

SCHOOL BUS PRIORITY

Connected Vehicle
Student Safety
Pilot Program



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Project Partners:



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EXECUTIVE SUMMARY

Applied Information, Inc. (AI) has partnered with Blue Bird Corporation (Blue Bird), Navistar, Inc. (IC Bus), the Infrastructure Automotive Technology Laboratory (iATL), MetroTrafix, HEM Data, Temple, Inc. (Temple), the Fulton County School System (FCSS), the City of Alpharetta (City), and Kimley-Horn to implement a first of its kind School Bus Priority – Connected Vehicle Student Safety Pilot Program (Pilot Program). The primary goal of the Pilot Program is to improve safety and mobility for school bus drivers and students as they travel to and from school each day by deploying cutting-edge connected vehicle (CV) technology. CV technology is deployed on FCSS buses and at traffic signals along the school bus route that provide priority service to the school bus, in the form of a green light, as it approaches each traffic signal along its route and thereby allows it to pass through the intersection unimpeded.

By providing priority service to the school bus, the Pilot Program sought to reduce travel times, improve route reliability, increase average bus speeds, and reduce the total number of times the bus must stop at an intersection which, when taken together, will enable the Pilot Program to deliver better on time performance and enhance safety of the school bus driver and students. The Pilot Program also sought to reduce the total fuel consumed by the school bus which will reduce harmful emissions and FCSS expenditures on fuel required to operate the bus. Two FCSS school buses, one diesel-fueled school bus and one propane-fueled school bus, were equipped with CV technology as part of the Pilot Program for a period of two months to conduct a Before and After Analysis (B&AA). The before and after period each lasted one month and the data for the analysis was collected directly from the school bus as well the FCSS data logger. Bus drivers of each school bus were interviewed as part of the Pilot Program to obtain feedback and document any observed qualitative benefits of the Pilot Program.

Once completed, the B&AA demonstrated significant and measurable improvements in each of the key performance measures analyzed as part of the Pilot Program. All performance measures calculated as part of the B&AA showed improvements ranging between 7% and 40%. **Table i** includes the average improvement, shown as a percentage, in route travel time, average school bus speed, and the total number of stops between the before and after analysis periods. **Table ii** shows the average improvement in fuel consumption and the average improvement in miles per gallon (MPG) for each bus and the overall Pilot Program.

Table i – Travel Time, Speed, Number of Stops Results Summary

Bus	Average Improvement (%)		
	Travel Time	Speed	Number of Stops
IC Bus	-12.4%	14.2%	-40.2%
Blue Bird Bus	-14.0%	20.5%	-40.5%
Program Summary	-13.3%	18.0%	-40.4%

Table ii – Fuel Consumption Results Summary

Bus	Average Improvement (%)	
	MPG	Fuel/Emissions
IC Bus	13.4%	-12.4%
Blue Bird Bus	6.7%	-7.4%

The Pilot Program, as highlighted in the above tables, demonstrated a clear and measurable reduction in route travel time for both school buses as a result of the decrease in total number of unscheduled stops and an increase in average speed of the bus along the route. Less time on the road and fewer bus stops equates to direct safety and mobility benefits for the bus driver, students, parents, nearby motorists, and the FCSS. The Pilot Program enabled bus drivers to more frequently arrive at school on time and allow students to eat breakfast before going to class and starting their day.

Improved on time performance as a result of the Pilot Program meant less time that buses were running behind schedule which reduced stress on the bus driver and allowed them to spend more time focused on safe driving and onboard student behavior. Experience has shown that students onboard a school bus are more likely to stand up and/or engage in unsafe behaviors when the bus stops. By reducing the number of times the bus make unscheduled stops along its route, the Pilot Program was able to reduce the likelihood that students engage in these types of activities and generally created a more safe environment onboard the school bus.

Last, but certainly not least, the reduction in travel times, higher average speeds, and less frequent stops resulted in a significant decrease in the amount of fuel consumed by the school bus. The reduction in fuel consumption produced by the Pilot Program translates to direct savings of FCSS expenditures on fuel and a reduces harmful emissions from the school bus. By reducing emissions, the Pilot Program can improve overall air quality and create a more healthy and livable community.

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PROJECT OVERVIEW

Applied Information, Inc. (AI) has partnered with Blue Bird Corporation (Blue Bird), Navistar, Inc. (IC Bus), Infrastructure Automotive Technology Laboratory (iATL), MetroTrafix, HEM Data, Temple, Inc. (Temple), the Fulton County School System (FCSS), the City of Alpharetta (City), and Kimley-Horn to implement a first of its kind Traffic Signal Priority School Bus Safety Connected Vehicle Pilot Program (Pilot Program). The goal of the Pilot Program is to improve safety and mobility for bus drivers and students traveling to and from school each day. The initial phase of the Pilot Program includes deployment and integration of cutting-edge connected vehicle (CV) technology on FCSS buses and at traffic signals to provide priority service to the school bus along its route. By providing priority service, the Pilot Program will seek to reduce travel times, improve route reliability, increase average bus speeds and reduce the total number of times the bus must stop at an intersection as it completes its route to reduce distractions and increase safety of students onboard. The Pilot Program will also seek to reduce fuel consumption, fuel expenditures, and bus emissions.

Kimley-Horn and Associates, Inc. (Kimley-Horn) has been retained by AI and its partners to assist with the Pilot Program and perform a before and after analysis of the deployed CV technology and to help quantify the performance improvements achieved as a result of the Pilot Program. The analysis and this report specifically analyzed six (6) different metrics, each of which are highlighted in the list below. The performance metrics and improvements highlighted in this report will provide the basis on which future phases of the Pilot Program are developed and implemented.

Before and After Analysis Performance Metrics:

- Reduction in bus on the road time for each route,
- Increase in bus average speed for each route,
- Reduction in total number of stops at signalized intersections along the route,
- Reduction in bus fuel consumption for each type of fuel,
- Reduction in bus emissions,
- Any behavioral changes of students on bus observed by bus driver.

PROJECT BACKGROUND

The initial phase of the Pilot Program includes two (2) FCSS school buses, each of which is responsible for pick-up and drop-off of students in the morning and afternoon for three schools. Pick-up and drop-off is completed for each school separately with Manning Oaks Elementary School occurring first, Alpharetta High School second, and Webb Bridge Middle School last. Each of the two school buses have been outfitted with onboard units (OBUs) that can communicate via the cellular network with a field monitoring unit (FMU) programmed at signalized intersections along each bus route to provide traffic signal priority. As the school bus approaches a traffic signal with an FMU, the signal from the OBU is received by the FMU and requests priority service from the local traffic signal controller. The initial phase of the Pilot Program includes priority programming at a total of sixty-two (62) signalized intersections along bus routes used by the two Pilot Program buses.

FCSS FACILITIES

The two (2) school buses included in the initial phase of the Pilot Program are based at the North Fulton Transportation Center (Transportation Center) located off Maxwell Road in the City. Each day, the bus begins and ends its morning and afternoon route at the Transportation Center and conducts pick-up and drop-off for three FCSS schools: Manning Oaks Elementary School, Alpharetta High School, and Webb Bridge Middle School. The addresses of the Transportation Center and each of the three FCSS schools are included below.

- **North Fulton Transportation Center** – 410 South Main Street, Alpharetta, GA
- **30009 Manning Oaks Elementary School** – 405 Cumming Street, Alpharetta, GA 30004
- **Alpharetta High School** – 3595 Webb Bridge Road, Alpharetta, GA 30005
- **Webb Bridge Middle School** – 4455 Webb Bridge Road, Alpharetta, GA 30005

SCHOOL BUS AND DRIVERS

The initial phase of the Pilot Program included data collection, an analysis of trip data from two different FCSS buses, each of which has been outfitted with an OBU as part of the Pilot Program. The two buses are manufactured by different companies and run on different types of fuel. Each FCSS school bus is described in further detail below along with the driver typically responsible for driving it.

- **FCSS School Bus #4252 (IC Bus)** – The IC Bus was manufactured by Navistar, Inc. and runs on diesel fuel. The bus is primarily driven by Lynda Epps-Davis on Bus Route ID #21-4252. Refer to **Table 1** for a detailed route table for Bus Route ID #21-4252. The bus completes pick-up and drop-off in the morning and afternoon for Manning Oaks Elementary School, Webb Bridge Middle School, and Alpharetta High School.
- **FCSS School Bus #4612 (Blue Bird Bus)** – The Blue Bird Bus was manufactured by the Blue Bird Corporation and runs on propane fuel. The bus is primarily driven by Timothy Potts on Bus Route ID #21-4612. Refer to **Table 2** for a detailed route table for Bus Route ID #21-4612. The bus completes pick-up and drop-off in the morning and afternoon for Manning Oaks Elementary School, Webb Bridge Middle School, and Alpharetta High School.

FCSS maintains software that tracks the GPS location and speed of each school bus at a frequency of approximately once every thirty seconds when the bus is in motion. Data from the FCSS system was used as the primary data source for calculating performance improvements.

BUS ROUTES

Each school bus included in the Pilot Program conducts pick-up and drop-off along a scheduled, predefined route each day for each of the three schools. Each bus begins and ends its morning and afternoon route at the Transportation Center. **Table 1** and **Table 2** included detailed route information for each bus included in the Pilot Program. Each route has been divided in multiple route segments and each table includes the route segment start location and time, the route segment end location and time, the total number of scheduled student stops along the route segment, and the total scheduled route segment travel time. Detailed FCSS route schedules for Bus #4252 (IC Bus) and Bus #4612 (Blue Bird Bus) are included in the **Appendix A**. When picking up students in the morning, buses must adhere to the schedule and cannot leave a stop earlier than the scheduled stop pick-up time. And, when dropping off

students in the afternoon, buses must wait for a parent/guardian to arrive at a bus stop before leaving for the next stop. For this reason, these route segments have been excluded from the overall performance improvement metric calculations. These trips are marked with an asterisk (*) in the route tables.

Table 1 – IC Bus Route Information

Route #	Route Desc.	Route Seg.	Route Start	Route End	Sched. Stops	Start Time	End Time	Total Time
1	AM Elem	1	North Fulton Transportation Center	235 Jayne Ellen Way	0	6:29 AM	6:43 AM	0:14:00
		2*	235 Jayne Ellen Way	Jordan Court at Westfield Drive	17	6:43 AM	7:09 AM	0:26:00
		3	Jordan Court at Westfield Drive	Manning Oaks Elementary School	0	7:09 AM	7:14 AM	0:05:00
2	AM High	1	Manning Oaks Elementary School	Lake Windward Drive at Lake Windward Overlook	0	7:26 AM	7:31 AM	0:05:00
		2*	Lake Windward Drive at Lake Windward Overlook	Bentwood Trace at Mossy Place	15	7:31 AM	7:44 AM	0:13:00
		3	Bentwood Trace at Mossy Place	Alpharetta High School	0	7:44 AM	7:49 AM	0:05:00
3	AM Middle	1	Alpharetta High School	Newport Bay Passage at Caney Creek Landing	0	8:01 AM	8:13 AM	0:12:00
		2*	Newport Bay Passage at Caney Creek Landing	Clubhouse Drive at Lighthouse Pointe Court	8	8:13 AM	8:22 AM	0:09:00
		3	Clubhouse Drive at Lighthouse Pointe Court	Webb Bridge Middle School	0	8:22 AM	8:33 AM	0:11:00
		4	Webb Bridge Middle School	North Fulton Transportation Center	0	8:33 AM	8:50 AM	0:17:00
4	PM Elem	1	North Fulton Transportation Center	Manning Oaks Elementary School	0	1:45 PM	2:08 PM	0:23:00
		2	Manning Oaks Elementary School	235 Jayne Ellen Way	0	2:33 PM	2:35 PM	0:02:00
		3*	235 Jayne Ellen Way	Jordan Court at Westfield Drive	17	2:35 PM	2:59 PM	0:24:00
5	PM High	1	Jordan Court at Westfield Drive	Alpharetta High School	0	2:59 PM	3:10 PM	0:11:00
		2	Alpharetta High School	Lake Windward Drive at Lake Windward Overlook	0	3:37 PM	3:47 PM	0:10:00
		3*	Lake Windward Drive at Lake Windward Overlook	Bentwood Trace at Mossy Place	15	3:47 PM	3:59 PM	0:12:00
6	PM Middle	1	Bentwood Trace at Mossy Place	Webb Bridge Middle School	0	3:59 PM	4:03 PM	0:04:00
		2	Webb Bridge Middle School	Newport Bay Pass at Caney Creek Landing	0	4:20 PM	4:30 PM	0:10:00
		3*	Newport Bay Passage at Caney Creek Landing	Newport Bay Passage and Linkside Drive	8	4:30 PM	4:38 PM	0:08:00
		4	Newport Bay Passage at Linkside Drive	North Fulton Transportation Center	0	4:38 PM	5:00 PM	0:22:00

Table 2 – Blue Bird Bus Route Information

Route #	Route Desc.	Route Seg.	Route Start	Route End	Sched. Stops	Start Time	End Time	Total Time
1	AM Elem	1	North Fulton Transportation	Economy Hotel	0	5:54 AM	6:19 AM	0:25:00
		2*	Economy Hotel	Northwinds Parkway at Rowan Avenue	12	6:19 AM	6:59 AM	0:40:00
		3	Northwinds Parkway at Rowan Avenue	Manning Oaks Elementary School	0	6:59 AM	7:12 AM	0:13:00
2	AM High	1	Manning Oaks Elementary School	1205 Beacon Hill Crossing	0	7:19 AM	7:30 AM	0:11:00
		2*	1205 Beacon Hill Crossing	Windward Parkway at Compass Point	6	7:30 AM	7:38 AM	0:08:00
		3	Windward Parkway at Compass Point	Alpharetta High School	0	7:38 AM	7:50 AM	0:12:00
3	AM Middle	1	Alpharetta High School	Barnesley Lane at Garrick Point	0	8:08 AM	8:08 AM	0:00:00
		2*	Barnesley Lane at Garrick Point	Hebden Bridge Lane at Hollymount Road	9	8:08 AM	8:19 AM	0:11:00
		3	Hebden Bridge Lane at Hollymount Road	Webb Bridge Middle School	0	8:19 AM	8:28 AM	0:09:00
		4	Webb Bridge Middle School	North Fulton Transportation	0	8:30 AM	8:55 AM	0:25:00
4	PM Elem	1	North Fulton Transportation	Manning Oaks Elementary	0	2:00 PM	2:10 PM	0:10:00
		2	Manning Oaks Elementary School	Kimball Bridge Road at Stratham Drive	0	2:35 PM	2:43 PM	0:08:00
		3*	Kimball Bridge Road at Stratham Drive	Avery at Northwinds (East)	11	2:43 PM	3:09 PM	0:26:00
5	PM High	1	Avery at Northwinds (East)	Alpharetta High School	0	3:09 PM	3:12 PM	0:03:00
		2	Alpharetta High School	1205 Beacon Hill Crossing	0	3:37 PM	3:50 PM	0:13:00
		3*	1205 Beacon Hill Crossing	Windward Pkwy at Admiral Crossing	6	3:50 PM	3:59 PM	0:09:00
6	PM Middle	1	Windward Pkwy at Admiral Crossing	Webb Bridge Middle School	0	3:59 PM	4:00 PM	0:01:00
		2	Webb Bridge Middle School	Barnesley Lane at Garrick Point	0	4:10 PM	4:29 PM	0:19:00
		3*	Barnesley Lane at Garrick Point	Hebden Bridge Lane at Hollymount Road	9	4:29 PM	4:38 PM	0:09:00
		4	Hebden Bridge Lane at Hollymount Road	North Fulton Transportation	0	4:38 PM	5:00 PM	0:22:00

SIGNALIZED INTERSECTIONS

The Pilot Program included a total of sixty-two (62) signalized intersections that were equipped with FMUs and were located along routes traveled by the two school buses. Each FMU was programmed to request priority service from the local traffic signal controller either by extending an existing green phase or truncating an opposing green phase and safely transitioning to green to serve the approaching school bus and enable it to progress through the intersection unimpeded. **Figure 1** below includes a map highlighting each signalized intersection that was configured to provide priority service as part of the Pilot Program and **Table 3** lists each intersection. Priority service remains active for approximately 60 - 90 seconds to ensure the school bus is able to successfully progress through the intersection. By providing priority service, the likelihood that the school bus has to stop at that intersection is significantly reduced.

Not all signalized intersections along the school bus route were configured to provide priority. Intersections along the route that were not within the City of Alpharetta and therefore not under the City's control, were not configured to provide priority service. Additionally, the intersection at North Point Parkway and Kimball Bridge Road was originally scheduled for inclusion in the Pilot Program, however, the signal was currently under construction and therefore not included. The Blue Bird school bus was the only bus to interact with this signal and was during completion of the route for PM middle school drop-offs.



Figure 1 – Priority Enabled Signalized Intersections

Table 3 – Signalized Intersections with Priority Enabled

Int. #	Intersection	Int. #	Intersection	Int. #	Intersection
1	Academy Street at Haynes Bridge Road	22	Old Milton Parkway at Vista Forest Drive	43	Westside Parkway at Encore Parkway
2	Academy Street at Park Plaza	23	GA 9 at Academy Street	44	Westside Parkway at Hembree Road
3	Cumming Street at Henderson Parkway	24	GA 9 at Cogburn Road	45	Westside Parkway at Kimball Bridge Road
4	Haynes Bridge Road at GA 400 SB Ramp	25	GA 9 at Cumming Street	46	Westside Parkway at Maxwell Road
5	Haynes Bridge Road at Lakeview Parkway	26	GA 9 at Lowes Driveway	47	Westside Parkway at Old Milton Parkway
6	Haynes Bridge Road at Morrison Parkway	27	GA 9 at Maxwell Road	48	Westside Parkway at Old Roswell Road
7	Kimball Bridge Road at Buice Road	28	GA 9 at Mayfield Road	49	Westside Parkway at Sanctuary Parkway
8	Kimball Bridge Road at Tuxford Drive	29	GA 9 at Old Milton Parkway	50	Windward Parkway at Alderman Drive
9	Kimball Bridge Road at Waters Road	30	GA 9 at Windward Parkway	51	Windward Parkway at Clubhouse Drive
10	Mansell at Westside Parkway	31	Webb Bridge Road at Park Bridge Parkway/Shirley Bridge Road	52	Windward Parkway at Edison Drive
11	Maxwell Road at Hembree Road	32	Webb Bridge Road at Alpharetta High School Driveway	53	Windward at GA 400 NB Ramp
12	Morrison Parkway at Lakeview Parkway	33	Webb Bridge Road at Lake Windward Drive	54	Windward at GA 400 SB Ramp
13	North Point Parkway at Alpharetta High School Driveway	34	Webb Bridge Road at Morris Road	55	Windward Parkway at Hyatt Place Plaza
14	North Point Parkway at Morris Road	35	Webb Bridge Road at Park Glenn Drive	56	Windward Parkway at Jordan Court
15	North Point Parkway at Preston Ridge Road	36	Webb Bridge Road at Webb Bridge Middle School Driveway	57	Windward Parkway at Marconi Drive
16	North Point Parkway at Webb Bridge Road	37	Webb Bridge Road at Webb Bridge Way	58	Windward Parkway at North Point Parkway
17	Old Milton Parkway at Cotton Creek Entry	38	Webb Bridge Road at Westside Parkway	59	Windward Parkway at Union Hill Road
18	Old Milton Parkway at North Point Parkway	39	Westside Parkway at Avalon Way	60	Windward Parkway at Westfield Drive
19	Old Milton Parkway at Park Bridge Parkway	40	Westside Parkway at Maxwell Road	61	Windward Parkway at Deerfield Parkway
20	Old Milton Parkway at Southbridge Parkway	41	Westside Parkway at Colonial Center Parkway	62	Windward Parkway at Windward Concourse
21	Old Milton Parkway at State Bridge Parkway	42	Westside Parkway at Cumming Street		

CV TECHNOLOGY

A total of sixty-two (62) FMUs that had been installed at signalized intersections as part of a previous project were used to provide priority service along bus routes used by the two school buses. As part of the current project, an OBU was installed on the IC school bus and the Blue Bird school bus. All FMUs and the two OBUs were configured to communicate directly with AI's cloud-hosted, web-based Glance software. When an OBU was within range of an intersection with an FMU, the FMU was configured to request priority service from the local traffic signal controller. Once received, the traffic signal controller was programmed to either extend the green phase if it was already active or to truncate an active opposing green phase and safety transition to serve the approaching school bus.

The OBU on each school bus was configured to log and transmit its GPS coordinates approximately once every five seconds while the bus was in motion. Data from each school bus was then transmitted to and archived by AI's Glance software. Users with proper credentials can log in to the Glance software to access and analyze this data as well as download it for further processing. **Figure 2** includes a screenshot of the Glance software display of trajectory data from the Blue Bird Bus on May 18th, 2022.

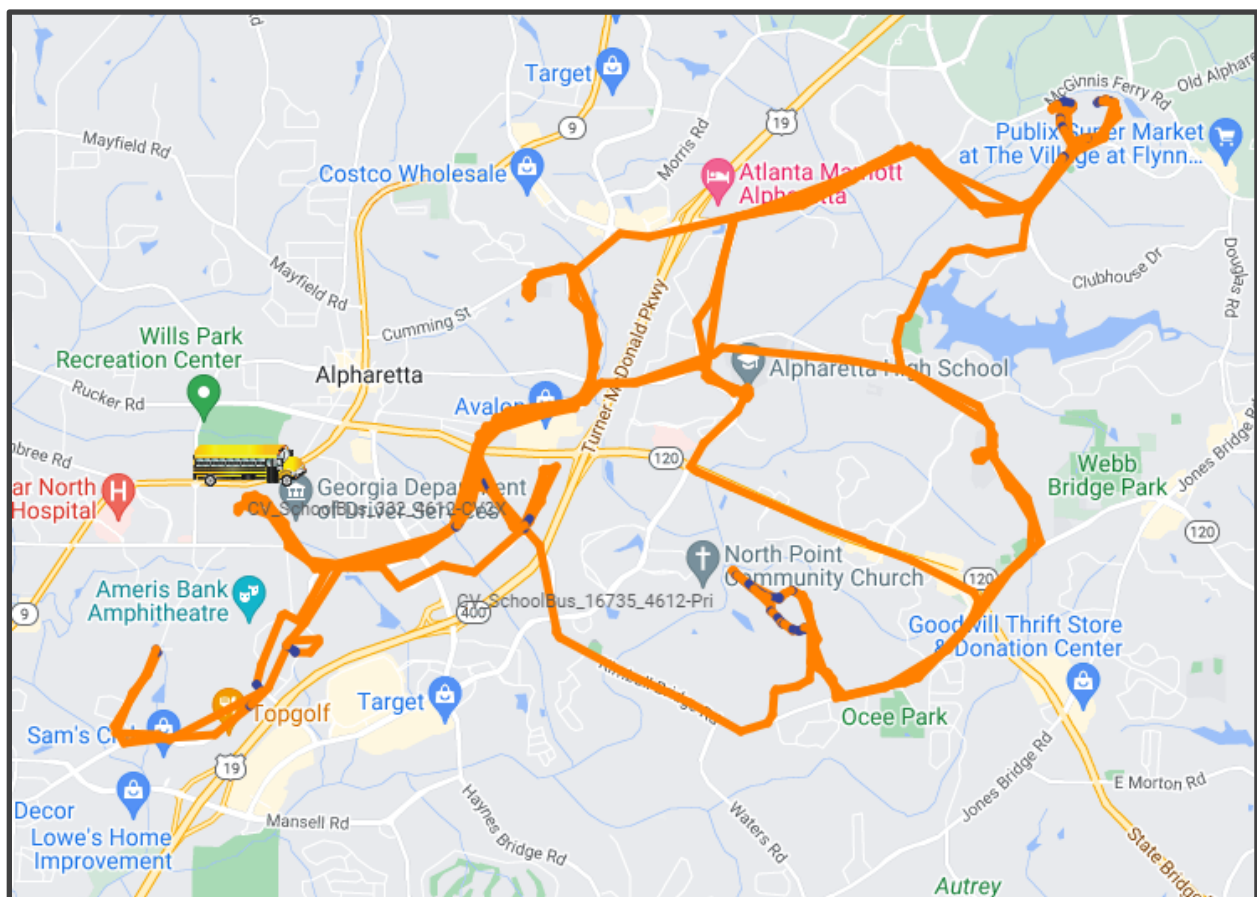


Figure 2 – Glance Software Blue Bird Bus Location Information from May 18

TASKS AND SCHEDULE

The initial phase of the Pilot Program lasted approximately four months and was comprised of four distinct tasks conducted by multiple Pilot Program participants. Each task was completed sequentially with each lasting approximately one month. Each of the four tasks are described in greater detail below.

- **Task #1 – Technology Installation and Configuration.** This task lasted approximately one month and included procurement, installation, and configuration of the CV hardware required to complete the initial phase of the project. Initial phase CV hardware included two OBUs, one for each school bus, and FMUs installed at almost all of the signalized intersections along each bus route. The task also included configuration of the traffic signal controllers at each signalized intersection to provide the school bus with traffic signal priority through FMU programming as well as setup and configuration of the Glance software used to view bus trip data for the analysis. AI personnel, Temple personnel, and City staff (including their consultants) completed all installation and configuration required to complete the task.
- **Task #2 – Before Conditions Data Collection.** This task included data collection for the before conditions analysis period which was conducted on all school days between Friday, March 25, 2022 and Wednesday, April 27, 2022 and excluded weekends and any administrative only school days. All data for the before conditions analysis period was collected prior to enabling school bus traffic signal priority on any bus routes. AI personnel were responsible for all data collection efforts, distribution of collected data, and coordination with all Pilot Program partners.
- **Task #3 – After Conditions Data Collection.** This task included data collection for the after conditions analysis period, which was conducted on school days between Thursday, April 28, 2022 and Thursday, May 26, 2022 and excluded weekends, administrative only school days, and Spring Break, which was from May 4, 2022 to May 8, 2022. All data for the after conditions analysis period was collected after enabling school bus traffic signal priority for all bus routes. AI personnel were responsible for all data collection efforts, distribution of collected data, and coordination with all Pilot Program partners.
- **Task #4 – Data Analysis and Report Development.** This task lasted approximately one month for data processing, analysis and report development. The Kimley-Horn team worked with AI personnel to develop a method for analyzing and comparing the data for the before and after analysis periods. The data analysis consisted of three (3) data sources used to evaluate six (6) metrics.

METHODOLOGY

SCHOOL BUS DATA LOGGER

Time stamped location data from the FCSS school bus data logger was used to obtain three of the five performance metrics included in the before and after analysis. The school bus data logger collects data approximately once every thirty seconds and includes a timestamp, GPS coordinates, location description, heading, speed, and current route distance. When the bus is running but is not moving, data logger frequency decreases to approximately once every five minutes. This data was used to calculate and then compare route travel times, average route speed, and the average total number of stops along the route.

Individual routes were further separated into smaller segments to better quantify performance improvements using the GPS location data and route location descriptions. Start and end points for each individual route segment are included in **Appendix A**. In general, the portion of the route that includes student pick-ups or drop-offs was separated from the portion immediately before and the portion immediately after student pick-ups or drop-offs which included the portion of the trip between the school and the first/last student pick-up or drop-off. Once each route was separated into smaller route segments, the performance metrics highlighted below were calculated for each route and route segment.

- Average Travel Time – calculated for each route segment by subtracting the timestamp at the route segment end point from the timestamp at the route segment start point.
- Average Speed – calculated by averaging each individual speed data point between the route segment start point and the route segment end point.
- Average Total Number of Stops – calculated by adding all individual speed data points equal to zero between the route segment start point and the route segment end point. Successive data points with a speed of zero were treated as a single stop.

FUEL LOGS

Fuel logs for the IC school bus were obtained from FCSS and used to calculate average fuel consumption. Fuel logs for the Blue Bird school bus were not available and thus another data source had to be used to calculate the average fuel consumption for that bus. The fuel log for the bus includes the date and time of each fueling event, the current odometer reading, the unit cost of fuel, and the quantity of fuel added. Fueling did not occur immediately before or after the analysis periods and thus the analysis periods were adjusted to accurately evaluate the fuel log data and to calculate average miles per gallon (MPG) and gallons per 100 miles for the IC school bus.

- Average Fuel Consumption (IC Bus) – calculated by first summing the total mileage taken from odometer readings and the total fuel usage from the fuel logging reading. Average fuel consumption in the form of MPG and gallons per 100 miles were calculated for the before and after period.

Average emissions for each route segment were calculated for each school bus based on the calculated average fuel consumed. The equation used to calculate average emissions from a school bus using diesel fuel was obtained from the U.S. Energy Information Administration (EIA) and is detailed below.

- Average Emissions (IC Bus) – calculated for the before and after period by multiplying the total gallons of diesel fuel consumed by 22.5 pounds of CO₂ emissions per gallon of diesel fuel consumed.

HEM DATA LOGGER SOFTWARE

Software and data loggers from HEM data was utilized as a part of the Pilot Program to collect and archive data from the Controller Area Network (CAN Bus) located on each school bus. Each data logger provided a host of information about the bus on a second-by-second basis including the school bus GPS coordinates, wheel-based speed from the bus odometer, fuel consumption, heading, and parking brake status. This data was then downloaded from the HEM Data software and imported into the ArcGIS application for further processing.

Within ArcGIS, each individual data point was spatially displayed with a single black dot. Individual data points with a school bus speed of zero were shown in yellow and those where the parking brake was active were shown in red. By Georgia state law, a school bus is required to engage the parking brake when boarding or offboarding students. This allowed the team to determine whether the stop was a scheduled stop to pick-up or drop-off students or an unscheduled stop at an intersection. Start and end locations for each route segment were then used to develop a series of queries to obtain data for the relevant period and calculate the desired performance metrics, notably average fuel consumption. Refer to **Appendix A** for detailed start and end information for each route and route segment and **Appendix B** for maps denoted the bus route paths.

- Average Fuel Consumption (Blue Bird Bus) – calculated for each route segment for the before and after period by subtracting the total fuel consumed at the end of the route segment by the total fuel consumed at the beginning of the route segment.

Average emissions for each route segment were calculated for each school bus based on the calculated average fuel consumed. The equation used to calculate average emissions for a propane powered school bus was obtained from the U.S. EIA and is detailed below.

- Average Emissions (Blue Bird Bus) – calculated for each route segment for the before and after period by multiplying the total gallons of propane fuel consumed by 12.7 pounds of CO₂ emissions per gallon of propane fuel consumed.

CALCULATIONS

The calculations result is a series of average performance metrics for each school bus and individual route segment on each day included in the before and after analysis. There are a total of nineteen days of before data and nineteen days of after data included in the analysis with the exception of outlier data observed throughout the data processing period. Data was removed for days or periods in which there were no and/or incomplete data or the school bus did not follow its typical scheduled route. Based on this methodology, each route has a total of three route segments with a fourth route segment included for the AM and PM routes for Webb Bridge Middle School as the school bus returns to the Transportation Center.

The AM 2 route segment for each school includes student pick-ups was excluded from the analysis as bus drivers are required to adhere to their schedule and cannot leave a stop earlier than the scheduled pick-up time. As a result of these requirements, the school bus should not see any positive or negative changes in performance metrics between the before and after analysis period. The PM 3 route segments for each school experience similar variability, so these results are also excluded from the analysis.

A total of twenty (20) route segments were analyzed for both the IC and Blue Bird school bus. This includes the route from the Transportation Center to the first bus stop, the morning route transporting students from their neighborhoods to either Manning Oaks Elementary School, Alpharetta High School, or Webb Bridge Middle School, the route between from the last school to the next bus stop, and the route back to the Transportation Center. It also includes the afternoon segments of the route from the Transportation Center to the first school, the afternoon route transporting students from the elementary, middle or high

school to the first drop off, the first drop off to the last drop off, the route between the last bus stop and the next school, and the route back to the Transportation Center. Due to the variability in travel time, AM 2 and PM 2 route segments were not included in the final analysis, so a total of fourteen (14) route segments are reported in the **Analysis Findings** section.

Table 1 and **Table 2** included in the Project Background section include detailed route information for each school bus including the start and end location, the total number of scheduled stops for pick-ups and drop-offs, the start and end time, and the total scheduled travel time for each route segment.

ANALYSIS FINDINGS

As noted in the methodology section of this report, several different data sources were used to calculate and analyze the effects of the Pilot Program on various performance metrics including average travel time, speed, total number of stops, fuel consumption, and emissions. In addition to these quantitative performance metrics, the analysis also includes qualitative findings obtained from interviews conducted with each of the two school bus drivers participating in the Pilot Program.

BUS DRIVER INTERVIEWS

As part of the analysis, interviews with the drivers of both school buses included in the Pilot Program were conducted. Interviews were conducted on Tuesday, May 24, 2022 and sought to better understand their overall perception of the Pilot Program and any of their general observations based on their experiences during the before and after analysis periods. According to feedback obtained, the most notable benefit experienced by each driver was their ability to easily progress through some of the more congested intersections during the after period once the school bus priority solution was activated. The bus drivers noted the greatest reduction in travel times during home run trips between the Transportation Center and a school, a school and the first student pick-up or drop-off, and the last pick-up or drop off back to a school or the Transportation Center. The drivers were also able to leave the Transportation Center in the after period later than they typically would during the before period by up to five minutes and were able to save up to ten minutes when completing their route back to the Transportation Center at the end of the day. Similar benefits were also noted by the two school bus drivers during the route segment from the last student pick-up in the morning to a school.

As a result of the Pilot Program, school bus drivers were more consistently on schedule and arrived at their destination on time during the after period when compared to the before period. For the route segments that were required to adhere to a set schedule, the school bus priority system helped bus drivers remain on that schedule instead of occasionally running behind. The bus drivers also noted that they felt safer driving the route during the after period because they were typically less worried and/or stressed about being late and/or trying to get back on schedule or make up time. This allowed the school bus driver to focus more of their attention on the road and the behavior of onboard students. Lastly, the drivers indicated that there was less opportunity for students to move around and/or participate in unsafe behaviors on the school bus which was likely due to the reduction in total number of times that the school

bus was required to stop at an intersection. Drivers indicated that when the bus stops, students are more likely to stand-up, move around, or otherwise engage in unsafe behaviors.

Bus drivers did report an area of improvement with the priority solution implemented as part of the Pilot Program including a small number of instances where the priority solution would serve the movement too early because the school bus would be stopped at a nearby pick-up or drop off location or signalized intersection. As the bus left the stop and approached the signalized intersection, it would miss the green phase and have to stop at the intersection. During instances where a shorter total green phase was provided at an intersection, the school bus would sometimes get blocked by slower moving vehicles and would not be able to get through the intersection during signal's green phase and would need to stop at the intersection. AI worked with the bus drivers to update the timing of priority to mitigate the delay.

FCSS DATA

FCSS school bus location data was processed for the IC and Blue Bird school bus to obtain average travel times, speeds, and total number of stops for both the before and after period. FCSS data did not include fuel consumption or emissions data and thus an alternate data source was used to calculate these performance metrics.

AVERAGE TRAVEL TIME

Table 4 and **Table 5** show the average travel time for each individual route segment during all AM and PM routes for the IC Bus and Blue Bird Bus respectively. The change in average travel time between the before and after analysis period as a result of the Pilot Program is shown in the last column as a percent change with an increase in performance shown in green and a decrease in performance shown in red. For context, the route segment distance and the total number of signalized intersections with priority enabled and without priority enabled are located on the route segment are also included.

Table 4 – IC Bus Average Travel Time

School	Route	Route Distance (mi)	Priority Signalized Intersections		Average Travel Time (hh:mm:ss)		
			Enabled	Not Enabled	Before	After	% Change
Manning Oaks Elementary School	AM 1	2.0	4	2	00:07:25	00:06:14	-16.0%
	AM 3	1.2	4	0	00:04:45	00:04:05	-14.1%
	Summary	3.1	8	2	00:12:11	00:10:19	-15.3%
Alpharetta High School	AM 1	3.5	7	0	00:10:09	00:09:14	-9.0%
	AM 3	1.5	2	0	00:04:45	00:04:46	0.3%
	Summary	5.1	9	0	00:14:54	00:14:00	-6.0%
Webb Bridge Middle School	AM 1	3.8	3	0	00:11:07	00:10:55	-1.8%
	AM 3	3.3	3	0	00:10:28	00:09:48	-6.3%
	AM 4	5.7	14	1	00:17:22	00:15:00	-13.6%
	Summary	12.8	20	1	00:38:56	00:35:43	-8.3%
All AM Routes		21.0	37	3	01:06:01	01:00:03	-9.0%
Manning Oaks Elementary School	PM 1	2.4	4	2	00:11:22	00:08:55	-21.5%
	PM 2	0.9	1	0	00:02:47	00:02:33	-8.3%
	Summary	3.3	5	2	00:14:09	00:11:28	-18.9%
Alpharetta High School	PM 1	2.6	7	0	00:08:16	00:07:04	-14.5%
	PM 2	2.4	4	0	00:07:09	00:06:31	-8.9%
	Summary	4.9	11	0	00:15:25	00:13:35	-11.9%
Webb Bridge Middle School	PM 1	1.1	3	0	00:04:01	00:03:31	-12.6%
	PM 2	2.3	2	0	00:08:04	00:07:26	-7.9%
	PM 4	7.3	12	1	00:21:23	00:17:01	-20.4%
	Summary	10.7	17	1	00:33:28	00:27:57	-16.5%
All PM Route		19.0	33	3	01:03:01	00:53:00	-15.9%
All IC Bus Routes		40.0	70	6	02:09:02	01:53:03	-12.4%

Table 5 – Blue Bird Bus Average Travel Time

School	Route	Route Distance (mi)	Priority Signalized Intersections		Average Travel Time (hh:mm:ss)		
			Enabled	Not Enabled	Before	After	% Change
Manning Oaks Elementary School	AM 1	4.9	6	0	00:09:22	00:09:04	-3.4%
	AM 3	2.7	7	1	00:07:52	00:06:13	-20.9%
	Summary	7.6	13	1	00:17:14	00:15:17	-11.4%
Alpharetta High School	AM 1	4.1	13	0	00:11:26	00:08:46	-23.2%
	AM 3	3.7	10	0	00:08:35	00:06:53	-19.7%
	Summary	7.8	23	0	00:20:01	00:15:40	-21.7%
Webb Bridge Middle School	AM 1	4.4	9	1	00:10:40	00:10:04	-5.6%
	AM 3	3.0	4	2	00:09:14	00:09:14	-0.1%
	AM 4	5.7	14	1	00:16:33	00:14:07	-14.7%
	Summary	13.1	27	4	00:36:27	00:33:25	-8.3%
All AM Routes		28.5	63	5	01:13:42	01:04:21	-12.7%
Manning Oaks Elementary School	PM 1	4.0	9	1	00:12:48	00:10:22	-19.0%
	PM 2	2.2	5	1	00:06:42	00:04:33	-32.1%
	Summary	6.2	14	2	00:19:30	00:14:55	-23.5%
Alpharetta High School	PM 1	2.4	7	1	00:09:00	00:06:54	-23.3%
	PM 2	4.2	10	0	00:09:54	00:08:09	-17.6%
	Summary	6.7	17	1	00:18:54	00:15:03	-20.3%
Webb Bridge Middle School	PM 1	2.8	4	0	00:08:24	00:07:16	-13.5%
	PM 2	3.1	3	2	00:09:53	00:09:41	-2.0%
	PM 4	5.3	9	2	00:15:58	00:14:33	-8.9%
	Summary	11.1	16	4	00:34:15	00:31:30	-8.0%
All PM Routes		24.0	47	7	01:12:39	01:01:28	-15.4%
All Bluebird Bus Routes		52.5	110	12	02:26:20	02:05:49	-14.0%

The data above shows an overall average travel time improvement, or reduction, of 16 minutes, or 12.4%, for the IC Bus and an improvement of 20 minutes, or 14.0%, for the Blue Bird Bus as a result of the Pilot Program. Together, the two school buses saw an average travel time improvement, or reduction, of 13.3%. All segments saw a significant decrease in average travel time except for IC Bus AM High 3 route segment with a 0.3% increase in travel time.

AVERAGE SPEED

Table 6 and **Table 7** show the average speed for each individual route segment during all AM and PM routes for the IC Bus and Blue Bird Bus respectively. The change in average speed between the before and after analysis period as a result of the Pilot Program is shown in the last column as a percent change with an increase in performance shown in green and a decrease in performance shown in red. For context, the route segment distance and number of signalized intersections with priority enabled located on the route segment are also included. The summary values are based on a weighted average of the total route segment distance.

Table 6 – IC Bus Average Speed

School	Route	Route Distance (mi)	Priority Signalized Intersections		Average Speed (mph)		
			Enabled	Not Enabled	Before	After	% Change
Manning Oaks Elementary School	AM 1	2.0	4	2	14.4	16.0	10.8%
	AM 3	1.2	4	0	13.5	14.1	4.8%
	Summary	3.1	8	2	14.1	15.3	8.7%
Alpharetta High School	AM 1	3.5	7	0	17.5	20.2	15.7%
	AM 3	1.5	2	0	16.5	16.4	-0.3%
	Summary	5.1	9	0	17.2	19.0	11.0%
Webb Bridge Middle School	AM 1	3.8	3	0	17.2	18.4	7.4%
	AM 3	3.3	3	0	16.4	17.5	6.8%
	AM 4	5.7	14	1	18.4	21.9	19.1%
	Summary	12.8	20	1	17.5	19.7	12.7%
All AM Routes		21.0	37	3	16.9	18.9	11.8%
Manning Oaks Elementary School	PM 1	2.4	4	2	11.6	13.1	12.2%
	PM 2	0.9	1	0	13.7	13.4	-2.6%
	Summary	3.3	5	2	12.2	13.1	9.3%
Alpharetta High School	PM 1	2.6	7	0	16.0	19.7	22.8%
	PM 2	2.4	4	0	15.6	18.0	15.9%
	Summary	4.9	11	0	15.8	18.9	19.6%
Webb Bridge Middle School	PM 1	1.1	3	0	12.4	13.6	9.4%
	PM 2	2.3	2	0	14.9	15.6	5.1%
	PM 4	7.3	12	1	19.7	23.9	21.7%
	Summary	10.7	17	1	17.9	21.1	16.2%
All PM Routes		19.0	33	3	16.3	19.1	16.9%
All IC Bus Routes		40.0	70	6	16.6	19.0	14.2%

Table 7 – Blue Bird Bus Average Speed

School	Route	Route Distance (mi)	Priority Signalized Intersections		Average Speed (mph)		
			Enabled	Not Enabled	Before	After	% Change
Manning Oaks Elementary School	AM 1	4.9	6	0	27.2	29.8	9.6%
	AM 3	2.7	7	1	18.6	22.9	4.3%
	Summary	7.6	13	1	24.1	27.3	13.4%
Alpharetta High School	AM 1	4.1	13	0	19.1	25.0	30.7%
	AM 3	3.7	10	0	20.9	27.0	29.2%
	Summary	7.8	23	0	20.0	26.0	29.9%
Webb Bridge Middle School	AM 1	4.4	9	1	21.3	23.3	9.3%
	AM 3	3.0	4	2	16.6	16.1	-3.0%
	AM 4	5.7	14	1	19.3	24.3	25.5%
	Summary	13.1	27	4	19.4	22.1	14.0%
All AM Routes		28.5	63	5	20.8	24.6	18.0%
Manning Oaks Elementary School	PM 1	4.0	9	1	12.1	22.3	83.9%
	PM 2	2.2	5	1	16.7	22.8	36.9%
	Summary	6.2	14	2	13.7	22.5	63.8%
Alpharetta High School	PM 1	2.4	7	1	18.7	21.9	16.9%
	PM 2	4.2	10	0	20.4	25.0	22.4%
	Summary	6.7	17	1	19.8	23.9	20.5%
Webb Bridge Middle School	PM 1	2.8	4	0	17.2	19.5	13.4%
	PM 2	3.1	3	2	16.5	18.0	9.4%
	PM 4	5.3	9	2	18.0	19.3	7.3%
	Summary	11.1	16	4	17.4	19.0	9.4%
All PM Routes		24.0	47	7	17.1	21.3	24.2%
All Bluebird Bus Routes		52.5	110	12	19.1	23.0	20.5%

As a result of the Pilot Program, the majority of the route segments saw an improvement, or increase, in average speed between the before and after conditions due, in large part, to the reduction in total number of stops at signalized intersections. The IC Bus saw an increase in average speed of 2.4 mph, or 14.2%, and the Blue Bird Bus saw an increase in average speed of 3.9 mph, or 20.5%. The overall improvement, or increase, in average speed for both school buses included in the Pilot Program was 18.0%. The Blue Bird performance improvement in average speed was likely higher because there were more signals with priority along routes traveled by this bus when compared with routes traveled by the IC Bus.

AVERAGE NUMBER OF STOPS

Table 8 and **Table 9** show the average number of stops for each individual route segment for all AM and PM routes for the IC Bus and Blue Bird Bus respectively. The change in total number of stops between the before and after analysis period as a result of the Pilot Program is shown in the last column as a percent change with an increase in performance shown in green and a decrease in performance shown in red. For context, the route segment distance and number of signalized intersections with priority enabled intersections located on the route segment are also included.

Table 8 – IC Bus Average Number of Stops

School	Route	Route Distance (mi)	Priority Signalized Intersections		Average Stops		
			Enabled	Not Enabled	Before	After	% Change
Manning Oaks Elementary School	AM 1	2.0	4	2	3.7	2.4	-35.2%
	AM 3	1.2	4	0	2.9	2.3	-22.7%
	Summary	3.1	8	2	6.7	4.7	-29.7%
Alpharetta High School	AM 1	3.5	7	0	4.9	2.7	-44.7%
	AM 3	1.5	2	0	2.5	1.8	-27.0%
	Summary	5.1	9	0	7.3	4.5	-38.7%
Webb Bridge Middle School	AM 1	3.8	3	0	3.5	2.6	-25.9%
	AM 3	3.3	3	0	4.4	2.9	-33.5%
	AM 4	5.7	14	1	9.7	3.7	-62.1%
	Summary	12.8	20	1	17.6	9.2	-47.7%
All AM Routes		21.0	37	3	31.6	18.4	-41.8%
Manning Oaks Elementary School	PM 1	2.4	4	2	5.9	4.0	-32.5%
	PM 2	0.9	1	0	2.0	2.0	0.0%
	Summary	3.3	5	2	7.9	6.0	-24.3%
Alpharetta High School	PM 1	2.6	7	0	5.3	3.1	-40.5%
	PM 2	2.4	4	0	3.9	2.2	-42.9%
	Summary	4.9	11	0	9.1	5.3	-41.5%
Webb Bridge Middle School	PM 1	1.1	3	0	3.1	2.3	-26.2%
	PM 2	2.3	2	0	3.8	2.1	-45.3%
	PM 4	7.3	12	1	6.7	3.1	-53.5%
	Summary	10.7	17	1	13.6	7.5	-45.0%
All PM Routes		19.0	33	3	30.6	18.8	-38.6%
All IC Bus Routes		40.0	70	6	62.2	37.2	-40.2%

Table 9 – Blue Bird Bus Average Number of Stops

School	Route	Route Distance (mi)	Priority Signalized Intersections		Average Stops		
			Enabled	Not Enabled	Before	After	% Change
Manning Oaks Elementary School	AM 1	4.9	6	0	3.9	2.8	-28.0%
	AM 3	2.7	7	1	4.3	2.1	-51.1%
	Summary	7.6	13	1	8.2	4.9	-40.2%
Alpharetta High School	AM 1	4.1	13	0	6.3	3.3	-47.6%
	AM 3	3.7	10	0	4.1	2.2	-46.9%
	Summary	7.8	23	0	10.4	5.5	-47.3%
Webb Bridge Middle School	AM 1	4.4	9	1	4.2	2.9	-30.2%
	AM 3	3.0	4	2	4.6	5.1	11.9%
	AM 4	5.7	14	1	6.9	2.6	-62.5%
	Summary	13.1	27	4	15.7	10.6	-32.1%
All AM Routes		28.5	63	5	34.3	21.1	-38.7%
Manning Oaks Elementary School	PM 1	4.0	9	1	5.6	2.3	-58.8%
	PM 2	2.2	5	1	4.4	2.1	-53.0%
	Summary	6.2	14	2	10.0	4.4	-56.3%
Alpharetta High School	PM 1	2.4	7	1	3.7	2.3	-38.6%
	PM 2	4.2	10	0	4.9	2.8	-43.2%
	Summary	6.7	17	1	8.6	5.0	-41.3%
Webb Bridge Middle School	PM 1	2.8	4	0	4.0	2.1	-48.8%
	PM 2	3.1	3	2	5.0	3.9	-20.5%
	PM 4	5.3	9	2	6.0	3.9	-34.4%
	Summary	11.1	16	4	15.0	9.9	-33.7%
All PM Routes		24.0	47	7	33.5	19.3	-42.3%
All Bluebird Bus Routes		52.5	110	12	67.9	40.4	-40.5%

As a result of the Pilot Program, all but one of the route segments showed a significant improvement, or decrease, in the average number of stops between the before and after analysis period. The IC Bus saw a decrease in average daily stops on all routes from 62.2 stops to 37.2 stops, or 40.2%, and the Blue Bird Bus saw a decrease in average number of stops from 67.9 stops to 40.4 stops, or 40.5%. The overall improvement, or decrease, in average daily stops for both school buses included in the Pilot Program was 40.4%.

FUEL LOGS

In addition to using HEM Data, fuel logs for the IC Bus were also obtained from FCSS and used to calculate average fuel consumption. The fuel log for the school bus includes the date and time of each fueling event, the current odometer reading, the unit cost of the fuel, and the quantity of fuel added. Fuel Log data was only available for the IC Bus and has been included in **Table 10**.

Table 10 – IC Bus Average Fuel Consumption

Metric	Before	After	% Change
MPG	4.9	5.6	13.4%
Gal/100 Miles	20.3	17.8	-12.4%

The IC Bus shows a clear improvement in both miles per gallon and gallons per 100 miles during the after period when compared with the before period. The IC Bus saw an increase in average miles per gallon on all routes from 4.9 MPG to 5.6 MPG, or 13.4%, and saw a decrease in gallons per 100 miles from 20.3 to 17.8, or -12.4%.

HEM DATA

AVERAGE FUEL CONSUMPTION

Table 11 and **Table 12** show the average fuel consumption for each individual route segment for all AM and PM routes for the IC Bus and Blue Bird Bus respectively. The change in average fuel consumption between the before and after analysis period as a result of the Pilot Program is shown in the last column as a percent change with an increase in performance shown in green and a decrease in performance shown in red. For context, the route segment distance and number of signalized intersections with priority enabled intersections located on the route segment are also included.

Table 11 – IC Bus Fuel Consumption

School	Route	Route Distance (mi)	Priority Signalized Intersections		Fuel Consumption (gal)		
			Enabled	Not Enabled	Before	After	% Difference
Manning Oaks Elementary School	AM 1	2.0	4	2	0.3	0.2	-13.7%
	AM 3	1.2	4	0	0.2	0.2	3.9%
	Summary	3.1	8	2	0.5	0.4	-6.4%
Alpharetta High School	AM 1	3.5	7	0	0.4	0.4	-15.7%
	AM 3	1.5	2	0	0.2	0.2	-4.7%
	Summary	5.1	9	0	0.7	0.6	-11.9%
Webb Bridge Middle School	AM 1	3.8	3	0	0.6	0.5	-4.5%
	AM 3	3.3	3	0	0.5	0.5	-4.5%
	AM 4	5.7	14	1	0.7	0.6	-14.3%
	Summary	12.8	20	1	1.8	1.6	-8.4%
All AM Routes		21.0	37	3	2.9	2.7	-8.9%
Manning Oaks Elementary School	PM 1	2.4	4	2	0.4	0.4	-1.8%
	PM 2	0.9	1	0	0.1	0.1	-6.0%
	Summary	3.3	5	2	0.5	0.5	-2.7%
Alpharetta High School	PM 1	2.6	7	0	0.4	0.3	-12.6%
	PM 2	2.4	4	0	0.4	0.3	-9.2%
	Summary	4.9	11	0	0.7	0.7	-11.0%
Webb Bridge Middle School	PM 1	1.1	3	0	0.2	0.2	-11.8%
	PM 2	2.3	2	0	0.7	0.7	1.4%
	PM 4	7.3	12	1	0.3	0.3	0.9%
	Summary	10.7	17	1	1.2	1.2	-0.9%
All PM Routes		19.0	33	3	2.5	2.3	-4.3%
All IC Bus Routes		40.0	70	6	5.4	5.0	-6.8%

Table 12 – Blue Bird Bus Fuel Consumption

School	Route	Route Distance (mi)	Priority Signalized Intersections		Fuel Consumption (gal)		
			Enabled	Not Enabled	Before	After	% Change
Manning Oaks Elementary School	AM 1	4.9	6	0	0.9	0.8	-5.5%
	AM 3	2.7	7	1	0.7	0.7	-1.8%
	Summary	7.6	13	1	1.6	1.5	-3.9%
Alpharetta High School	AM 1	4.1	13	0	1.0	0.8	-20.7%
	AM 3	3.7	10	0	0.8	0.7	-16.4%
	Summary	7.8	23	0	1.8	1.5	-18.7%
Webb Bridge Middle School	AM 1	4.4	9	1	0.9	0.8	-10.4%
	AM 3	3.0	4	2	0.5	0.5	-0.2%
	AM 4	5.7	14	1	1.1	1.0	-9.4%
	Summary	13.1	27	4	2.5	2.3	-8.0%
All AM Routes		28.5	63	5	5.9	5.3	-10.2%
Manning Oaks Elementary School	PM 1	4.0	9	1	0.7	0.8	12.6%
	PM 2	2.2	5	1	0.6	0.5	-16.9%
	Summary	6.2	14	2	1.3	1.3	-0.7%
Alpharetta High School	PM 1	2.4	7	1	0.6	0.6	-11.5%
	PM 2	4.2	10	0	1.0	0.8	-12.9%
	Summary	6.7	17	1	1.6	1.4	-12.3%
Webb Bridge Middle School	PM 1	2.8	4	0	0.8	0.8	-6.1%
	PM 2	3.1	3	2	1.3	1.3	-0.2%
	PM 4	5.3	9	2	0.5	0.5	1.5%
	Summary	11.1	16	4	2.6	2.6	-1.7%
All PM Routes		24.0	47	7	5.6	5.3	-4.5%
All Bluebird Bus Routes		52.5	110	12	11.4	10.6	-7.4%

As a result of the Pilot Program, a large majority of the route segments showed a significant improvement, or decrease, in the average fuel consumption between the before and after analysis period. The IC Bus saw a decrease in average fuel consumption on all routes from 5.4 gallons to 5.0 gallons, or 6.8%, and the Blue Bird Bus saw a decrease in average fuel consumption from 11.4 gallons to 10.6 gallons, or 7.4%. The overall improvement, or decrease, in average fuel consumption for both school buses included in the Pilot Program was 7.2%.

AVERAGE EMISSIONS

Table 13 and **Table 14** show the average emissions for each individual route segment for all AM and PM routes for the IC Bus and Blue Bird Bus respectively. The change in average emissions between the before and after analysis period as a result of the Pilot Program is shown in the last column as a percent change with an increase in performance shown in green and a decrease in performance shown in red. For context, the route segment distance and number of signalized intersections with priority enabled intersections located on the route segment are also included.

Table 13 – IC Bus Emissions

School	Route	Route Distance (mi)	Priority Signalized Intersections		Emissions (lb CO ₂)		
			Enabled	Not Enabled	Before	After	% Change
Manning Oaks Elementary School	AM 1	2.0	4	2	6.2	5.4	-13.7%
	AM 3	1.2	4	0	4.4	4.6	3.9%
	Summary	3.1	8	2	10.6	9.9	-6.4%
Alpharetta High School	AM 1	3.5	7	0	9.8	8.2	-15.7%
	AM 3	1.5	2	0	5.1	4.9	-4.7%
	Summary	5.1	9	0	14.9	13.2	-11.9%
Webb Bridge Middle School	AM 1	3.8	3	0	12.7	12.1	-4.5%
	AM 3	3.3	3	0	11.6	11.1	-4.5%
	AM 4	5.7	14	1	15.9	13.6	-14.3%
	Summary	12.8	20	1	40.2	36.9	-8.4%
All AM Routes		21.0	37	3	65.8	59.9	-8.9%
Manning Oaks Elementary School	PM 1	2.4	4	2	9.3	9.2	-1.8%
	PM 2	0.9	1	0	2.5	2.4	-6.0%
	Summary	3.3	5	2	11.8	11.5	-2.7%
Alpharetta High School	PM 1	2.6	7	0	8.5	7.5	-12.6%
	PM 2	2.4	4	0	8.0	7.2	-9.2%
	Summary	4.9	11	0	16.5	14.7	-11.0%
Webb Bridge Middle School	PM 1	1.1	3	0	4.4	3.9	-11.8%
	PM 2	2.3	2	0	16.5	16.8	1.4%
	PM 4	7.3	12	1	5.9	6.0	0.9%
	Summary	10.7	17	1	26.8	26.6	-0.9%
All PM Routes		19.0	33	3	55.2	52.8	-4.3%
All IC Bus Routes		40.0	70	6	120.9	112.8	-6.8%

Table 14 – Blue Bird Bus Emissions

School	Route	Route Distance (mi)	Priority Signalized Intersections		Emissions (lb CO ₂)		
			Enabled	Not Enabled	Before	After	% Change
Manning Oaks Elementary School	AM 1	4.9	6	0	11.1	10.5	-5.5%
	AM 3	2.7	7	1	8.6	8.5	-1.8%
	Summary	7.6	13	1	19.7	18.9	-3.9%
Alpharetta High School	AM 1	4.1	13	0	12.2	9.6	-20.7%
	AM 3	3.7	10	0	10.5	8.8	-16.4%
	Summary	7.8	23	0	22.7	18.4	-18.7%
Webb Bridge Middle School	AM 1	4.4	9	1	11.7	10.5	-10.4%
	AM 3	3.0	4	2	6.0	6.0	-0.2%
	AM 4	5.7	14	1	14.6	13.2	-9.4%
	Summary	13.1	27	4	32.3	29.7	-8.0%
All AM Routes		28.5	63	5	74.6	67.1	-10.2%
Manning Oaks Elementary School	PM 1	4.0	9	1	9.3	10.5	12.6%
	PM 2	2.2	5	1	7.7	6.4	-16.9%
	Summary	6.2	14	2	17.0	16.9	-0.7%
Alpharetta High School	PM 1	2.4	7	1	8.1	7.1	-11.5%
	PM 2	4.2	10	0	12.2	10.7	-12.9%
	Summary	6.7	17	1	20.3	17.8	-12.3%
Webb Bridge Middle School	PM 1	2.8	4	0	10.4	9.7	-6.1%
	PM 2	3.1	3	2	16.6	16.5	-0.2%
	PM 4	5.3	9	2	6.3	6.4	1.5%
	Summary	11.1	16	4	33.2	32.6	-1.7%
All PM Routes		24.0	47	7	70.5	67.3	-4.5%
All Bluebird Bus Routes		52.5	110	12	145.2	134.4	-7.4%

As a result of the Pilot Program, all but two of the route segments showed a significant improvement, or decrease, in the average fuel consumption between the before and after analysis period. The IC Bus saw a decrease in average emissions on all routes from 120.9 pounds of CO₂ to 112.8 pounds of CO₂, or 6.8%, and the Blue Bird Bus saw a decrease in average fuel consumption from 145.2 pounds of CO₂ to 134.4 pounds of CO₂, or 7.4%. The overall improvement, or decrease, in average fuel consumption for both school buses included in the Pilot Program was 7.1%. The results are similar to the average fuel consumption because emissions were calculated based on fuel consumption. The U.S. EIA estimates that one gallon of diesel fuel consumed is equivalent to 22.5 pounds of CO₂ and that one gallon of propane fuel consumed is equivalent to 12.7 pounds of CO₂.

Average fuel consumption using HEM data is summarized in **Table 15**. The data compares MPG and gallons per 100 miles between the before and after periods for both the IC Bus and the Blue Bird Bus.

Table 15 – HEM Data Average Fuel Consumption

Bus	Metric	Miles per Gallon		
		Before	After	% Change
IC	MPG	5.8	6.3	8.8%
	Gal/100 Miles	17.2	15.8	-8.0%
BB	MPG	3.9	4.2	6.7%
	Gal/100 Miles	25.3	23.8	-6.3%

Both the IC Bus and Blue Bird Bus show a 6-9% improvement in both metrics shown in the table above, MPG and gallons per 100 miles. The largest improvement was seen in MPG for the bus. During the before period, the IC Bus was averaging about 5.8 MPG. After the Pilot Program activation, the IC Bus average increase 8.8% to 6.3 MPG.

CONCLUSION

The Traffic Signal Priority School Bus Safety Connected Vehicle Pilot Program demonstrated significant and measurable improvements in performance across different areas. All five of the performance metrics calculated as part of the before and after analysis saw improvements ranging between 7% and 40%. **Table 16** shows the average improvement in travel time, speed, total number of stops, fuel consumption, and vehicle emissions between the before and after period. IC Bus fuel consumption and vehicle emissions results shown below were obtained from the fuel logs. Blue Bird bus fuel consumption and vehicle emissions results shown below were obtained from the HEM data logger.

Table 16 – FCSS Results Summary

School Bus	Routes	Average Improvement (%)			
		Travel Time	Speed	Number of Stops	Fuel Consumption/ Emissions
IC Bus	AM Routes	-9.0%	11.8%	-41.8%	N/A
	PM Routes	-15.9%	16.9%	-38.6%	N/A
	All Routes	-12.4%	14.2%	-40.2%	-13.4%
Blue Bird Bus	AM Routes	-12.7%	18.0%	-38.7%	-10.2%
	PM Routes	-15.4%	24.2%	-42.3%	-4.5%
	All Routes	-14.0%	20.5%	-40.5%	-7.4%
Program Summary		-13.3%	18.0%	-40.4%	-10.4

A reduction in school bus route travel time, which was often the result of a decrease in total number of stops along the route, can have numerous benefits to the bus driver, the onboard students, and the FCSS as a whole. Bus drivers noted that often times prior to the school bus priority system implemented as part of the Pilot Program, they would run behind schedule and arrive late to stops and/or the school due to traffic congestion and time spent stopped at signalized intersections. The priority system resulted in a significant drop in the total number of times the school bus had to stop along its route, which in turn led to a drop in the time required to complete the route. This allowed drivers to more often get students to school on time and provide them with sufficient time to eat breakfast before beginning class. Better on-time performance and less time running behind schedule reduced stress for the bus driver and allowed them to spend more time focused on safe driving and onboard student behavior.

Experience has shown that students onboard a bus are more likely to stand up and/or engage in unsafe behaviors including rowdiness, noisiness, and conflicts/disagreements more frequently when the bus stops. By reducing the average number of times the bus was required to stop along its route, the Pilot Program was able to reduce the likelihood that students engaged in these types of activities and generally created a more safe environment on the school bus.

APPENDIX A – BUS ROUTE TABLES

Table A-1 shows the bus arrival times for each stop along the IC Bus morning and afternoon routes based on the driver route sheets.

Table A-1 – IC Bus Route Arrival Times

Route	Stops	Arrival Time
AM Elementary	North Fulton Transportation	6:29 AM
	235 Jayne Ellen Way	6:44 AM
	Jayne Ellen Way at Denna Drive	6:44 AM
	Denna Drive at Denna Place	6:45 AM
	Cumming Street at Manning Drive	6:50 AM
	1033 Pine Grove Drive	6:53 AM
	Pine Grove Drive at North Creek Circle	6:53 AM
	Pine Grove Drive at Preston Court	6:54 AM
	North Creek Circle at Ridge Court	6:56 AM
	North Creek Circle at Jessup Court	6:57 AM
	2071 Winthrop Commons	7:01 AM
	Carmel Way	7:02 AM
	N Main Street at Winthrop Chase Drive	7:04 AM
	N Main Street at Edgemont Drive	7:04 AM
	N Main Street at Water Oak Place	7:05 AM
	N Main Street at Archmont Trace	7:06 AM
	789 N Main Street	7:07 AM
Jordan Court at Westfield Drive	7:09 AM	
Manning Oaks Elementary	7:14 AM	
AM High	Manning Oaks Elementary	7:26 AM
	Lake Windward Drive at Lake Windward Overlook	7:31 AM
	Lake Windward Drive at Lake Windward Land	7:31 AM
	Harbour Ridge Drive at Harbour Land	7:32 AM
	Harbour Ridge Drive at Harbour Ridge Run	7:34 AM
	Harbour Ridge Drive at Harbour Ridge Court	7:34 AM
	5170 Harbour Ridge Drive	7:35 AM
	Lake Windward Drive at Longcreek Point	7:36 AM
	Lake Windward Drive at Creek Ridge Point	7:37 AM
	Willow Treeway at Willow Overlook	7:40 AM
	Willow Treeway at Pin Oak Lane	7:40 AM
	Willow Treeway at Wildwood Court	7:41 AM
	Willow Treeway at White Oak Pass	7:42 AM
	White Oak Pass at Stone Creek Court	7:43 AM
	White Oak Pass at Bentwood Trace	7:43 AM
Bentwood Trace at Mossy Place	7:44 AM	
Alpharetta High School	7:49 AM	

Table A-1 – IC Bus Route Arrival Times (continued)

Route	Stops	Arrival Time
AM Middle	Alpharetta High School	8:13 AM
	Newport Bay Pass at Caney Creek Land	8:13 AM
	Newport Bay Pass at Landings Chase	8:15 AM
	Newport Bay Drive at Newport Court	8:16 AM
	Newport Bay Drive at Newport Heights	8:18 AM
	3595 Newport Bay Drive	8:18 AM
	3545 Newport Bay Drive	8:19 AM
	Newport Bay Drive at Newport Freeway	8:20 AM
	Newport Bay Pass at Linkside Drive	8:21 AM
	Webb Bridge Middle School	8:33 AM
	North Fulton Transportation	8:50 AM
PM Elementary	North Fulton Transportation	1:45 PM
	Manning Oaks Elementary	2:08 PM
	Manning Oaks Elementary	2:33 PM
	235 Jayne Ellen Way	2:35 PM
	Jayne Ellen Way at John Christopher Dr	2:36 PM
	Jayne Ellen Way at Denna Drive	2:36 PM
	Denna Drive at Denna Place	2:36 PM
	Cumming Street at Manning Drive	2:40 PM
	1033 Pine Grove Drive	2:43 PM
	Pine Grove Drive at North Creek Circle	2:44 PM
	Pine Grove Drive at Preston Court	2:45 PM
	North Creek Circle at Ridge Court	2:46 PM
	North Creek Circle at Jessup Court	2:47 PM
	2071 Winthrope Commons	2:51 PM
	Carmel Way	2:52 PM
	N Main Street at Winthrope Chase Drive	2:54 PM
	N Main Street at Edgemont Drive	2:54 PM
	N Main Street at Water Oak Place	2:55 PM
	N Main Street at Archmont Trace	2:56 PM
789 N Main Street	2:56 PM	
Jordan Court at Westfield Drive	2:59 PM	
Alpharetta High School	3:10 PM	

Table A-1 – IC Bus Route Arrival Times (continued)

Route	Stops	Arrival Time
PM High	Alpharetta High School	3:37 PM
	Lake Windward Drive at Lake Windward Overlook	3:47 PM
	Lake Windward Drive at Lake Windward Land	3:48 PM
	Harbour Ridge Drive at Harbour Land	3:49 PM
	Harbour Ridge Drive at Harbour Overlook	3:50 PM
	Harbour Ridge Drive at Harbour Ridge Run	3:50 PM
	Harbour Ridge Drive at Harbour Ridge Court	3:51 PM
	5170 Harbour Ridge Drive	3:51 PM
	Lake Windward Drive at Longcreek Point	3:53 PM
	Lake Windward Drive at Creek Ridge Point	3:53 PM
	2088 Lake Windward Drive	3:55 PM
	Willow Tree Way at Willow Overlook	3:56 PM
	Willow Tree Way at Pin Oak Lane	3:56 PM
	Willow Tree Way at Wildwood Court	3:56 PM
	Willow Tree Way at White Oak Pass	3:57 PM
	Willow Tree Way at Stone Creek Court	3:58 PM
	White Oak Pass at Bentwood Trace	3:59 PM
	Bentwood Trace at Mossy Place	3:59 PM
Webb Bridge Middle School	4:05 PM	
PM Middle	Webb Bridge Middle School	4:20 PM
	Newport Bay Passage at Caney Creek Landing	4:30 PM
	Newport Bay Passage at Landings Chase	4:31 PM
	Newport Bay Drive at Newport Court	4:33 PM
	Newport Bay Drive at Newport Shore	4:34 PM
	Newport Bay Drive at Newport Heights	4:35 PM
	3595 Newport Bay Drive	4:35 PM
	3545 Newport Bay Drive	4:36 PM
	Newport Bay Drive at Newport Freeway	4:37 PM
	Newport Bay Passage at Linkside Drive	4:37 PM
	North Fulton Transportation	5:00 PM

Table A-2 shows the bus arrival times for each stop along the Blue Bird Bus morning and afternoon routes based on the driver route sheets.

Table A-2 – Blue Bird Bus Route Arrival Times

Route	Stops	Arrival Time
AM Elementary	North Fulton Transportation	5:54 AM
	Economy Hotel	6:19 AM
	Encore Parkway at Overture Drive	6:33 AM
	Old Roswell Road at Heyward Lane	6:37 AM
	Echo at Northpoint	6:40 AM
	Fanfare Way at Arts Summit	6:42 AM
	Fanfare Way at Forte Lane	6:43 AM
	Heights at Northwinds	6:49 AM
	7925 Westside Parkway	6:51 AM
	Avery at Northwinds (East)	6:52 AM
	Kimball Bridge Road at Stratham Drive	6:55 AM
	Northwinds Parkway at Ellis Avenue	6:57 AM
	Northwinds Parkway at Rowan Avenue	6:59 AM
	Manning Oaks Elementary	7:12 AM
AM High	Manning Oaks Elementary	7:19 AM
	1205 Beacon Hill Crossing	7:30 AM
	Beacon Hill Way at Wynridge Crossing	7:31 AM
	Wynridge Crossing at Wynridge Path	7:33 AM
	Wynridge Crossing at Wynridge Pointe	7:34 AM
	Wynridge Crossing at Hillcrest Heights	7:34 AM
	Windward Parkway at Admiral Crossing	7:36 AM
	Alpharetta High School	7:50 AM
AM Middle	Alpharetta High School	8:08 AM
	Barnesley Lane at Garrick Point	8:08 AM
	Barnesley Lane at N St Phillip Lane	8:09 AM
	Barnesley Lane at Crofters Pass	8:12 AM
	Barnesley Lane at Longstone Landing	8:13 AM
	Hebden Bridge Lane at Great Rissington Way	8:15 AM
	Hebden Bridge Lane at Culworth Manor	8:16 AM
	Hebden Bridge Lane at Ebley Place	8:17 AM
	Hebden Bridge Lane at Tivdale Court	8:18 AM
	Hebden Bridge Lane at Hollymount Road	8:19 AM
	Webb Bridge Middle School	8:28 AM
	North Fulton Transportation	8:55 AM

Table A-2 – Blue Bird Bus Route Arrival Times (continued)

Route	Stops	Arrival Time
PM Elementary	North Fulton Transportation	2:00 PM
	Manning Oaks Elementary	2:35 PM
	Kimball Bridge Road at Stratham Drive	2:43 PM
	Northwinds Parkway at Ellis Avenue	2:45 PM
	Northwinds Parkway at Rowan Avenue	2:47 PM
	Encore Parkway at Overture Drive	2:51 PM
	Old Roswell Road at Heyward Lane	2:55 PM
	Echo at Northpoint	2:58 PM
	Fanfare Way at Arts Summit	3:00 PM
	Fanfare Way at Forte Lane	3:01 PM
	Heights at Northwinds	3:07 PM
	7925 Westside Parkway	3:09 PM
	Avery at Northwinds (East)	3:09 PM
	Alpharetta High School	3:12 PM
PM High	Alpharetta High School	3:37 PM
	1205 Beacon Hill Crossing	3:50 PM
	Beacon Hill Way at Wynridge Crossing	3:53 PM
	Wynridge Crossing at Wynridge Path	3:55 PM
	Wynridge Crossing at Wynridge Pointe	3:56 PM
	Wynridge Crossing at Hillcrest Heights	3:57 PM
	Windward Parkway at Admiral Crossing	3:59 PM
Webb Bridge Middle School	4:00 PM	
PM Middle	Webb Bridge Middle School	4:10 PM
	Barnesley Lane at Garrick Point	4:29 PM
	Barnesley Lane at N St Phillip Lane	4:30 PM
	Barnesley Lane at Crofters Pass	4:32 PM
	Barnesley Lane at Longstone Landing	4:33 PM
	Hebden Bridge Lane at Great Rissington Way	4:34 PM
	Hebden Bridge Lane at Culworth Manor	4:35 PM
	Hebden Bridge Lane at Ebley Place	4:36 PM
	Hebden Bridge Lane at Tivdale Court	4:37 PM
	Hebden Bridge Lane at Hollymount Road	4:38 PM
	North Fulton Transportation	4:55 PM

APPENDIX B – ROUTE MAPS

APPENDIX A – BUS ROUTE TABLES

Table A-1 shows the bus arrival times for each stop along the IC Bus morning and afternoon routes based on the driver route sheets.

Table A-1 – IC Bus Route Arrival Times

Route	Stops	Arrival Time
AM Elementary	North Fulton Transportation	6:29 AM
	235 Jayne Ellen Way	6:44 AM
	Jayne Ellen Way at Denna Drive	6:44 AM
	Denna Drive at Denna Place	6:45 AM
	Cumming Street at Manning Drive	6:50 AM
	1033 Pine Grove Drive	6:53 AM
	Pine Grove Drive at North Creek Circle	6:53 AM
	Pine Grove Drive at Preston Court	6:54 AM
	North Creek Circle at Ridge Court	6:56 AM
	North Creek Circle at Jessup Court	6:57 AM
	2071 Winthrope Commons	7:01 AM
	Carmel Way	7:02 AM
	N Main Street at Winthrope Chase Drive	7:04 AM
	N Main Street at Edgemont Drive	7:04 AM
	N Main Street at Water Oak Place	7:05 AM
	N Main Street at Archmont Trace	7:06 AM
	789 N Main Street	7:07 AM
Jordan Court at Westfield Drive	7:09 AM	
Manning Oaks Elementary	7:14 AM	
AM High	Manning Oaks Elementary	7:26 AM
	Lake Windward Drive at Lake Windward Overlook	7:31 AM
	Lake Windward Drive at Lake Windward Land	7:31 AM
	Harbour Ridge Drive at Harbour Land	7:32 AM
	Harbour Ridge Drive at Harbour Ridge Run	7:34 AM
	Harbour Ridge Drive at Harbour Ridge Court	7:34 AM
	5170 Harbour Ridge Drive	7:35 AM
	Lake Windward Drive at Longcreek Point	7:36 AM
	Lake Windward Drive at Creek Ridge Point	7:37 AM
	Willow Treeway at Willow Overlook	7:40 AM
	Willow Treeway at Pin Oak Lane	7:40 AM
	Willow Treeway at Wildwood Court	7:41 AM
	Willow Treeway at White Oak Pass	7:42 AM
	White Oak Pass at Stone Creek Court	7:43 AM
	White Oak Pass at Bentwood Trace	7:43 AM
Bentwood Trace at Mossy Place	7:44 AM	

Route	Stops	Arrival Time
	Alpharetta High School	7:49 AM

Table A-1 – IC Bus Route Arrival Times (continued)

Route	Stops	Arrival Time
AM Middle	Alpharetta High School	8:13 AM
	Newport Bay Pass at Caney Creek Land	8:13 AM
	Newport Bay Pass at Landings Chase	8:15 AM
	Newport Bay Drive at Newport Court	8:16 AM
	Newport Bay Drive at Newport Heights	8:18 AM
	3595 Newport Bay Drive	8:18 AM
	3545 Newport Bay Drive	8:19 AM
	Newport Bay Drive at Newport Freeway	8:20 AM
	Newport Bay Pass at Linkside Drive	8:21 AM
	Webb Bridge Middle School	8:33 AM
	North Fulton Transportation	8:50 AM
PM Elementary	North Fulton Transportation	1:45 PM
	Manning Oaks Elementary	2:08 PM
	Manning Oaks Elementary	2:33 PM
	235 Jayne Ellen Way	2:35 PM
	Jayne Ellen Way at John Christopher Dr	2:36 PM
	Jayne Ellen Way at Denna Drive	2:36 PM
	Denna Drive at Denna Place	2:36 PM
	Cumming Street at Manning Drive	2:40 PM
	1033 Pine Grove Drive	2:43 PM
	Pine Grove Drive at North Creek Circle	2:44 PM
	Pine Grove Drive at Preston Court	2:45 PM
	North Creek Circle at Ridge Court	2:46 PM
	North Creek Circle at Jessup Court	2:47 PM
	2071 Winthrope Commons	2:51 PM
	Carmel Way	2:52 PM
	N Main Street at Winthrope Chase Drive	2:54 PM
	N Main Street at Edgemont Drive	2:54 PM
	N Main Street at Water Oak Place	2:55 PM
	N Main Street at Archmont Trace	2:56 PM
	789 N Main Street	2:56 PM
Jordan Court at Westfield Drive	2:59 PM	
Alpharetta High School	3:10 PM	

Table A-1 – IC Bus Route Arrival Times (continued)

Route	Stops	Arrival Time
PM High	Alpharetta High School	3:37 PM
	Lake Windward Drive at Lake Windward Overlook	3:47 PM
	Lake Windward Drive at Lake Windward Land	3:48 PM
	Harbour Ridge Drive at Harbour Land	3:49 PM
	Harbour Ridge Drive at Harbour Overlook	3:50 PM
	Harbour Ridge Drive at Harbour Ridge Run	3:50 PM
	Harbour Ridge Drive at Harbour Ridge Court	3:51 PM
	5170 Harbour Ridge Drive	3:51 PM
	Lake Windward Drive at Longcreek Point	3:53 PM
	Lake Windward Drive at Creek Ridge Point	3:53 PM
	2088 Lake Windward Drive	3:55 PM
	Willow Tree Way at Willow Overlook	3:56 PM
	Willow Tree Way at Pin Oak Lane	3:56 PM
	Willow Tree Way at Wildwood Court	3:56 PM
	Willow Tree Way at White Oak Pass	3:57 PM
	Willow Tree Way at Stone Creek Court	3:58 PM
	White Oak Pass at Bentwood Trace	3:59 PM
	Bentwood Trace at Mossy Place	3:59 PM
Webb Bridge Middle School	4:05 PM	
PM Middle	Webb Bridge Middle School	4:20 PM
	Newport Bay Passage at Caney Creek Landing	4:30 PM
	Newport Bay Passage at Landings Chase	4:31 PM
	Newport Bay Drive at Newport Court	4:33 PM
	Newport Bay Drive at Newport Shore	4:34 PM
	Newport Bay Drive at Newport Heights	4:35 PM
	3595 Newport Bay Drive	4:35 PM
	3545 Newport Bay Drive	4:36 PM
	Newport Bay Drive at Newport Freeway	4:37 PM
	Newport Bay Passage at Linkside Drive	4:37 PM
	North Fulton Transportation	5:00 PM

Table A-2 shows the bus arrival times for each stop along the Blue Bird Bus morning and afternoon routes based on the driver route sheets.

Table A-2 – Blue Bird Bus Route Arrival Times

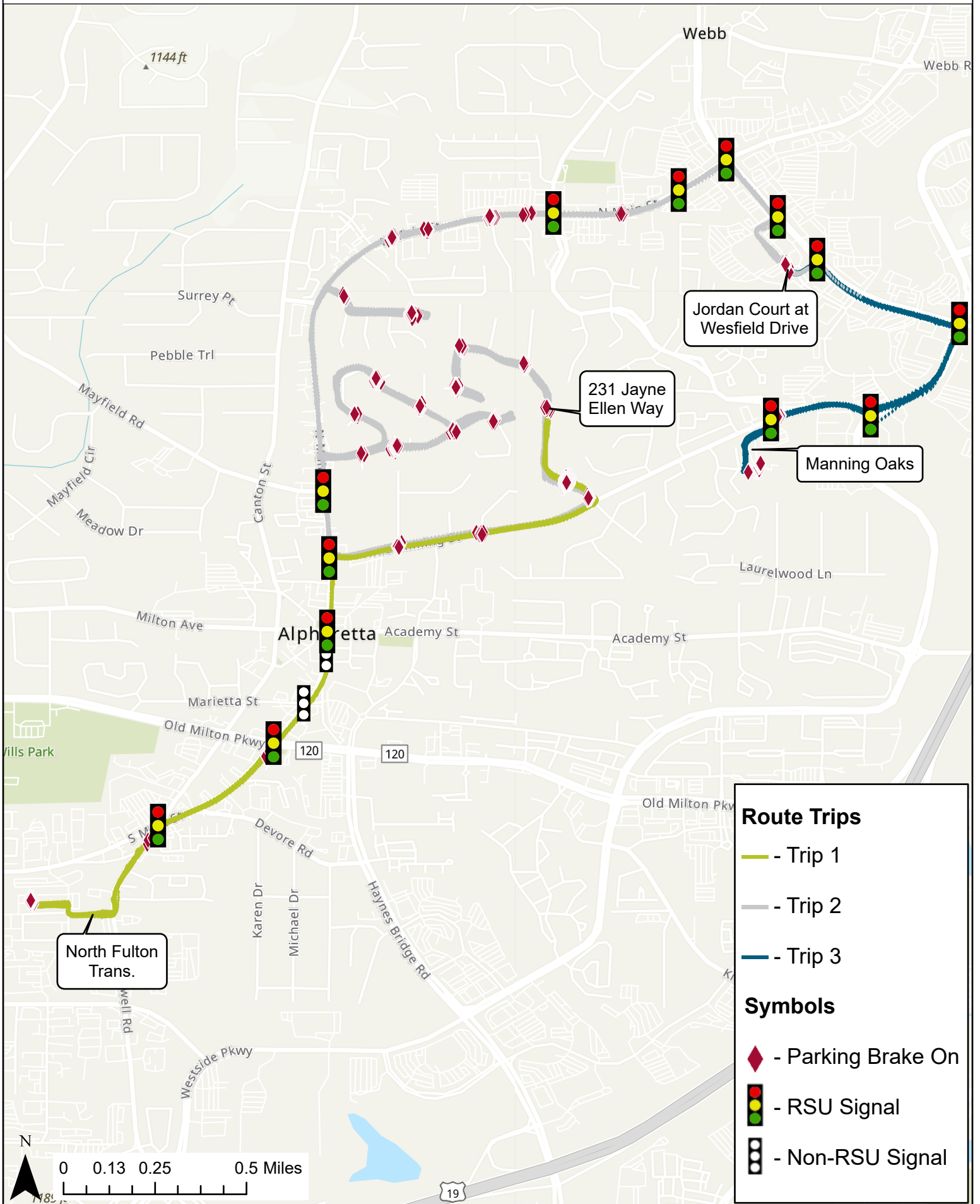
Route	Stops	Arrival Time
AM Elementary	North Fulton Transportation	5:54 AM
	Economy Hotel	6:19 AM
	Encore Parkway at Overture Drive	6:33 AM
	Old Roswell Road at Heyward Lane	6:37 AM
	Echo at Northpoint	6:40 AM
	Fanfare Way at Arts Summit	6:42 AM
	Fanfare Way at Forte Lane	6:43 AM
	Heights at Northwinds	6:49 AM
	7925 Westside Parkway	6:51 AM
	Avery at Northwinds (East)	6:52 AM
	Kimball Bridge Road at Stratham Drive	6:55 AM
	Northwinds Parkway at Ellis Avenue	6:57 AM
	Northwinds Parkway at Rowan Avenue	6:59 AM
	Manning Oaks Elementary	7:12 AM
AM High	Manning Oaks Elementary	7:19 AM
	1205 Beacon Hill Crossing	7:30 AM
	Beacon Hill Way at Wynridge Crossing	7:31 AM
	Wynridge Crossing at Wynridge Path	7:33 AM
	Wynridge Crossing at Wynridge Pointe	7:34 AM
	Wynridge Crossing at Hillcrest Heights	7:34 AM
	Windward Parkway at Admiral Crossing	7:36 AM
	Alpharetta High School	7:50 AM
AM Middle	Alpharetta High School	8:08 AM
	Barnesley Lane at Garrick Point	8:08 AM
	Barnesley Lane at N St Phillip Lane	8:09 AM
	Barnesley Lane at Crofters Pass	8:12 AM
	Barnesley Lane at Longstone Landing	8:13 AM
	Hebden Bridge Lane at Great Rissington Way	8:15 AM
	Hebden Bridge Lane at Culworth Manor	8:16 AM
	Hebden Bridge Lane at Ebley Place	8:17 AM
	Hebden Bridge Lane at Tividale Court	8:18 AM
	Hebden Bridge Lane at Hollymount Road	8:19 AM
	Webb Bridge Middle School	8:28 AM
	North Fulton Transportation	8:55 AM

Table A-2 – Blue Bird Bus Route Arrival Times (continued)

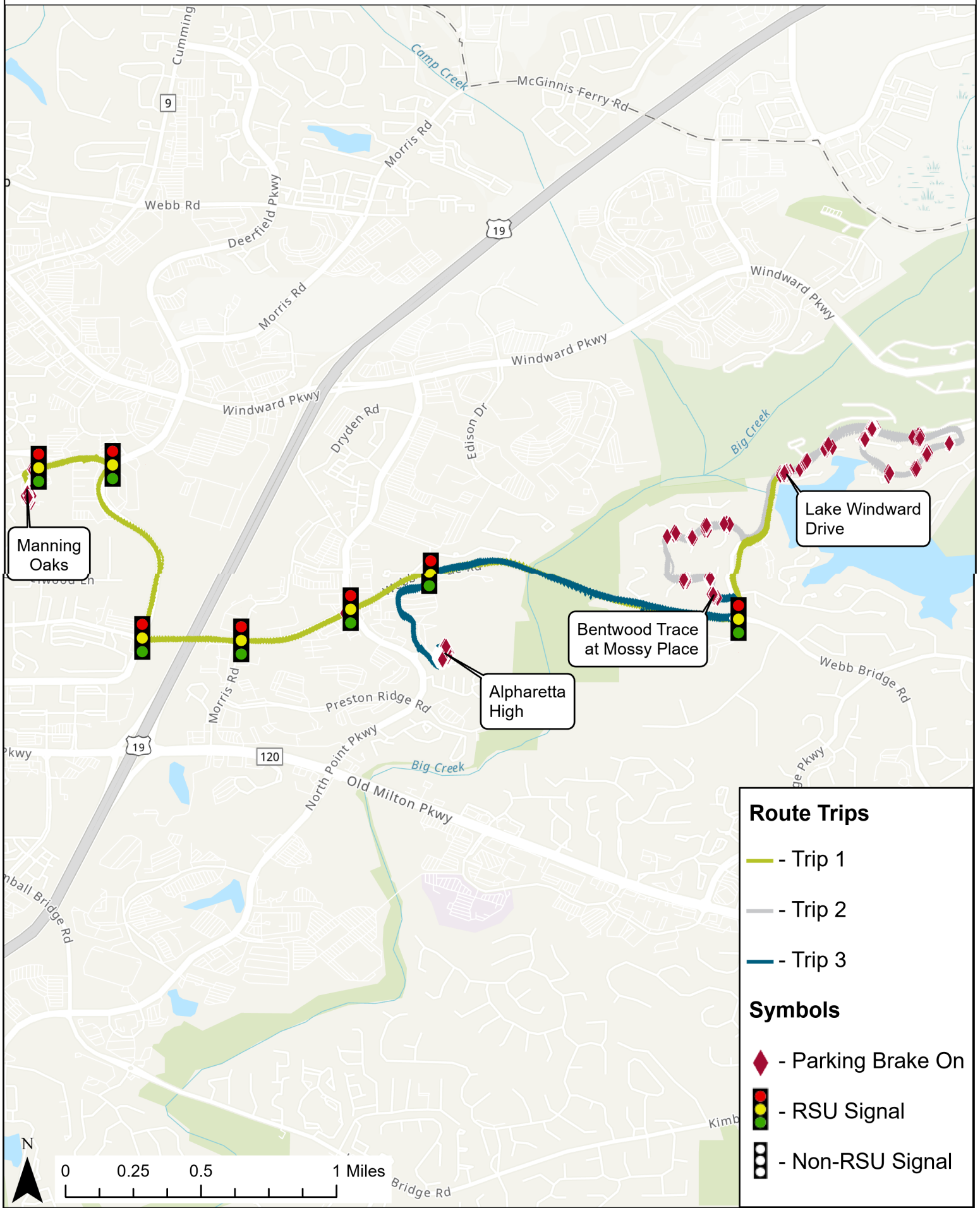
Route	Stops	Arrival Time
PM Elementary	North Fulton Transportation	2:00 PM
	Manning Oaks Elementary	2:35 PM
	Kimball Bridge Road at Stratham Drive	2:43 PM
	Northwinds Parkway at Ellis Avenue	2:45 PM
	Northwinds Parkway at Rowan Avenue	2:47 PM
	Encore Parkway at Overture Drive	2:51 PM
	Old Roswell Road at Heyward Lane	2:55 PM
	Echo at Northpoint	2:58 PM
	Fanfare Way at Arts Summit	3:00 PM
	Fanfare Way at Forte Lane	3:01 PM
	Heights at Northwinds	3:07 PM
	7925 Westside Parkway	3:09 PM
	Avery at Northwinds (East)	3:09 PM
	Alpharetta High School	3:12 PM
PM High	Alpharetta High School	3:37 PM
	1205 Beacon Hill Crossing	3:50 PM
	Beacon Hill Way at Wynridge Crossing	3:53 PM
	Wynridge Crossing at Wynridge Path	3:55 PM
	Wynridge Crossing at Wynridge Pointe	3:56 PM
	Wynridge Crossing at Hillcrest Heights	3:57 PM
	Windward Parkway at Admiral Crossing	3:59 PM
	Webb Bridge Middle School	4:00 PM
PM Middle	Webb Bridge Middle School	4:10 PM
	Barnesley Lane at Garrick Point	4:29 PM
	Barnesley Lane at N St Phillip Lane	4:30 PM
	Barnesley Lane at Crofters Pass	4:32 PM
	Barnesley Lane at Longstone Landing	4:33 PM
	Hebden Bridge Lane at Great Rissington Way	4:34 PM
	Hebden Bridge Lane at Culworth Manor	4:35 PM
	Hebden Bridge Lane at Ebley Place	4:36 PM
	Hebden Bridge Lane at Tividale Court	4:37 PM
	Hebden Bridge Lane at Hollymount Road	4:38 PM
	North Fulton Transportation	4:55 PM

APPENDIX B – ROUTE MAPS

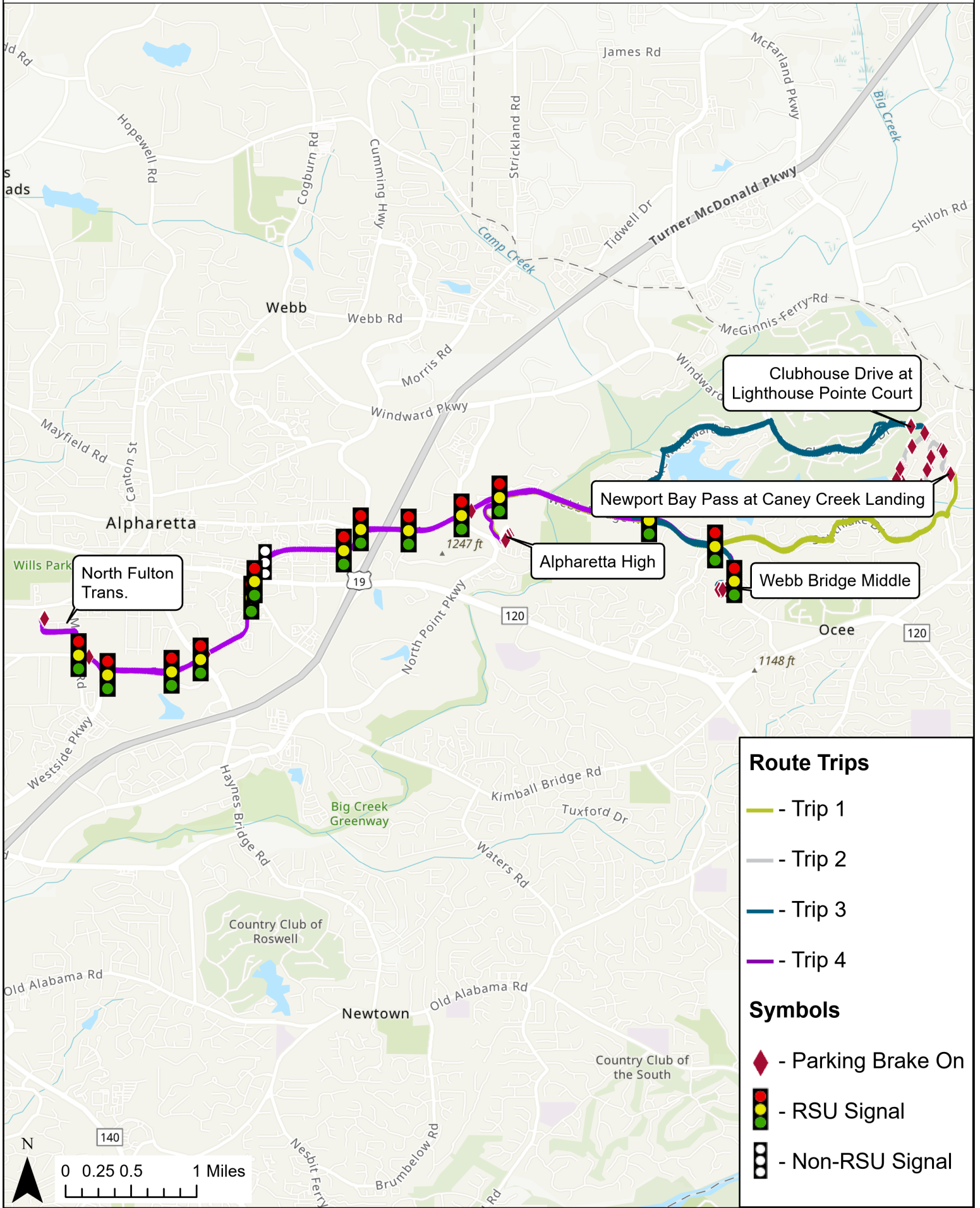
IC Bus - AM Elementary Route



IC | Bus - AM High Route



IC Bus - AM Middle Route



Clubhouse Drive at Lighthouse Pointe Court

Newport Bay Pass at Caney Creek Landing

Alpharetta High

Webb Bridge Middle

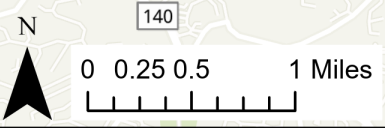
North Fulton Trans.

Route Trips

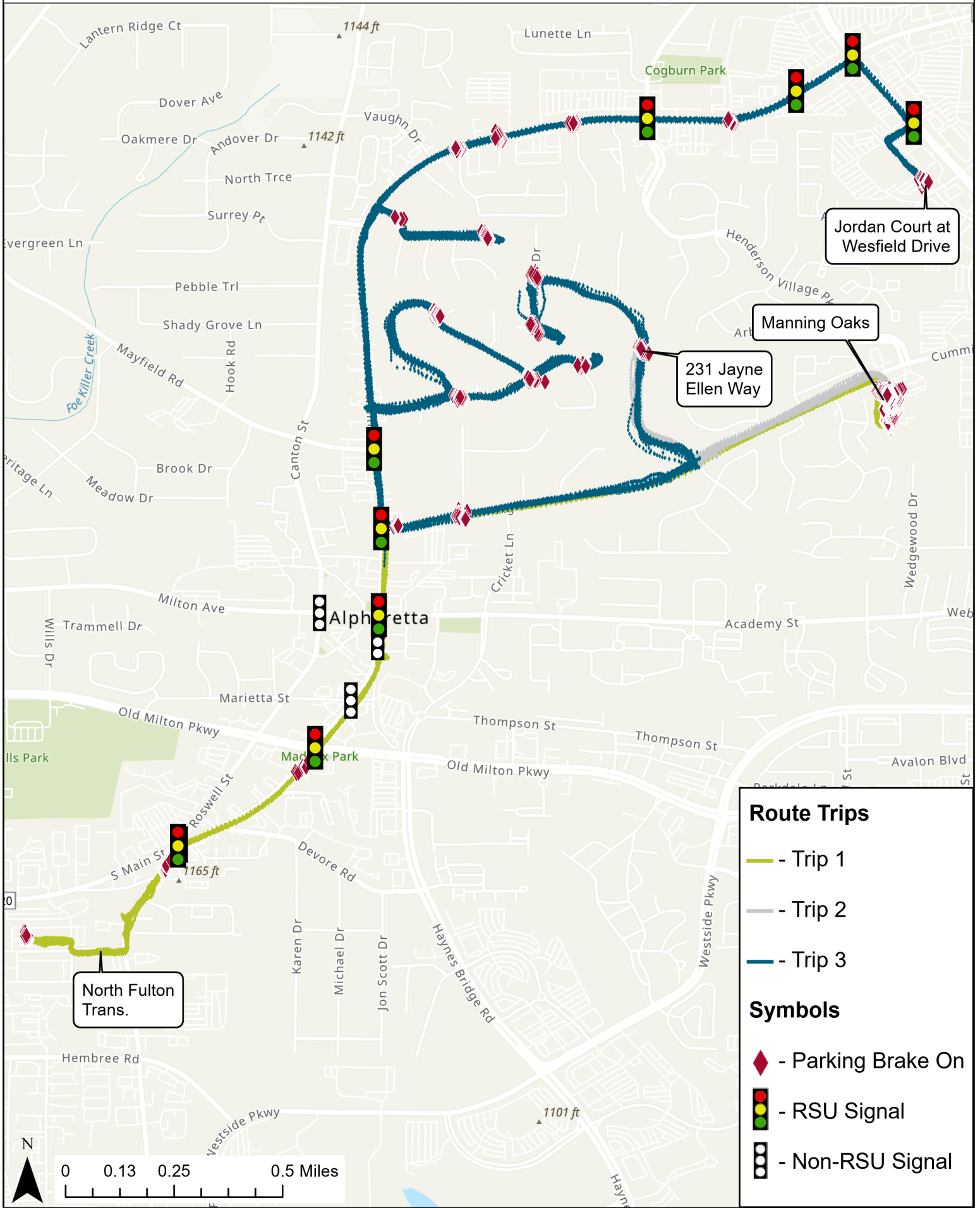
- - Trip 1
- - Trip 2
- - Trip 3
- - Trip 4

Symbols

- ◆ - Parking Brake On
- 🚦 - RSU Signal
- 🚦 - Non-RSU Signal



IC Bus - PM Elementary Route



North Fulton Trans.

Jordan Court at Wesfield Drive

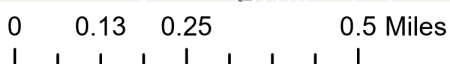
Manning Oaks

231 Jayne Ellen Way

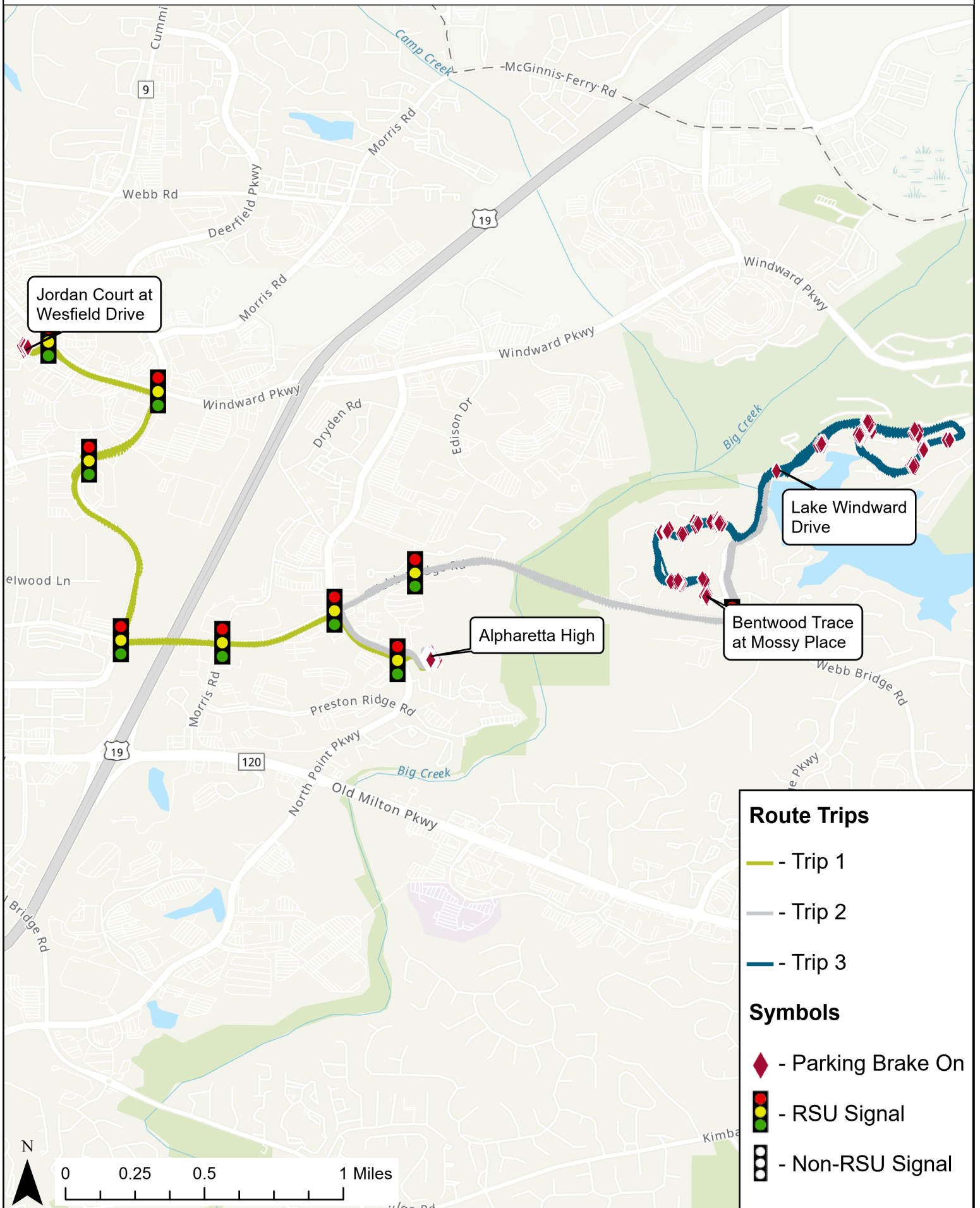
Alpharetta

Marjorie Park

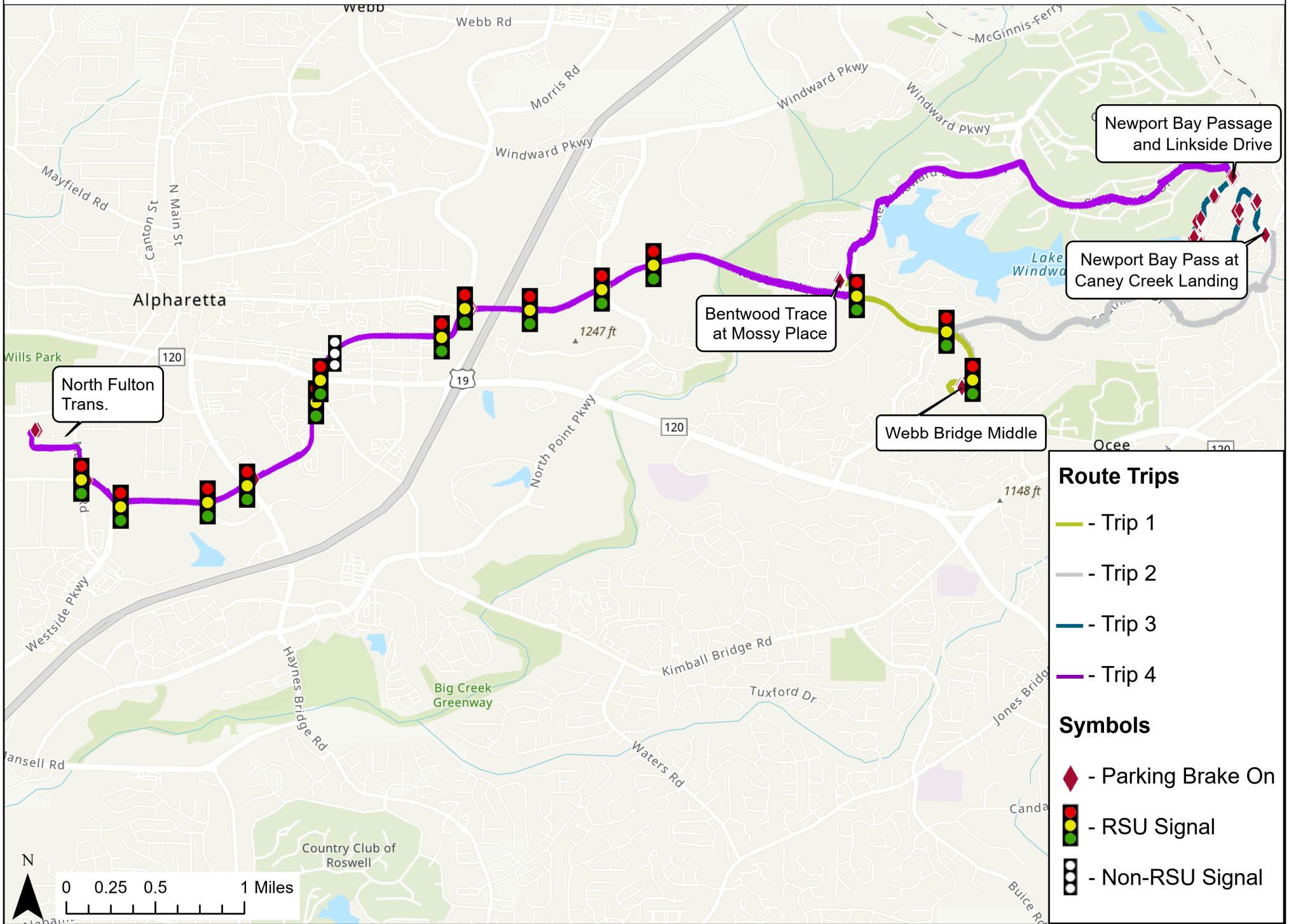
Cogburn Park



IC Bus - PM High Route



IC Bus - PM Middle Route



Newport Bay Passage and Linkside Drive

Newport Bay Pass at Caney Creek Landing

Bentwood Trace at Mossy Place



Webb Bridge Middle

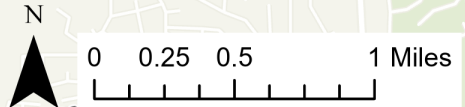
North Fulton Trans.

Route Trips

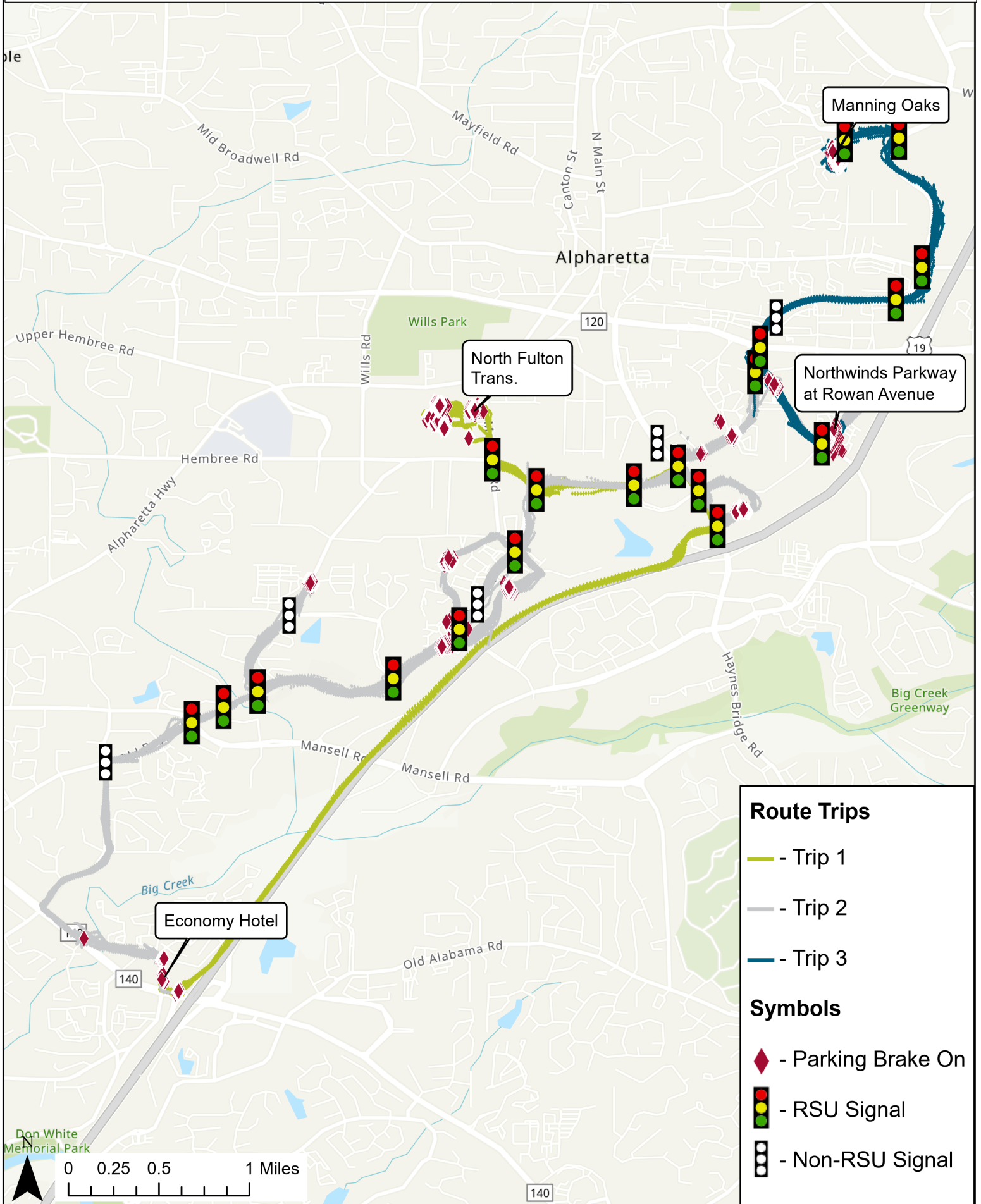
- - Trip 1
- - Trip 2
- - Trip 3
- - Trip 4

Symbols

- ◆ - Parking Brake On
-  - RSU Signal
-  - Non-RSU Signal





Blue Bird Bus - AM Elementary Route

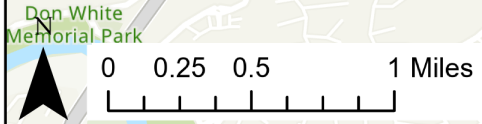


Route Trips

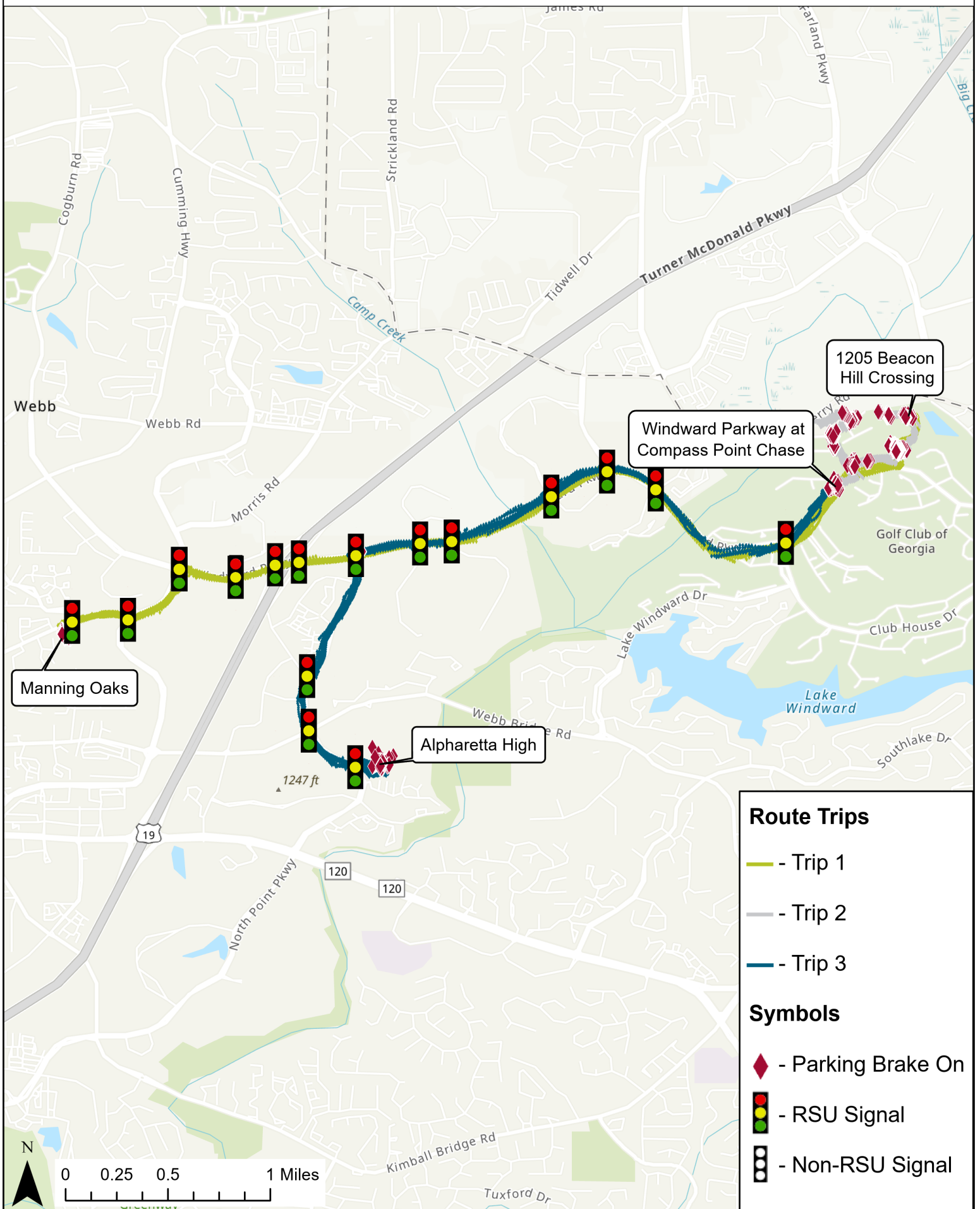
- - Trip 1
- - Trip 2
- - Trip 3

Symbols

- ◆ - Parking Brake On
-  - RSU Signal
-  - Non-RSU Signal



Blue Bird Bus - AM High Route



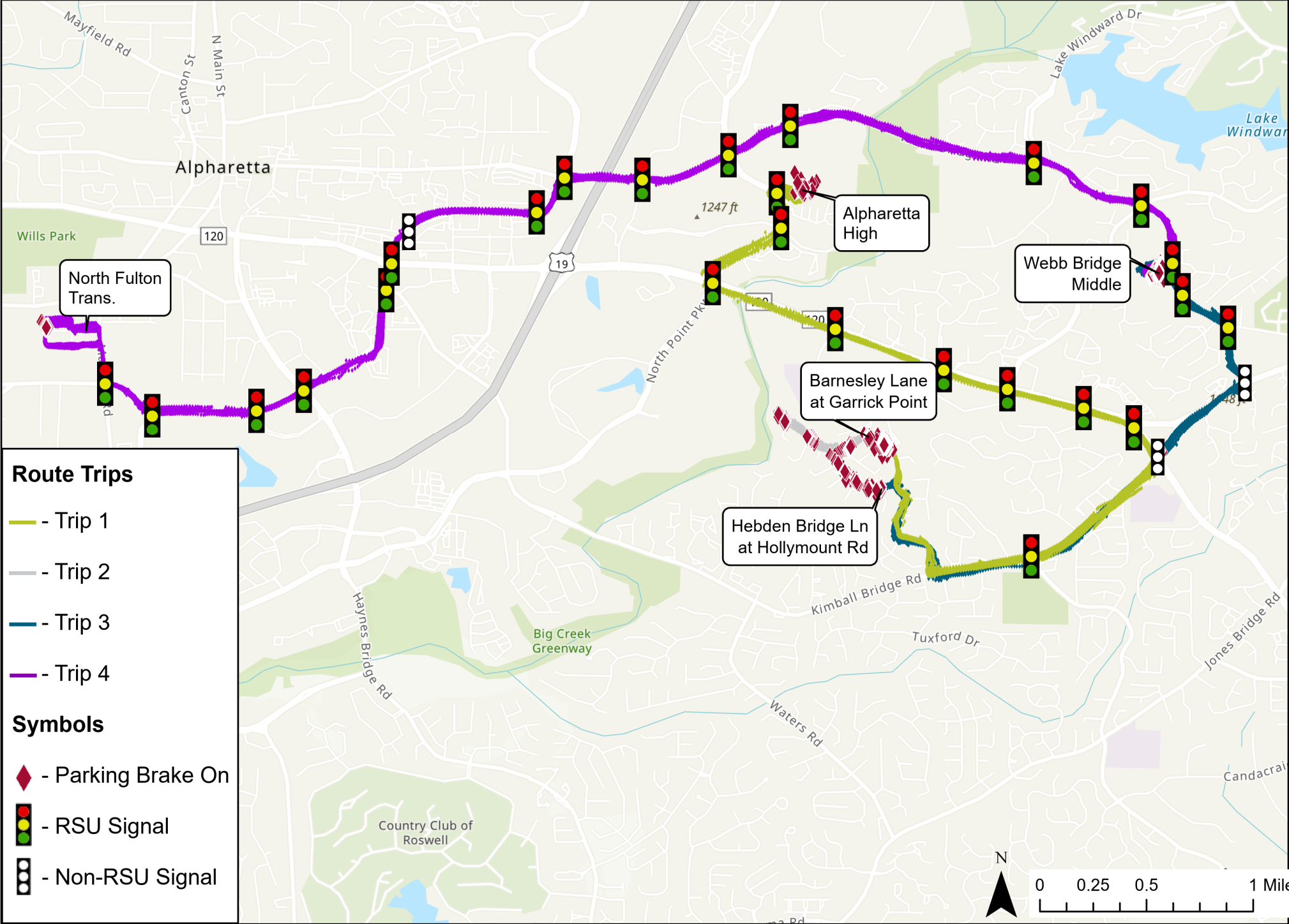
Route Trips

- - Trip 1
- - Trip 2
- - Trip 3

Symbols

- ◆ - Parking Brake On
- ●
● - RSU Signal
- - Non-RSU Signal



Blue Bird Bus - AM Middle Route



Route Trips

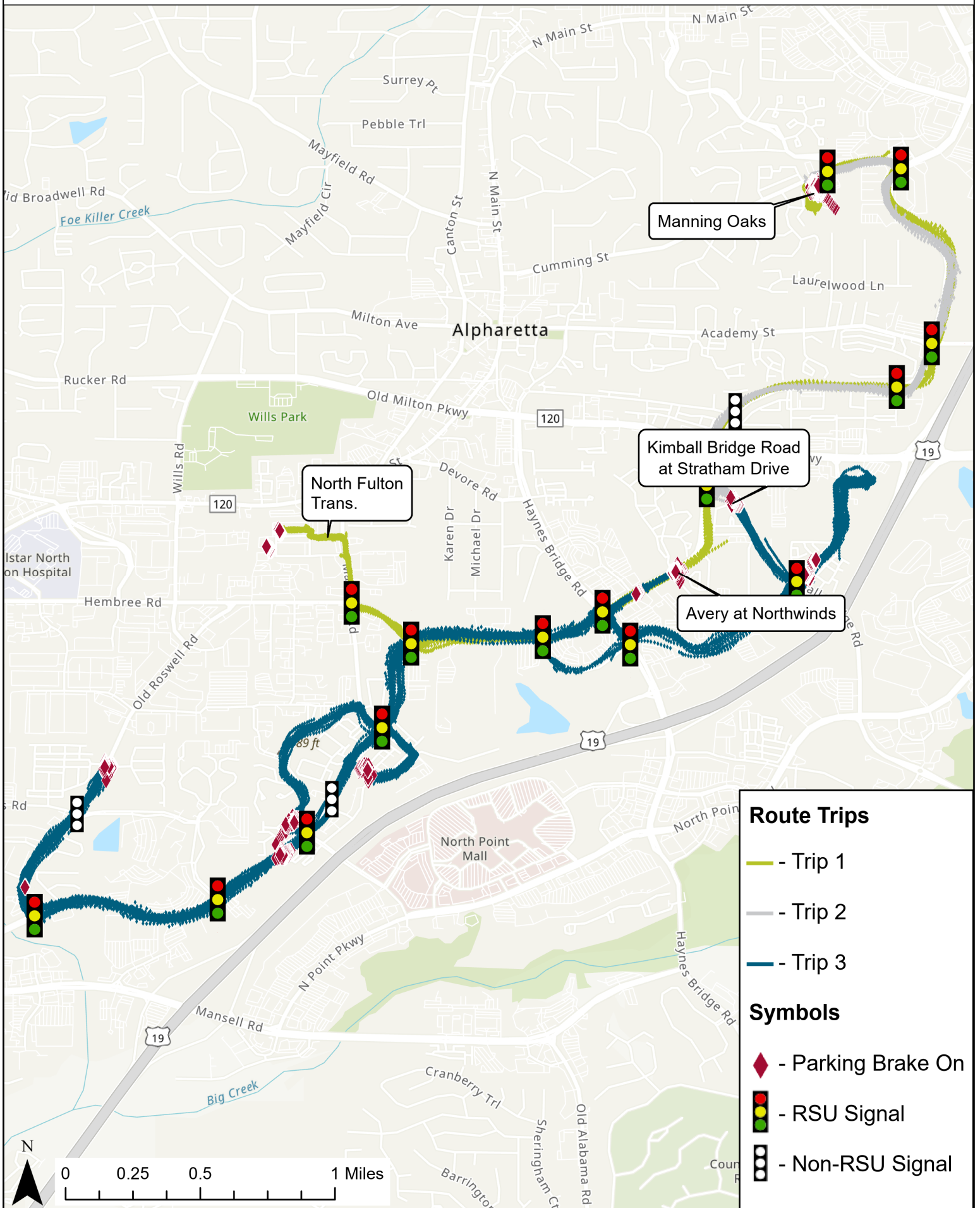
- - Trip 1
- - Trip 2
- - Trip 3
- - Trip 4

Symbols

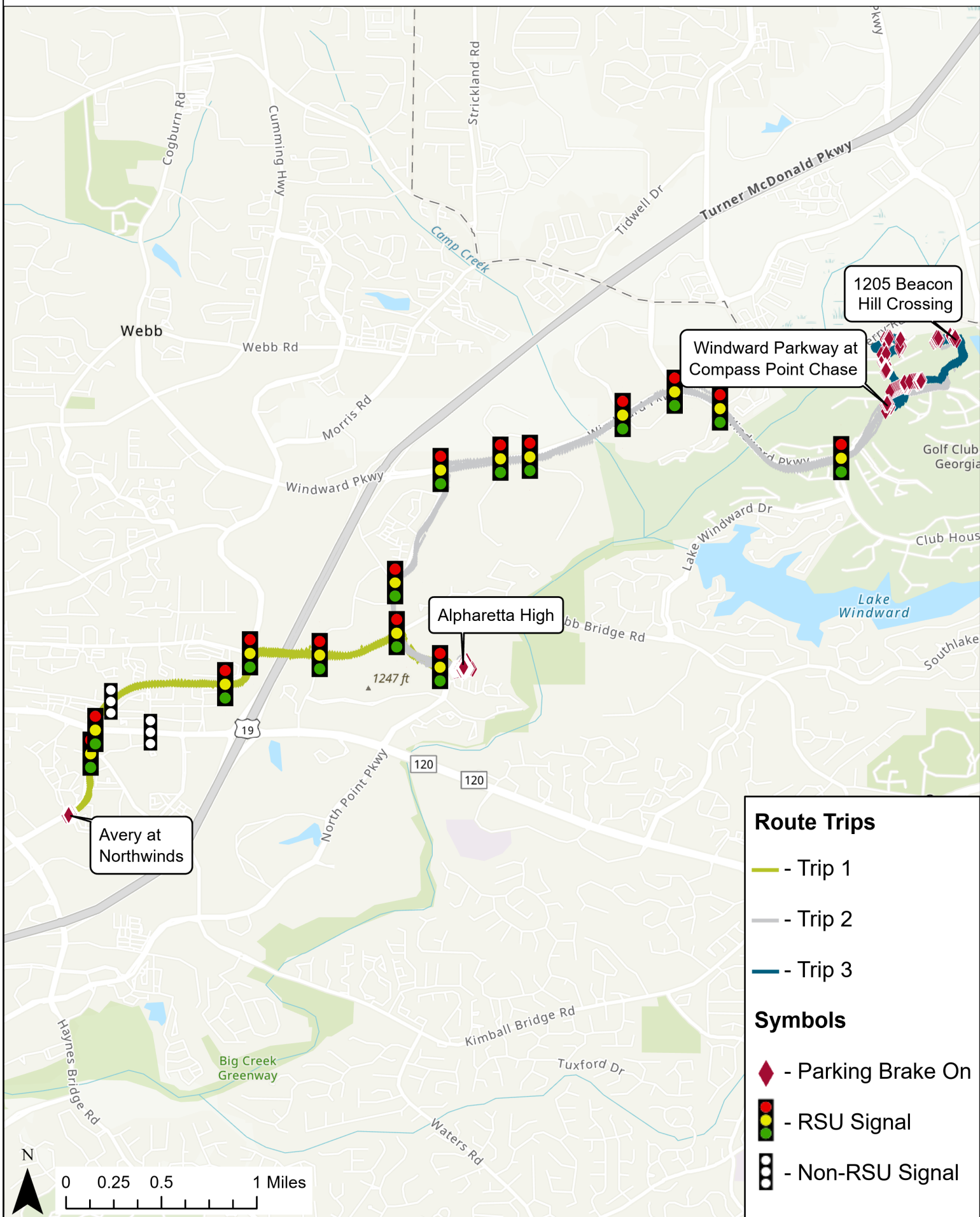
- ◆ - Parking Brake On
-  - RSU Signal
-  - Non-RSU Signal



Blue Bird Bus - PM Elementary Route



Blue Bird Bus - PM High Route



Route Trips

- - Trip 1
- - Trip 2
- - Trip 3

Symbols

- ◆ - Parking Brake On
- ●
● - RSU Signal
- Non-RSU Signal

