NATIONAL TRANSPORTATION SAFETY BOARD

OFFICE OF HIGHWAY SAFETY
WASHINGTON, D.C.

HIGHWAY FACTORS GROUP CHAIRMAN'S FACTUAL REPORT

A. CRASH INFORMATION

Location:	14000 block US 441, Delray Beach, Palm Beach County, Florida
Vehicle 1:	2019 International truck-tractor in combination with a 2008 Vanguard semi-trailer
Operator 1:	FirstFleet, Inc., Murfreesboro, Tennessee
Vehicle 2:	2018 Tesla Model 3
Operator 2:	Private operator
Date:	March 1, 2019
Time:	Approximately 6:17 a.m. (local time)
NTSB #:	**HWY19FH008**

B. HIGHWAY FACTORS GROUP

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C. CRASH SUMMARY

For a summary of the crash, refer to the *Crash Summary Report* in the docket for this investigation.

D. DETAILS OF THE HIGHWAY FACTORS INVESTIGATION

The Highway Factors investigation focused on the highway where the collision occurred; to include the roadway type, the design and usage, the posted speed limit, available signage, and

lighting. The investigation also examined the types of roadway users, the accident history; to include, crashes involving vehicles entering, exiting or crossing over the highway. The investigation also examined Florida Department of Transportation (FDOT) response to traffic patterns and accident history, planned improvements and issues related to the lack of traffic control devices; such as traffic signal lights, at high traffic volume locations adjacent to the highway. Lastly, the investigation will examine the need for additional traffic safety studies to determine the adequacy of the current safety plan and the need for additional traffic safety devices along the US 441 crash corridor.

1. Prefatory Data

1.1. U.S. Highway 441/Florida State Road 7

State Highway 441 (US 441), also known as State Road 7, is classified as an urban principal arterial roadway that is 433 miles long and runs north and south from the Georgia state line to Miami, Florida. US 441 is the preferred route for motorists traveling from Palm Beach County south due to the limited access available via the Florida Turnpike. North of Delray Beach, US 441 is four lanes in each direction. Between State Road 804 (SR-804), to the north and State Road 806 (SR-806), to the south; US 441 is two lanes in each direction divided by an earthen median. Within that five mile stretch of US 441, there are combined 34 roadways and private driveways and 17 highway crossovers. There are several large agricultural facilities, housing developments, recreational parks, a recycling plant and a cemetery. The highway alignment is flat and straight with no obstructions. US 441 is not classified as a restricted access highway because of the numerous intersections that access adjacent businesses and residential areas.

There are no traffic signals along the five mile stretch of US 441 which includes the crash intersection adjacent to the private driveway entrance for the agricultural facility, known as Pero Family Farms, LLC. The posted speed limit is 55 miles per hour. **Figure 1** is a satellite image showing US 441 in Delray Beach. The crash location is indicated by the yellow star.

Figure 1 Satellite image of US 441 in Delray Beach showing the location of the crash, indicated by the yellow star.

1.2. The Crash Location

At the crash location, US 441 is comprised of two travel lanes, measuring twelve feet in width, in each direction. The roadway is divided by a 25-foot wide earthen median. In the southbound direction, there is a 12-foot wide left turn lane that allows vehicles to crossover the highway to proceed northbound. A 12-foot wide right turn lane provides access to the private driveway into the agricultural facility located on the west side of the highway. Bicycle lanes, measuring five feet in width, are present on both sides of the highway. Vehicles exiting the agricultural facility, must come to a stop prior to entering the highway. A stop sign erected by FDOT was installed to the right of the driveway. Both sides of the highway have a flat roadway shoulder adjacent to a grassy median which slopes off into a drainage basin.

The agricultural facility, Pero Family Farms LLC, is a large agricultural firm that employs hundreds of workers and operates 24-hours a day, seven days a week. In addition to the corporation's own truck fleet, outside trucking companies provide support to the agricultural business. On average over one hundred large trucks enter or exit the facility. In addition to large trucks, a multitude of vans, smaller trucks and passenger vehicles enter and exit the facility dropping off or picking up workers. The large number of vehicles trying to enter the facility causes a traffic backup onto the highway shoulder**. Figure 2** shows the southbound view of US 441 as you approach the crash intersection. The combination vehicle struck by the Tesla is seen parked in the highway crossover area. The red arrow indicates the final rest location of the Tesla.

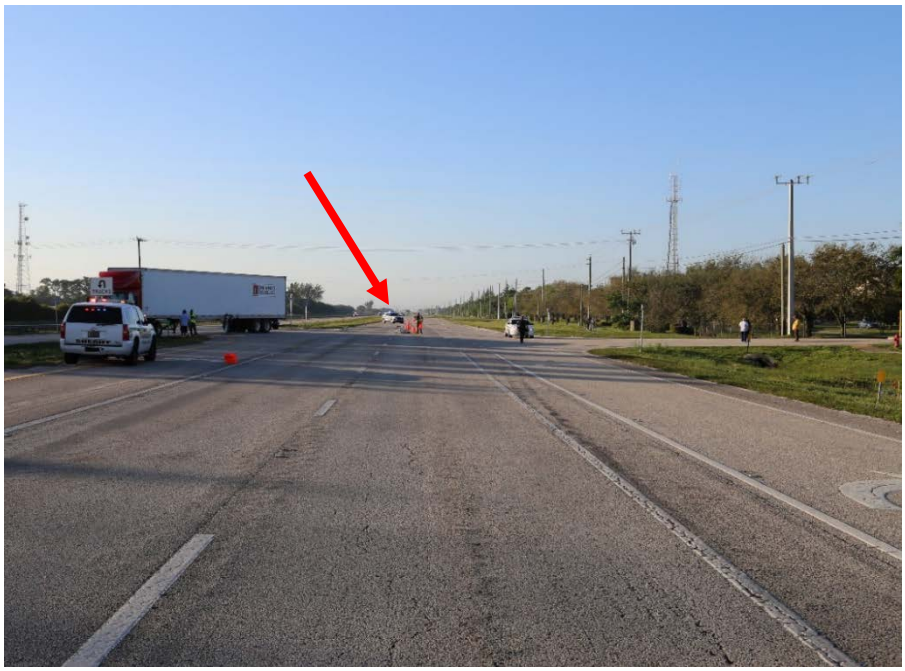

Figure 2 Southbound view of US 441 showing the approach to the crash intersection (PBSO)

The crash occurred when a truck tractor in combination with a semi-trailer traveling eastbound from the agricultural facility entered the highway and attempted to cross over the southbound lanes. The driver of the combination vehicle stopped to yield to oncoming northbound vehicular traffic which resulted in his vehicle blocking all the southbound lanes. The driver of the Tesla failed to react to the truck in his path and struck the semi-trailer in front of the rear dual tandem wheels on the left side of the truck. The Tesla under-rode the semi-trailer and continued southbound before stopping in the earthen median. **Figure 3** is a diagram of the crash scene provided by the Palm Beach County Sheriff's Department.

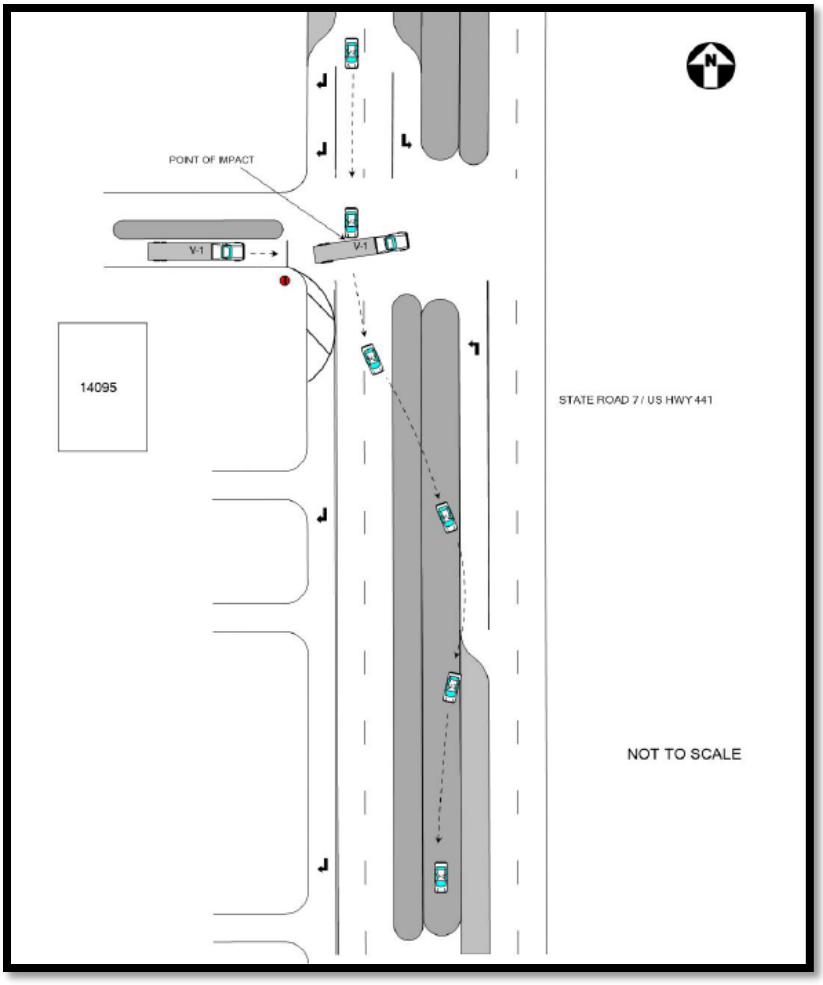

Figure 3 Diagram of the crash scene by PBSO

2. Traffic Metrics

The Florida Department of Transportation (FDOT) is the controlling authority for US 441. The 2017 Annual Average Daily Traffic (AADT) report found that 25,500 vehicles traveled US 441 between SR-804 and SR-806. Approximately 6.4% of those vehicles were heavy trucks. FDOT estimates that by 2020, the AADT will increase to 29, 800.[1] **Figure 4** is a satellite image of the five-mile US 441 corridor. The crash location is circled in yellow.

[1] See Highway Factors Attachment- FDOT US441/SR7 Roadway Data

Figure 4 Satellite image of the US 441 Corridor between SR-804 and SR-806. The crash location is circled in yellow.

3. Accident History

A review of crash data, provided by FDOT for the crash corridor, for the period starting January 1, 2010 and ending December 31, 2014 revealed that there were 146 crashes that occurred along the five-mile corridor of US 441 which included collisions that occurred at the intersection of both state roads. 65 crashes or 44.5% of the reported total number of crashes involved rear-end collisions. 75.3 % of these crashes occurred during the daylight hours with 71.2 % occurring on dry pavement. Many of the rear-end collisions were determined to be a trailing vehicle's failure to slow in time for vehicles slowing around them or turning. 14 crashes were categorized as "angle" collisions. Overall, the crash data revealed that the occurrence of rear-end collisions had increased over the five-year period and represented most of the occurrences. The frequency of angle crashes increased in 2013 and the occurrence that year was greater than the four previous years combined. The trend of crashes occurring during wet roadway conditions was higher in this corridor compared to the statewide average. Most of the crashes occurred at the intersections; specifically, 55 collisions occurred at the intersection with SR-804 and 57 collisions occurred at SR-806. The remaining 34 crashes occurred within the five-mile corridor.

Table 1 is a representation of FDOT's crash data for this corridor. The incidents are categorized by the time of day, the crash type, roadway condition and injury analysis. **Table 2** further breaks down the data based on the crash type by percentage of occurrence, compared overall to the number of crashes and the percentage of occurrence based on location and compared to crashes overall.

Table 1 FDOT five-year crash data for the U.S. 441 corridor between SR-804 and SR 806

Variable Category	Variable	Frequency	% of Crashes
Time of Day	Day	30	88.24
	Night	3	8.82
	Unknown	1	2.94
Crash Type	Rear-end	13	38.24
	Angle	6	17.65
	Sideswipe	5	14.71
	Backing	3	8.82
	Other	7	20.59
Injury-involved	Injury	18	52.94
	No Injury	16	47.06
Roadway Conditions	Dry	26	76.47
	Wet	7	20.59
	Unknown	1	2.94
Total		**34**	100.00

Table 2 Crashes occurring within the U.S. 441 corridor at intersections according to type and frequency

Crash Type	Total Occurrences	% of Crashes	Crashes at intersections within the corridor	% of Occurrence at intersections	% of Total Crashes within five-mile corridor
Rear-end	13	38.24	9	69.23	26.47
Angle	6	17.65	6	100.00	17.65
Sideswipe	5	14.71	4	80.00	11.76
Backing	3	8.82	3	100.00	8.82
Others	7	20.59	3	42.85	8.82
Total	34		**25**		73.52

In the immediate vicinity of U.S. 441 near the intersection with the private driveway entrance to the agricultural facility, Pero Family Farms, 7 crashes were reported to have occurred within the five-year period. Five of the seven collisions involved rear-end or angle impacts.

A closer examination of the crash data provided by FDOT for the five-mile corridor was conducted. Of the 34 collisions reported by FDOT to have occurred within the corridor, two crashes were found to have occurred outside of the specified area examined in this report and will not be discussed further. Only 32 of the crashes occurred within the U.S. 441 corridor between S.R. 804 and S.R. 806 and did not occur at the intersection of the two state roads. Six of the reported collisions occurred in the parking lots of various businesses adjacent to the highway, and one collision occurred inside of the recycling plant. Four crashes involved single vehicle "run off roadway" incidents and another three crashes involved roadway mishaps not related to the investigation. These mishaps include wildlife encursion onto the roadway, a vehicle colliding with an object that fell from a lead vehicle and the mechanical failure of a vehicle that resulted in the complete tire separation from the car. The remaining 20 collisions occurred on the highway. All the crashes occurred on U.S. 441 at the intersections of roadways, private driveways or within a hundred feet of these locations except one. **Figure 5** is a Google satellite map of the corridor, showing specific elements of the collisions. The crashes were broken down by their location, the involvement of unique vehicle types (i.e. bicycle, motorcycle, school bus), the type of collision sequence (initiating action) and the overall injuries sustained by the involved individuals. The red star denotes the location of the crash intersection.

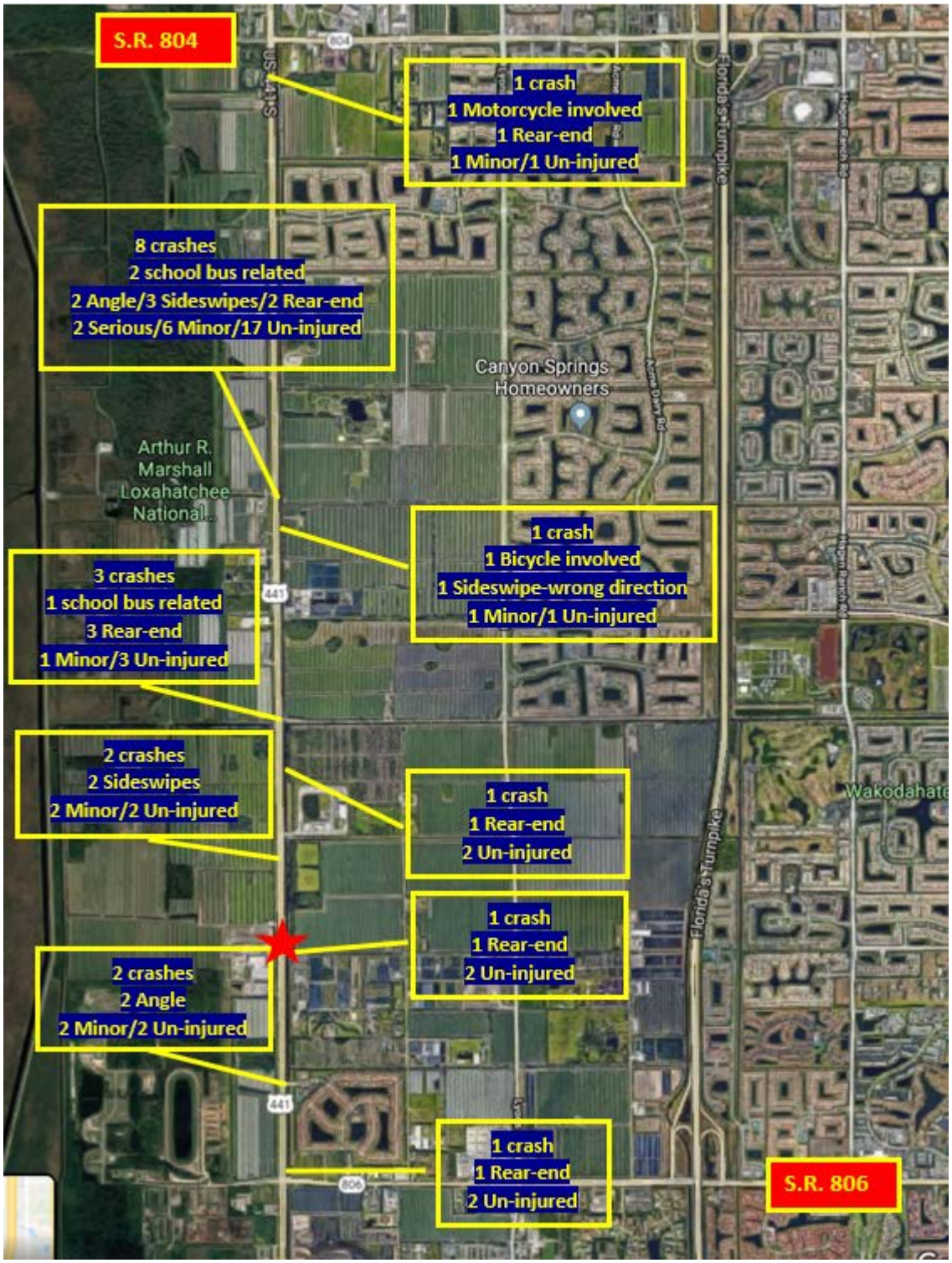

Figure 5 Google satellite map showing crash locations, types and injuries that occurred within the U.S. 441 crash corridor between 2010-2015. (Note: the red star denotes the location of the intersection of U.S. 441 and the private driveway for Pero Farms.)

4. Roadway Maintenance and Construction

Over the last five years, FDOT has completed several roadway maintenance and improvement projects to US 441 to include the adding of bike lanes, highway safety lighting, maintenance of drainage ditches, and pavement remarking. A roadway resurfacing project is currently pending for the crash corridor. In 2000, FDOT drafted a proposal to widen US 441, between the two major state roads, to three lanes in each direction. Currently, the construction on this project has not begun.[2]

No Speed study or Traffic Signal Warrant study has ever been conducted for the crash corridor. FDOT has proposed a re-surfacing project for the area. FDOT contracted a 3R Safety Review report in support of the project and the review was conducted in March of 2016. The report was finalized and submitted to FDOT in August 2016. The re-surfacing project is scheduled to begin in June 2019 and continue until October 2010. Based on the crash data and the field observations, the 3R Safety Review report made the following safety recommendations.

- The reduction of run-off crashes by installing rumble striping. According to the report, this recommendation required the coordination with and the approval of the adjacent homeowner associations.

- The installation of enhanced pedestrian features at the intersections of US 441 and US-804 and US 441 and SR-806, to include detectable warning surfaces, separating the push button for the pedestrian signals which currently share the same pole.

- In response to the 48 rear-end collisions that occurred at the two signalized intersections, install backplates with yellow retro-reflective borders for all signal heads.[3]

5. Highway Signage and Markings

In addition to signs indicating the posted 55 mile per hour speed limit; at the exit to the private driveway and prior to entering the highway, a stop sign was located on the right grassy shoulder of the roadway. At that location, a stop bar was also present to indicate the location vehicular traffic was required to stop before entering the highway. Both traffic control devices were installed and required to be maintained by FDOT. Due to exposure to the environment, the painted stop bar has almost been entirely obliterated. **Figure 6** is a photograph showing a close-up of the private driveway exit, the stop sign, and the faded stop bar.

[2] See Highway Factors Attachment- FDOT Add Lanes and Reconstruction Plans for SR 7
[3] See Highway Factors Attachment- FDOT 3R Safety Review report

Figure 6 Photograph showing close-up of private driveway exit, stop sign (circled in yellow) and faded stop bar (circled in red). (PBSO)

At the location of the highway crossovers in the five-mile crash corridor; a "Designated Truck U-Turn Ahead" sign has been installed by FDOT to facilitate the use of the highway crossovers by trucks and provide warning to other vehicular traffic that trucks will be turning at that location. **Figure 7** shows the "Truck U-turn" sign present at the crash intersection in the southbound direction. **Figure 8** shows the "Truck U-turn" sign present at the crash intersection in the northbound direction. **Figure 9** shows the additional paved surface on the northbound side of US 441 for combination vehicles that require additional space when making wide radius turns when turning from the southbound lanes.

Figure 7 Photograph of the designated "Truck U-turn" sign (shown in the yellow circle and located at the highway crossover in the southbound direction. The inset shows a close-up view of the sign (PBSO)

Figure 8 Photograph of the designated "Truck U-Turn" sign (shown in the yellow circle) and located at the highway crossover in the northbound direction.

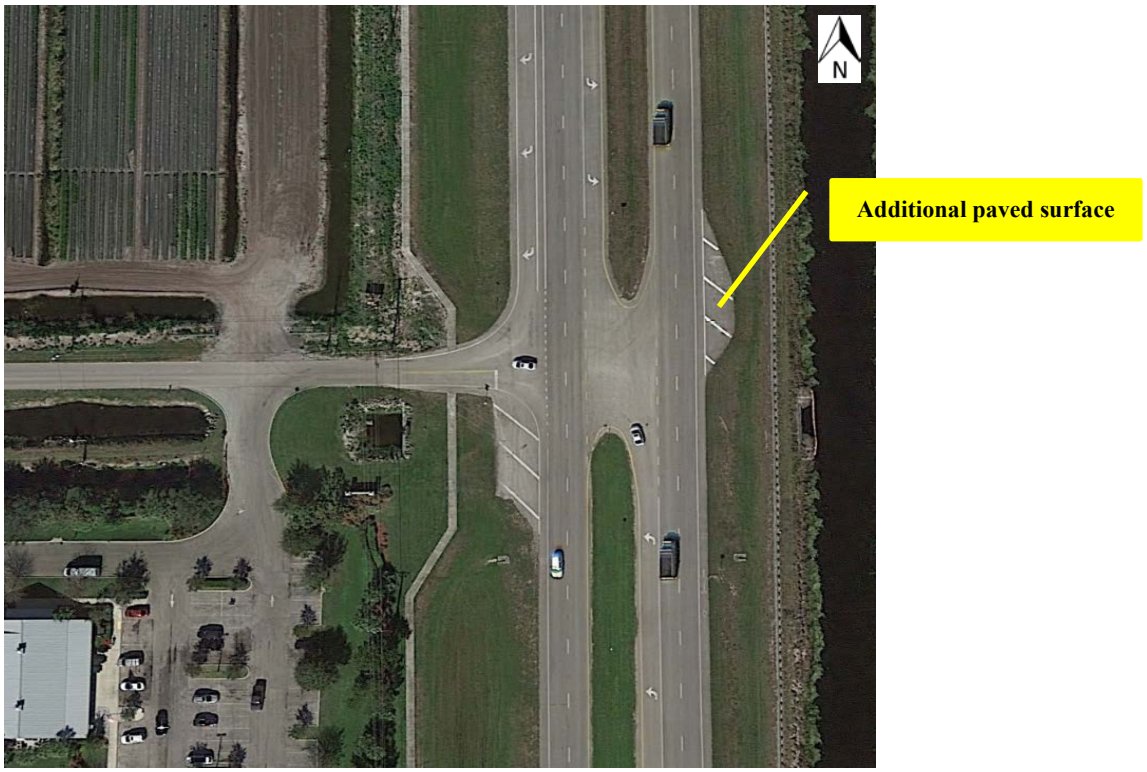

Figure 9 Shows additional paved surface in the northbound direction for combination vehicles that require additional space to make wide radius turns when turning from the southbound lanes.

6. Manual on Uniform Traffic Control Devices (MUTCD)

The Manual on Uniform Traffic Control Devices (MUTCD)[4] defines the minimum standards road managers nationwide use to install, ensure uniformity and maintain traffic control devices. The use of traffic control devices allows road facility managers to mitigate roadway hazards and address safety issues. FDOT installed the "Designated Truck U-Turn Ahead" sign at the intersection of the private driveway and US 44. However, there are no warning signs prior to the location to indicate to motorists that at this intersection, trucks will be frequently crossing the roadway. The MUTCD provides guidance in the use of supplementary warning signs to advise roadway users to expect vehicles entering and crossing over the roadway. An example of a supplemental warning sign that could have been installed by FDOT at the crash location is the "Truck Crossing" sign. The placement of a "Truck Crossing" warning sign, in advance of the approach to the intersection, can assist motorists in anticipating and recognizing traffic hazards by identifying locations where trucks would likely be crossing the highway. An illustration of the MUTCD "Truck Crossing" warning sign designated as W8-6 or W11-10 is shown in **Figure 10**.

[4] https://mutcd.fhwa.dot.gov/index.htm

Figure 10 Illustration of the MUTCD "Truck Crossing" warning signs designated as W8-6 and W11-10.

6.1. Traffic Signal Warrant Study

A warrant is a condition that an intersection must meet to justify the installation of a traffic signal. The MUTCD identifies nine types of warrants. These include:

- 8-hour Vehicular Volume
- 4-hour Vehicular Volume
- Peak Hour
- Pedestrian Volume
- School Crossing
- Coordinated Signal System
- Crash Experience
- Roadway Network
- Intersection Near a Grade Crossing

The primary pieces of data to be collected during a Traffic Signal Warrant Study include the layout of the intersection, the posted speed limit of the roadway, the volume of traffic to include turning movements, the presence of schools and recreational parks, pedestrians and bicyclists (note that cyclists can be designated as pedestrians or as vehicles) and crash data.

Though a traffic signal warrant study for the crash corridor has never been conducted; data collected for the 3R Safety Review report contains most of the same information that would have been required to evaluate the need for a traffic signal along the route. FDOT indicated that based on this data, the five-mile corridor of US 441 between SR 804 and SR 806 does not meet any of the signal warrant specifications because all the side streets have very low traffic volume.

6.2. Speed Study

A speed study is conducted to evaluate safety issues and identify the appropriate speed for a specific segment of the roadway. Data collection is an integral part of the process. The data collected should include crash data, roadway planning, adjacent land usage and speeds obtained

by monitoring free-flowing traffic[5]. The MUTCD recommends setting the posted speed limit near the 85th percentile speed.

FDOT has not conducted a speed study for the crash corridor. A request was made by investigators with the NTSB to FDOT to conduct an 85th percentile speed study for the crash corridor to evaluate the appropriateness of the designated roadway speed limit given the prevalence vehicles entering or turning from the highway that could potentially impact the free-flowing movement of traffic and the occurrence of crashes within this corridor at intersections with adjacent roadways, private driveways and designated truck U-turn areas. The speed study would potentially identify the need for additional crash mitigation methods for the involved area. FDOT declined to conduct either the 85th percentile speed study or the traffic signal warrant study indicating that all locations within the five-mile corridor had low traffic volume. This despite the numerous commercial businesses, public parks and the two residential communities that contain approximately 1,040 private residences that are accessed via U.S. 441.[6]

7. Highway User Survey

Investigators conducted a survey with representatives of the agricultural facility, Pero Family Farms, LLC. The president and the director of distribution both reported that the lack of traffic controls, specifically traffic signal lights, at the intersection for the driveway for the business, had been a great concern for many years. Large commercial trucks trying to cross the highway or leave the facility were found to be at a greater risk of accidents due to the traffic volume and the speed of the vehicles along the highway. The policy of Pero Farms, for their drivers, required all drivers to obey traffic control devices to include the stop sign located at the end of the driveway and prior to entering the highway. By Florida state law, drivers are required to stop prior to entering the roadway; proceed after ensuring that the roadway is clear and grant the right of way to all approaching vehicles and those vehicles traveling on the highway. Many of the trucks that enter and leave Pero Farms are not part of the agricultural business's fleet. These drivers are not subject to policies set down by Pero Farms for company drivers. It is the responsibility of the individual trucking company to monitor its drivers and compel compliance with the local traffic regulations The representatives from Pero Farms noted that even when truck drivers make a concerted effort to safely cross the highway, there is an element of risk associated with these large trucks crossing a roadway with vehicles traveling at highway speeds without adequate traffic controls. Security officers at the front gate of the Pero Farms facility estimates that approximately 100 large commercial vehicles enter or exit the facility daily.

In addition to the large volume of truck traffic; many of the employees travel by carpool in large vans to the facility. At peak hours of the day, vans and cars line up to drop off or pick up workers from the facility. Daily, the line of vehicles is observed extending from the facility's driveway and into the turn lane along the highway. Despite efforts by the front gate security guards for the facility to maintain some control over this traffic; in addition to their other duties, vehicular traffic continually backs up into the facility and onto the adjacent highway.

[5] Free-flowing speeds refers to the speed obtainable by a vehicle that is unimpeded by other vehicles, stops signs, signals or inclement weather.
[6] See Highway Factors Attachment-FDOT Correspondence

E. DOCKET MATERIAL

The following attachments and photographs are included in the docket for this investigation:

LIST OF ATTACHMENTS

Highway Factors Attachment- FDOT US441/SR7 Roadway Data

Highway Factors Attachment- FDOT Add Lanes and Reconstruction Plans for SR 7

Highway Factors Attachment- FDOT 3R Safety Review report

Highway Factors Attachment- FDOT Correspondence

LIST OF PHOTOGRAPHS

Highway Photo 1- Google Street View image of southbound US 441 at crash intersection

Highway Photo 2- Google Street View image of southbound US 441 approximately one mile north of crash intersection; showing advisory signage.

END OF REPORT

Sheryl Harley
Highway Crash Investigator