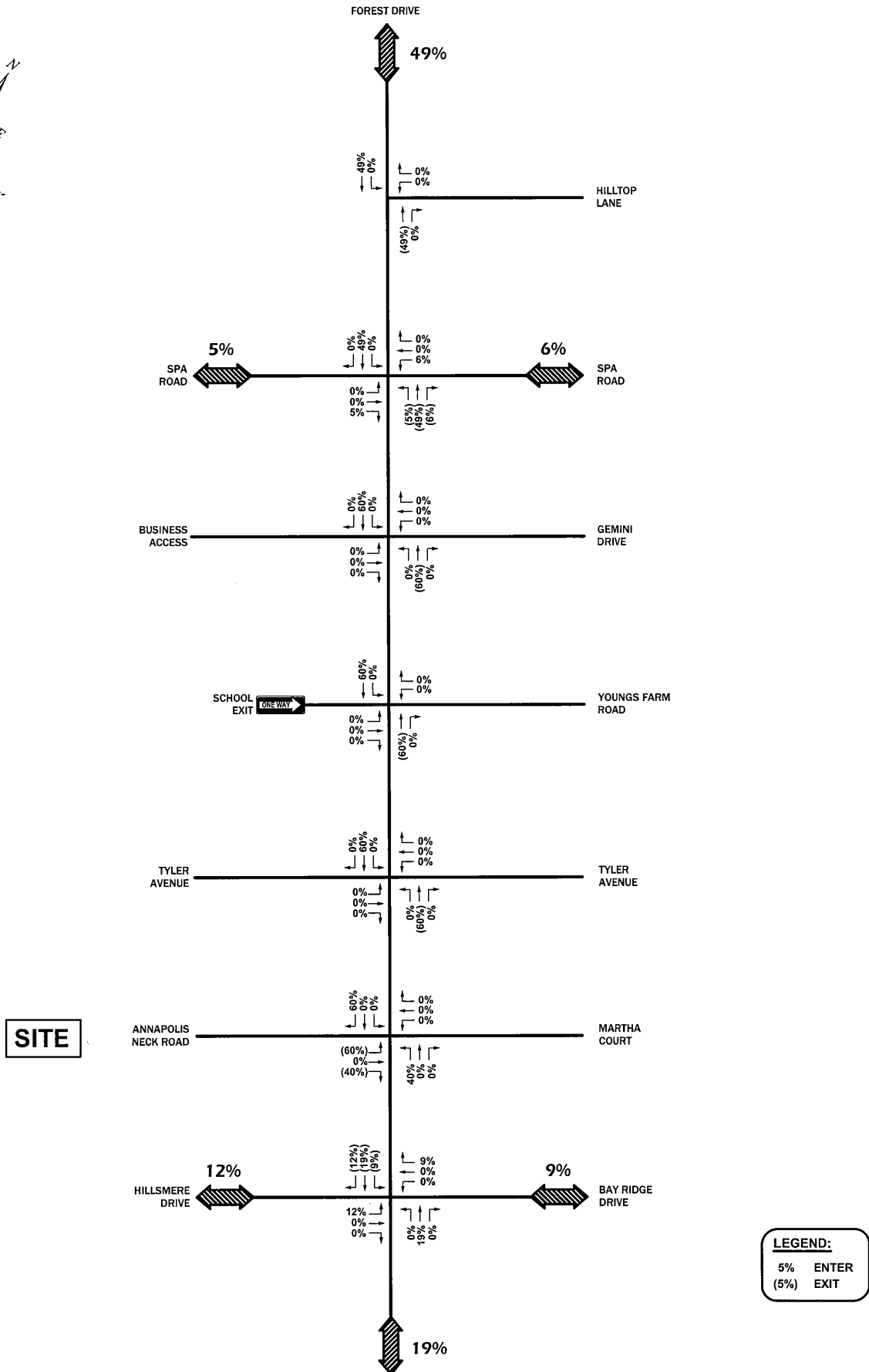
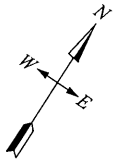


FIGURE 7

"New" Trip Distribution

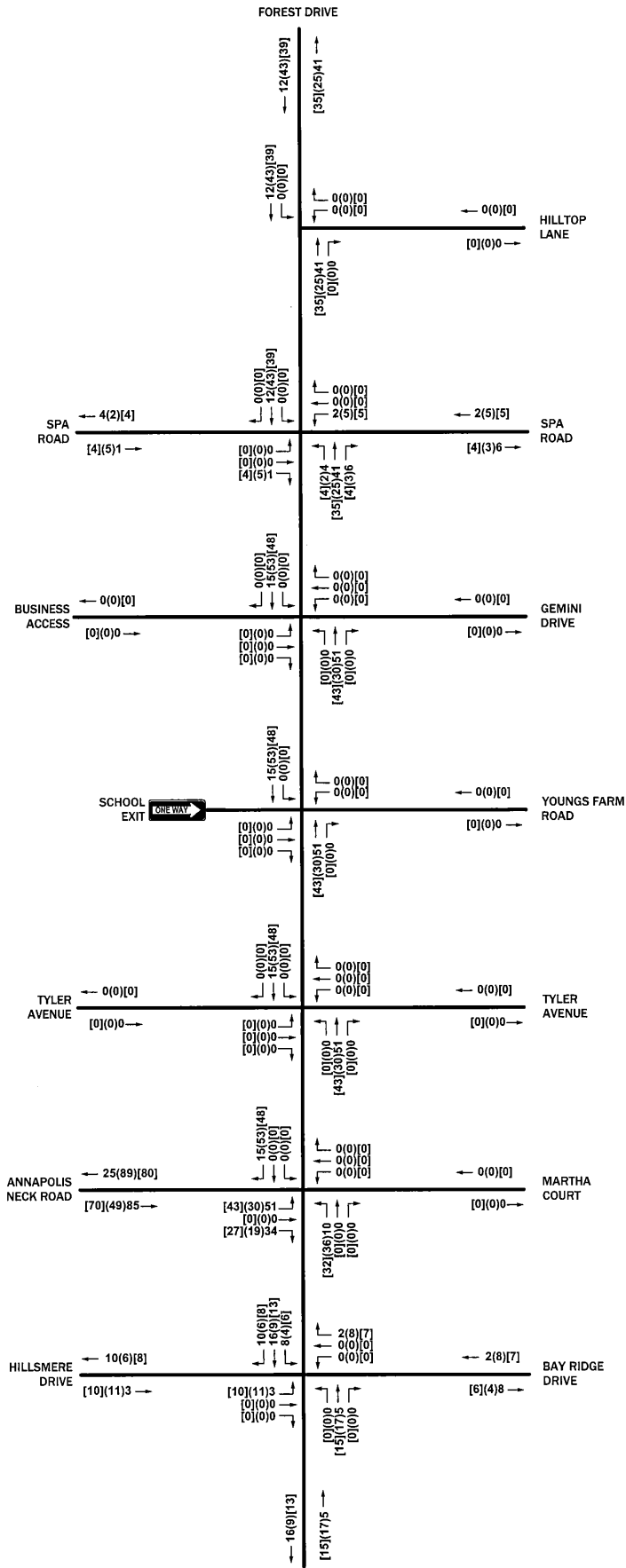
QUIET WATERS PRESERVE
CITY OF ANNAPOLIS, MARYLAND





Schematic-
Not To
Scale

SITE



	AM	(PM)	[SAT]
IN	25	89	80
OUT	85	49	70

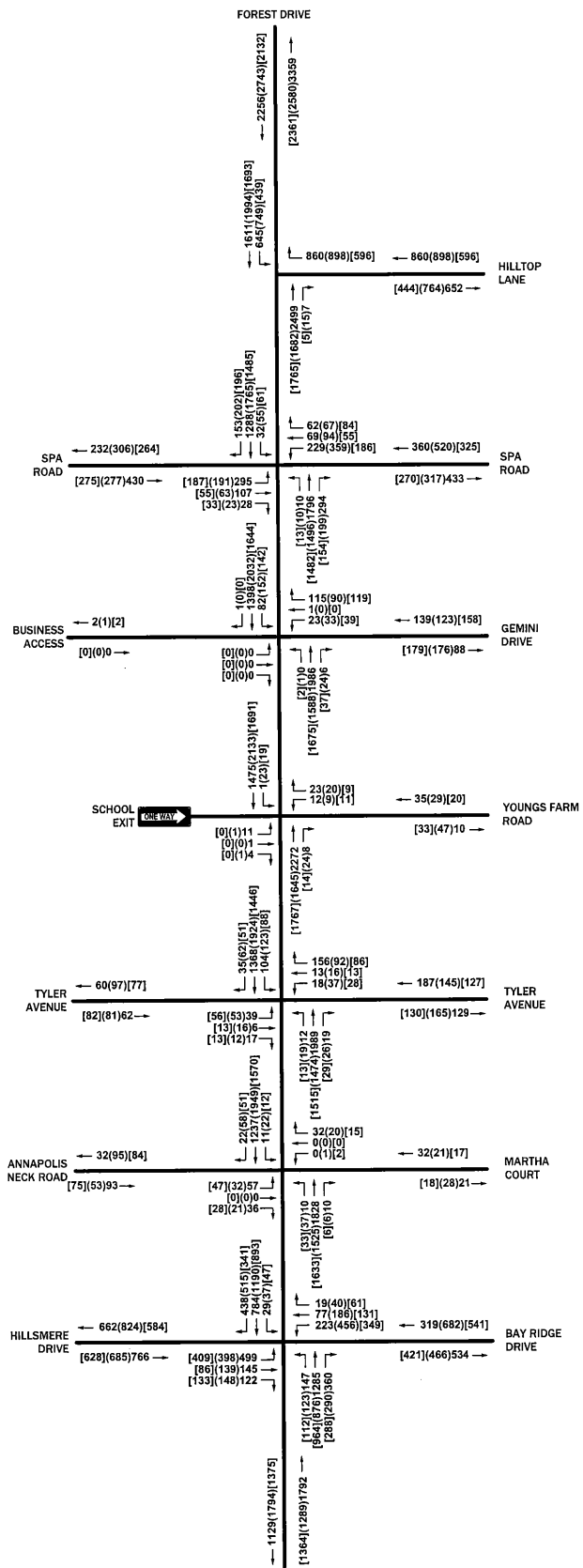
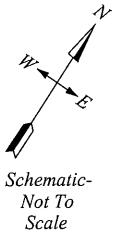
FIGURE 8

"New" Trip Assignment

QUIET WATERS PRESERVE

CITY OF ANNAPOLIS, MARYLAND

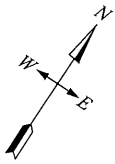




LEGEND:
 10 WEEKDAY MORNING PEAK HOUR
 (10) WEEKDAY AFTERNOON PEAK HOUR
 [10] SATURDAY MIDDAY PEAK HOUR

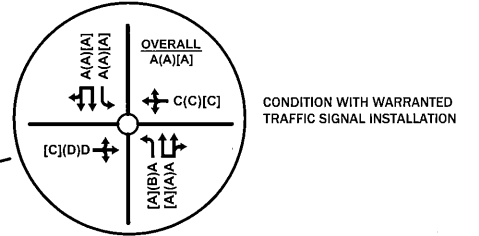
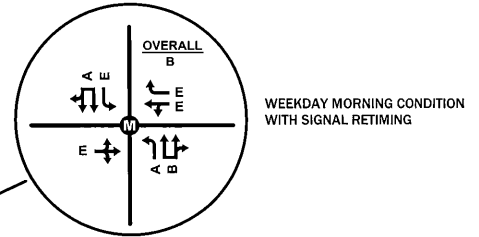
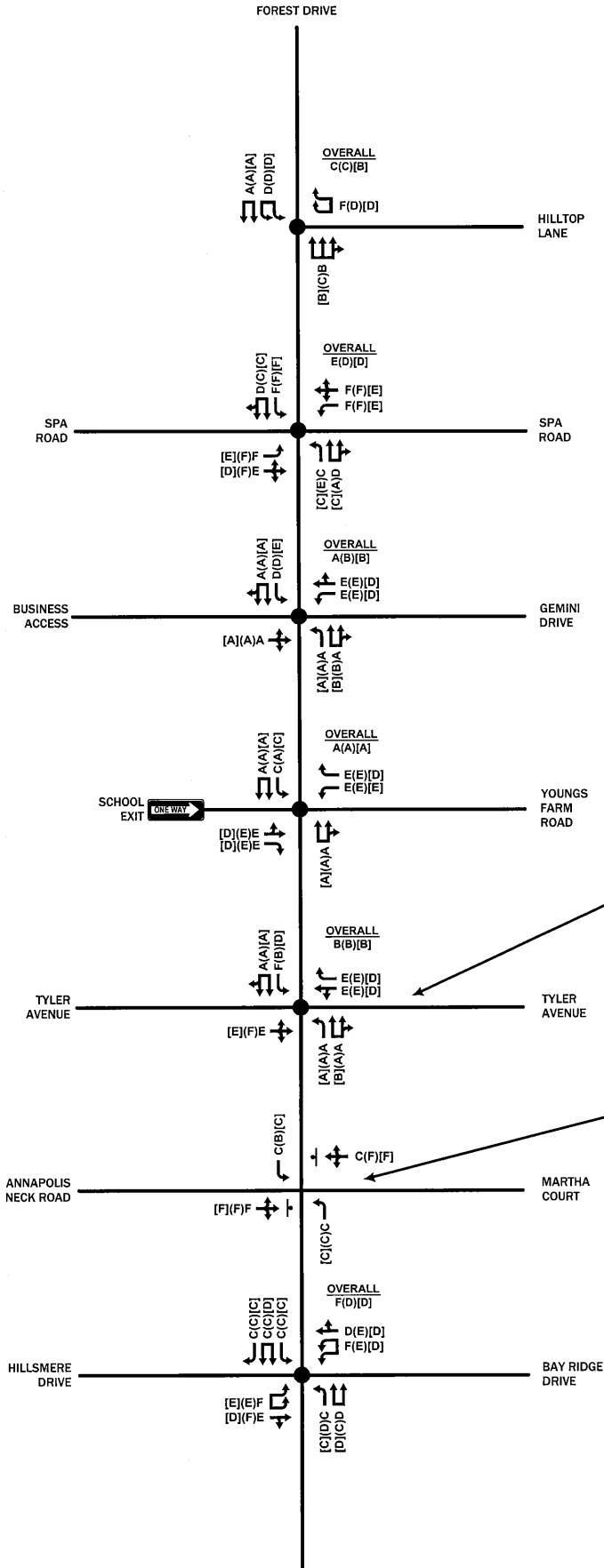
FIGURE 9
 2016 Future Peak Hour Traffic Volumes with Development
QUIET WATERS PRESERVE
 CITY OF ANNAPOLIS, MARYLAND





Schematic-
Not To
Scale

SITE



- LEGEND:**
- A WEEKDAY MORNING PEAK HOUR
 - (A) WEEKDAY AFTERNOON PEAK HOUR
 - [A] SATURDAY MIDDAY PEAK HOUR
 - ↪ EXISTING LANE/MOVEMENT
 - EXISTING TRAFFIC SIGNAL
 - ⊥ EXISTING STOP CONTROL
 - ⊙ EXISTING TRAFFIC SIGNAL WITH TIMINGS MODIFICATIONS
 - PROPOSED TRAFFIC SIGNAL

FIGURE 10
2016 Future Levels of Service with Development
QUIET WATERS PRESERVE
CITY OF ANNAPOLIS, MARYLAND



APPENDIX A

Level of Service and Queue Matrix Tables

Arterial Levels of Service along Forest Drive

Direction of Travel	Existing		Without Development		With Development Improvements		
	Travel Time (sec)	Arterial Speed (mph)	Travel Time (sec)	Arterial Speed (mph)	Travel Time (sec)	Arterial Speed (mph)	Arterial LOS
<u>Eastbound</u> Weekday Morning Weekday Afternoon Saturday Midday	275.7	27.4	273.6	25.8	292.7	24.1	C
	243.7	29.0	265.5	26.6	280.7	25.2	C
	248.0	28.5	300.9	23.5	295.1	23.9	C
<u>Westbound</u> Weekday Morning Weekday Afternoon Saturday Midday	308.2	25.8	335.0	23.7	352.6	22.5	C
	301.0	26.4	317.2	25.0	325.6	24.4	C
	301.8	26.3	343.7	23.1	369.9	21.5	C

Table 1 Level of Service Matrix Tables

Forest Drive and Hilltop Lane

Time Period		Weekday Morning Peak Hour				Weekday Afternoon Peak Hour				Saturday Midday Peak Hour				Time Period				
Design Year		2011		2016		2011		2016		2011		2016		Design Year				
Development Condition		Existing		w/o Dev		w/Devel		w/Devel		Existing		w/Devel		Development Condition				
Hilltop Lane	WB	Right	F	F	D	D	D	D	D	D	D	D	Base	Imps	Right	WB		
Forest Drive	SB	Left	102.0	125.0	125.3	53.2	53.9	54.0	54.0	50.3	47.9	47.8	D	D	---	Left	SB	
		Thru	45.2	47.4	47.4	40.5	38.0	38.1	38.1	45.6	41.7	41.5	D	D	---	Thru	SB	
		Right	A	A	A	A	A	A	A	A	A	A	A	A	A	---	Right	SB
	NB	Thru	0.5	0.8	0.8	0.5	0.8	0.8	0.8	0.3	0.6	0.6	A	A	---	Thru	NB	
		Right	B	B	B	C	C	C	C	B	B	B	B	B	B	---	Thru	NB
		Overall	14.6	16.7	17.2	29.0	34.0	34.4	34.4	10.4	15.4	16.3	16.3	B	B	---	Right	NB
Overall		C	C	C	C	C	C	C	B	B	B	B	B	B	---	Overall		
Overall		28.4	32.1	32.1	25.3	25.9	25.9	25.9	17.6	17.1	17.3	17.3	B	B	---	Overall		

Table 1 Level of Service Matrix Tables

Forest Drive and Spa Road

Time Period		Weekday Morning Peak Hour				Weekday Afternoon Peak Hour				Saturday Midday Peak Hour				Time Period	
Design Year		2011		2016		2011		2016		2011		2016		Design Year	
Development Condition		Existing		w/o Dev		Existing		w/o Dev		Existing		w/Devel		Development Condition	
												Base	Imps		
Spa Road	Left	F	89.6	F	98.9	F	100.4	F	131.9	F	57.8	E	62.9	E	Left
	Left Thru Right	E	71.4	E	74.6	E	79.6	F	94.5	D	52.0	D	D	D	EB
	Left Thru Right	F	136.2	F	200.1	F	90.2	F	118.5	E	58.3	E	62.8	E	Left
Forest Drive	Left Thru Right	F	111.9	F	148.3	F	81.0	F	100.8	F	54.4	E	69.5	E	Left Thru Right
	Left Thru Right	D	53.6	D	180.9	B	10.5	F	199.3	B	11.2	F	381.9	F	Left
	Left Thru Right	C	32.1	D	42.0	C	20.5	C	28.2	B	16.6	C	30.9	C	Thru Right
Forest Drive	Left Thru Right	A	6.4	B	12.2	A	7.7	D	39.7	A	11.7	C	21.3	C	Left
	Left Thru Right	C	21.1	C	33.0	A	6.5	A	7.3	B	13.3	C	25.0	C	Thru Right
	Left Thru Right	D	40.7	E	56.1	C	28.6	D	38.8	C	22.0	D	41.4	D	Left Thru Right
Overall				58.6		41.1		43.3		43.3		Overall			

Table 1 Level of Service Matrix Tables

Forest Drive and Gemini Drive

Time Period		Weekday Morning Peak Hour				Weekday Afternoon Peak Hour				Saturday Midday Peak Hour				Time Period			
Design Year		2011		2016		2011		2016		2011		2016		Design Year			
Development Condition		Existing		w/o Dev		w/Devel		w/Devel		Existing		w/Devel		Development Condition			
						Base		Imps				Base					
Gemini Drive	Left Thru Right	A	0.0	A	0.0	A	A	A	---	A	0.0	A	A	---	Left	EB	
	Left Thru Right	E	67.9	E	67.9	E	E	E	---	E	70.1	E	E	---	Left	WB	
	Left Thru Right	E	67.8	E	69.0	E	E	E	---	E	66.4	E	E	---	Thru	WB	
Forest Drive	Left Thru Right	A	0.0	A	0.0	A	A	A	---	A	3.1	A	A	---	Left	NB	
	Left Thru Right	A	4.1	A	5.9	A	B	B	---	A	9.6	B	B	---	Thru	NB	
	Left Thru Right	D	50.3	C	33.6	C	C	C	---	A	5.0	C	D	---	Right	NB	
Overall	Left Thru Right	A	6.7	A	7.7	A	A	A	---	A	7.2	A	A	---	Left	SB	
	Left Thru Right	A	1.9	A	3.0	A	A	A	---	A	1.4	A	A	---	Thru	SB	
	Left Thru Right	A	6.7	A	7.7	A	A	A	---	A	7.2	A	A	---	Right	SB	
Overall		9.3		10.3		10.1		10.5		10.8		11.9		12.0		Overall	

Table 1 Level of Service Matrix Tables

Forest Drive and Youngs Farm Road

Time Period		Saturday Morning Peak Hour		Weekday Morning Peak Hour		Weekday Afternoon Peak Hour		Saturday Midday Peak Hour		Time Period	
Design Year		2011		2016		2011		2016		Design Year	
Development Condition		Existing		w/o Dev		Existing		w/o Dev		Development Condition	
School Access	Left	E	E	E	E	E	E	D	D	School Access	Left
	Thru	73.4	73.4	69.4	69.4	69.4	69.4	54.2	54.2		Youngs Farm Road
Youngs Farm Road	Right	E	E	E	E	E	E	D	D	Youngs Farm Road	
	Right	67.4	67.4	68.8	68.8	68.8	68.8	53.2	53.2		Forest Drive
Forest Drive	Left	E	E	E	E	E	E	E	E	Forest Drive	
	Thru	69.4	69.6	69.6	71.5	71.5	71.5	56.3	56.3		Forest Drive
Forest Drive	Right	E	E	E	E	E	E	D	D	Forest Drive	
	Right	67.5	67.5	67.5	68.9	68.9	68.9	53.6	53.6		Forest Drive
Forest Drive	Left	A	A	A	A	A	A	A	A	Forest Drive	
	Thru	3.8	5.4	5.9	6.5	6.6	6.6	9.4	9.7		Forest Drive
Forest Drive	Right	A	B	C	A	A	A	C	C	Forest Drive	
	Right	9.8	19.1	23.3	1.0	1.1	1.1	22.2	28.8		Forest Drive
Forest Drive	Left	A	A	A	A	A	A	A	A	Forest Drive	
	Thru	6.3	6.3	6.3	1.2	1.2	1.2	0.7	0.7		Forest Drive
Forest Drive	Left	A	A	A	A	A	A	A	A	Forest Drive	
	Thru	6.3	7.0	7.3	4.5	4.5	4.5	7.3	7.5		Forest Drive
Overall		A	A	A	A	A	A	A	A	Overall	
Overall		6.3	7.3	7.3	4.5	4.5	4.5	7.3	7.5	Overall	

Table 1 Level of Service Matrix Tables

Forest Drive and Tyler Avenue

Time Period		Saturday Morning Peak Hour		Weekday Morning Peak Hour		Weekday Afternoon Peak Hour		Saturday Midday Peak Hour		Time Period		
Design Year		2011		2016		2011		2016		Design Year		
Development Condition		Existing	w/o Dev	Base	w/Devel	Existing	w/o Dev	Base	w/Devel	Development Condition		
				Imps	Imps			Imps	Imps			
Forest Drive	SB	D	E	F	E	A	B	B	D	Left	Forest Drive	
	Thru	43.8	76.3	84.4	77.3	4.3	17.7	17.8	43.5	Thru		Forest Drive
	Right	A	A	A	A	A	A	A	A	Right		
Forest Drive	NB	2.5	4.9	5.0	6.7	7.3	8.8	9.3	2.0	Left	Forest Drive	
	Thru	A	A	A	A	A	A	A	A	Thru		Forest Drive
	Right	0.6	1.0	1.3	8.6	1.9	5.0	6.5	6.7	Right		
Tyler Avenue	EB	A	A	A	B	A	A	A	B	Left	Tyler Avenue	
	Thru	6.3	8.2	8.6	12.0	4.7	4.5	4.7	12.4	Thru		Tyler Avenue
	Right	E	E	E	E	F	F	F	E	Right		
Tyler Avenue	WB	E	E	E	E	F	F	F	E	Left	Tyler Avenue	
	Thru	69.8	67.6	67.3	68.8	90.5	91.9	91.9	56.7	Thru		Tyler Avenue
	Right	E	E	E	E	E	E	E	E	Right		
Overall		E	E	E	E	E	E	E	E	Left	Overall	
		63.5	62.1	62.0	62.7	73.0	72.0	72.0	54.8	Thru		Overall
		E	E	E	E	E	E	E	E	Right		
Overall		73.5	76.0	75.9	75.1	61.6	60.9	60.9	52.2	Left	Overall	
		B	B	B	B	B	B	B	B	Thru		Overall
		11.5	14.0	14.3	16.5	11.8	12.3	12.5	11.8	Right		
Overall		A	A	A	A	A	A	A	A	Left	Overall	
		8.7	11.5	11.8	11.8	8.7	11.5	11.8	11.8	Thru		Overall
		A	B	B	B	B	B	B	B	Right		

Table 1 Level of Service Matrix Tables

Forest Drive and Annapolis Neck Road/Martha Court

Time Period		Weekday Morning Peak Hour				Weekday Afternoon Peak Hour				Saturday Midday Peak Hour				Time Period	
Design Year		2011		2016		2011		2016		2011		2016		Design Year	
Development Condition		Existing	w/o Dev	Base	w/Devel Imps ⁽²⁾	Existing	w/o Dev	Base	w/Devel Imps ⁽²⁾	Existing	w/o Dev	Base	w/Devel Imps ⁽²⁾	Development Condition	
Forest Drive	Left	C	C	C	A	B	B	B	A	B	C	C	A	NB	Forest Drive
	Thru	15.8	18.6	18.6	3.7	11.1	14.4	14.4	3.2	13.0	20.1	20.1	3.8		
	Right	(1)	(1)	(1)	5.5	(1)	(1)	(1)	7.9	(1)	(1)	(1)	7.1		
Annapolis Neck Road	Left	A	A	C	A	B	C	C	B	B	C	C	A	SB	Forest Drive
	Thru	0.0	0.0	18.6	1.9	13.1	17.7	21.0	14.4	11.8	16.7	19.0	9.9		
	Right	(1)	(1)	(1)	9.9	(1)	(1)	(1)	4.6	(1)	(1)	(1)	8.5		
Martha Court	Left	F	F	F	D	F	F	F	D	F	F	F	C	EB	Annapolis Neck Road
	Thru	288.4	753.2	>999.9	50.7	72.8	377.8	>999.9	35.9	125.6	1295.4	>999.9	26.8		
	Right	C	C	C	C	D	F	F	C	E	F	F	C		
Overall	Left	A	A	F	A	A	A	F	A	A	A	F	A	WB	Martha Court
	Thru	1.7	3.5	311.2	9.4	0.8	2.3	175.7	7.2	1.0	6.5	224.3	8.3		
	Right														

(1) This move operates at free-flow conditions.

(2) Intersection is signalized under 2016 Future With Development With Improvements conditions.

Table 1 Level of Service Matrix Tables

Forest Drive and Bay Ridge Avenue/Hillsmere Drive

Time Period		Weekday Morning Peak Hour				Weekday Afternoon Peak Hour				Saturday Midday Peak Hour				Time Period		
Design Year		2011		2016		2011		2016		2011		2016		Design Year		
Development Condition		Existing		w/o Dev		Existing		w/o Dev		Existing		w/o Dev		Development Condition		
				Base		Base		Base		Base		Base				
				Imps		Imps		Imps		Imps		Imps				
Forest Drive	Left	B	15.6	B	19.2	C	22.1	B	14.5	C	22.6	C	27.0	C	26.6	
	Thru	B	18.6	C	21.1	C	21.5	B	18.4	C	30.1	C	31.2	D	D	47.9
	Right	B	15.7	C	21.3	C	21.9	A	9.3	C	24.0	C	25.7	C	C	34.0
Hillsmere Drive	Left	C	23.7	C	30.2	C	31.2	C	22.8	D	49.6	D	51.4	C	C	23.7
	Thru	C	34.7	D	41.2	D	42.2	C	22.1	C	27.2	C	27.6	D	D	48.7
	Right	F	353.2	F	446.6	F	451.6	E	69.9	E	69.1	E	69.2	E	E	63.9
Bay Ridge Avenue	Left	E	78.5	F	81.8	F	81.8	F	69.6	E	70.3	E	70.3	D	D	50.1
	Thru	D	47.4	D	46.2	D	46.3	D	54.8	E	59.7	E	62.9	D	D	42.4
	Right	E	78.9	F	95.4	F	96.1	D	37.1	D	43.8	D	44.6	D	D	47.9
Overall		35.6		47.9		50.0		35.6		47.9		50.0		Overall		

Table 2 Queue Matrix Tables

Forest Drive and Hilltop Lane

Time Period		Existing Storage (feet)		Weekday Morning Peak Hour				Weekday Afternoon Peak Hour				Saturday Midday Peak Hour				Time Period	
Design Year				2011		2016		2011		2016		2011		2016		Design Year	
Development Condition				Existing		w/o Dev		Existing		w/o Dev		Existing		w/o Dev		Development Condition	
Hilltop Lane						Base		Base		Base		Base		w/Devel		WB	
Forest Drive						Imps		Imps		Imps		Imps		Imps		SB	
WB	Right	>500		676	740	740	---	504	569	571	---	248	280	280	---	Right	WB
SB	Left	400		377	403	403	---	395	418	419	---	236	242	241	---	Left	SB
	Thru	1006		0	0	0	---	0	0	0	---	0	0	0	---	Thru	
	Right															Right	
NB	Thru	1950		414	439	436	---	516	656	665	---	328	453	455	---	Thru	NB
	Right															Right	

Table 2 Queue Matrix Tables

Forest Drive and Spa Road

Time Period		Existing Storage (feet)		Weekday Morning Peak Hour				Weekday Afternoon Peak Hour				Saturday Midday Peak Hour				Time Period			
Design Year				2011		2016		2011		2016		2011		2016		Design Year			
Development Condition				Existing	w/o Dev	Base	w/Devel Imps	Existing	w/o Dev	Base	w/Devel Imps	Existing	w/o Dev	Base	w/Devel Imps	Development Condition			
Spa Road				Left	384	435	435	384	266	326	338	---	157	190	193	---	Left	Spa Road	
				EB	238	257	258	238	172	198	201	---	158	193	194	---	Left		EB
				Thru	341	426	430	341	413	520	528	---	200	270	278	---	Thru		WB
				Right	234	278	278	234	322	416	416	---	166	237	241	---	Right		
Forest Drive				Left	40	94	94	40	9	150	155	---	10	105	105	---	Left	Forest Drive	
				NB	651	826	833	651	526	688	714	---	500	900	938	---	Thru		NB
				Thru	2	2	6	2	2	2	3	---	5	10	14	---	Right		SB
				Right	974	1360	1388	974	88	108	125	---	320	925	959	---	Right		

Table 2 Queue Matrix Tables

Forest Drive and Gemini Drive

Time Period		Existing Storage (feet)		Weekday Morning Peak Hour				Weekday Afternoon Peak Hour				Saturday Midday Peak Hour				Time Period	
Design Year		Development Condition		2011		2016		2011		2016		2011		2016		Design Year	
Development Condition		Development Condition		Existing		w/o Dev		Existing		w/o Dev		Existing		w/o Dev		Development Condition	
						Base		Base		Base		Base		Base			
						Imps		Imps		Imps		Imps		Imps			
Gemini Drive	EB	Left	>100	0	0	0	---	0	0	0	---	0	0	0	---	Left	EB
		Thru														Thru	
		Right														Right	
Gemini Drive	WB	Left	100	54	55	55	---	69	73	73	---	66	68	68	---	Left	WB
		Thru														Thru	
		Right	1500	0	0	0	---	0	0	0	---	0	0	0	---	Right	
Forest Drive	NB	Left	TWLT	0	0	0	---	1	1	1	---	0	0	0	---	Left	NB
		Thru														Thru	
		Right	1413	285	595	673	---	407	457	458	---	351	310	311	---	Right	
Forest Drive	SB	Left	TWLT	19	42	50	---	12	71	74	---	39	69	80	---	Left	SB
		Thru														Thru	
		Right	964	167	233	236	---	64	98	113	---	35	27	35	---	Right	

Table 2 Queue Matrix Tables

Forest Drive and Youngs Farm Road

Time Period		Existing Storage (feet)	Weekday Morning Peak Hour				Weekday Afternoon Peak Hour				Saturday Midday Peak Hour				Time Period	
Design Year	Development Condition		2011		2016		2011		2016		2011		2016		Design Year	Development Condition
Development Condition			Existing	w/o Dev	w/Devel		Existing	w/o Dev	w/Devel		Existing	w/o Dev	w/Devel		Design Year	Development Condition
					Base	Imps			Base	Imps			Base	Imps		
School Access	EB	>150	17	17	17	---	5	5	5	---	9	9	9	---	2011	Left Thru Right
			7	7	7	---	1	1	1	---	0	0	0	---		
Youngs Farm Road	WB	>500	31	33	33	---	26	26	26	---	32	33	33	---	2011	Left Right
			14	15	15	---	13	13	13	---	0	0	0	---		
Forest Drive	NB	1551	137	150	150	---	334	466	484	---	312	623	643	---	2011	Thru Right
			1	1	1	---	1	1	1	---	1	1	1	---		
Forest Drive	SB	180	287	344	356	---	22	24	24	---	7	12	11	---	2011	Left Thru
						---				---						

Table 2 Queue Matrix Tables

Forest Drive and Tyler Avenue

Time Period		Existing Storage (feet)		Weekday Morning Peak Hour				Weekday Afternoon Peak Hour				Saturday Midday Peak Hour				Time Period		
Design Year				2011		2016		2011		2016		2011		2016		Design Year		
Development Condition				Existing		w/o Dev		Existing		w/o Dev		Existing		w/o Dev		Development Condition		
						Base		Base		Base		Base		w/Devel				
						Imps		Imps		Imps		Imps		Imps				
Forest Drive	SB	Left	TWLT	86	137	149	142	36	38	41	---	4	89	96	---	Left	SB	
		Thru Right	1551	314	319	328	581	853	941	---	52	58	59	---	Thru Right	Thru Right	Thru Right	
	NB	Left	250	0	1	4	2	2	2	2	---	8	8	8	---	Left	NB	
		Thru Right	2072	147	163	741	198	480	491	---	356	669	707	---	Thru Right	Thru Right	Thru Right	
	Tyler Avenue	EB	Left	>500	116	119	119	120	119	125	125	---	91	93	93	---	Left	EB
			Thru Right	>500	57	57	57	57	61	61	61	---	58	60	60	---	Thru Right	Thru Right
Tyler Avenue	WB	Left	>500	129	148	149	140	52	53	53	---	13	32	33	---	Left	WB	
		Thru Right	>500	148	149	140	52	53	53	---	13	32	33	---	Thru Right	Thru Right	Thru Right	

