Intersection Control Beacon Effectiveness Study

June 2019

Delaware Department of Transportation

RK&K

Executive Summary

This traffic study was requested by DelDOT to identify the effectiveness of Intersection Control Beacons (ICBs) in Delaware. DelDOT has utilized Intersection Control Beacons (ICBs) as countermeasures for intersections where there has been a high frequency of angle crashes, specifically Hazard Elimination Program (HEP) sites. However, prior to this study, there was a lack of supporting documentation to show how effective ICBs are. Furthermore, and perhaps contrary to expectations, crash data from several intersections in Delaware where ICBs were installed has shown that the intersections continued to have relatively high crash rates even after the ICB's were installed. As a result, DelDOT subsequently converted some of these locations to All-Way Stop Control.

The purpose of this traffic engineering study is to evaluate traffic safety at intersections where ICBs have been installed, which involves a review of available crash history and evaluation of the intersections with the *Highway Safety Manual's* predicted crash rate method. This study also summarizes research from local municipalities and states. Lastly, this study documents historical information from DelDOT's archives related to the installation of ICBs.

A review of the before and after crash data was inconclusive. Two (2) of the intersections had a significant decrease in the frequency of angle crashes following the installation of the ICB, whereas the remaining two (2) intersections saw a significant increase in the frequency of angle crashes after the ICBs were activated. At this time, it is difficult to determine if the changes at these intersections are solely a result of the ICB, or if changes to the surrounding area (e.g. rumble strips removal/installation) played a role in the increase and decrease of crashes at these intersections.

Predicted crash rates were calculated for 19 intersections with existing ICBs (13 rural and 6 urban) using the methodology presented in the *Highway Safety Manual*. The predicted crash rates were compared with the average crash rate for a five-year period (2013-2017) for each intersection. The results showed that the majority of intersections with ICBs in rural areas (9 of 13 intersections) and urban areas (5 of 6 intersections) had a higher frequency of angle crashes than predicted.

A review of existing research from other states and municipalities showed similar results. Research conducted in California, Florida, IOWA, Minnesota, and South Carolina found no significant reduction in angle crashes after the ICBs were activated. DelDOT's archives and research from several other states noted that some motorists are confused by ICBs and believe the ICB indicates that all of the approaches are stop controlled. This confusion has been linked to crashes at intersections with ICBs where a motorist on the stop-controlled approach pulled out in front of oncoming vehicles. Because of the potential for confusion, Minnesota removed all of the state's overhead ICBs in 2010[(6)].

Based on the limited information available for this study, combined with the majority of existing research from other states, ICBs do not appear to effective at reducing angle crashes. At this time, DelDOT may want to reconsider their current policies regarding the use of ICBs, potentially discontinuing the use of overhead ICBs and instead establishing guidance to install ground mounted flashing beacons or actuated flashing beacons as a safety countermeasure. DelDOT may also want to consider installing Hazard Identification Beacons (HIBs) on the Stop Ahead signs at locations with existing overhead ICBs.

Table of Contents

Index of Tables

I. Background and Study Purpose

At DelDOT's request, RK&K conducted this study to investigate the effectiveness of Intersection Control Beacons (ICBs) in Delaware. More specifically, the question was raised whether or not ICBs actually reduce crashes, and if so, how do they [ICBs] compare with other traditional safety countermeasures such as the use of All-Way Stop Control and rumble strips?

Intersection Control Beacons (ICBs) have been installed at multiple locations in Delaware where DelDOT determined there was a need to draw motorists' attention to the intersection. Historically, DelDOT installed ICBs at intersections with a high frequency of crashes, which included intersections identified by the Hazard Elimination Program (HEP), Highway Safety Improvement Program (HSIP), and the High Risk Rural Roads Program (HRRRP). ICBs have also been installed at locations where there wasn't a documented crash problem, but where there was a perceived safety issue. Such locations have included intersections within/near schools and at major industrial plant entrances. Accordingly, DelDOT's first ICB was installed in 1957 at the entrance to Delmarva Power on SR 9 (River Road) in New Castle County.

Over time, DelDOT has conducted follow-up studies at several of the intersections where ICBs have been installed. In some locations, the crash data showed little or no reduction in angle crashes. DelDOT subsequently converted these intersections to All-Way Stop Control (AWSC) in an attempt to address ongoing safety concerns. These actions have resulted in some staff at DelDOT questioning the effectiveness of ICBs, wondering if it would have been better to install other countermeasures such as rumble strips or AWSC rather than an ICB.

Based on the issues described above, the goal of this study is to determine answers to the following questions:

- How effective have ICBs been in Delaware?
- Are there certain locations (rural vs. urban, surrounding land use, etc.) where ICB's are more effective?
- Are there certain geometric features of intersections that correlate to improved effectiveness of ICBs?
- Are ICBs effective in preventing certain types of crashes (angle crashes, left turn crashes, etc.) and/or addressing specific types of safety issues such as vehicles disregarding STOP signs?
- How effective are ICBs in comparison to other countermeasures in terms of preventing crashes?

Additionally, based on the findings to the questions posed above, two supplemental goals of this study are 1) If ICB's are found to provide quantifiable benefits - to provide recommendations to DelDOT if there are specific conditions (location, geometrics, etc.…) where ICBs are most appropriate/effective, and to potentially develop a list of warrants for installing ICBs in Delaware, or 2) If ICB's are found to provide little quantifiable safety benefit – to make recommendations regarding the potential removal of existing ICB's, and possible modifications to DelDOT's warrants for considering AWSC.

II. Study Methodology

RK&K initiated this study by reviewing historical crash data and calculating the predicted crash rates for existing ICB locations in Delaware. RK&K also reviewed research that was conducted nationally and regionally. In addition, RK&K reviewed DelDOT's archives to better understand why ICBs have historically been installed throughout the state, and to determine what the criteria for installation/implementation has been.

It is important to note that as the study proceeded, a limitation became apparent that significantly impacted the breadth and depth of the study, and therefore, also the confidence in the study's findings. Specifically, DelDOT's current crash database only goes back to 2005, which prevented DelDOT from providing comprehensive crash data from the period before the majority of ICBs in Delaware were installed. This made it difficult to compare pre- and post-ICB crash data. More specifically, only four (4) intersections were identified that had sufficient before and after crash data to be included in the study. In addition, multiple ICBs in the state were removed or converted to signalized intersections or All-Way Stop Control (AWSC) without any documentation to explain why/when these changes were made.

III. Crash Trend Analysis

DelDOT requested that RK&K use crash data to evaluate ICBs in two (2) different ways. First, RK&K compared before and after crash data for ICB locations, looking for reductions in crashes by severity, type, and overall number of crashes after the ICB was installed. Next, RK&K compared the post-ICB installation crash rates with predictive crash rates for the intersections that RK&K calculated using the methodology contained in the *Highway Safety Manual* [(1)]. The results for both methods are summarized below.

A. Before/After Crash Comparison

DelDOT provided crash data for four (4) intersections where ICBs had previously been installed. At each intersection, crash records were provided for at least two (2) years prior to and two (2) years after the installation and activation of the ICB. For this comparison, RK&K only included angle, left-turn, and rear-end crashes. The summary of the before/after crash data for each intersection is provided below and the results are compared in **Tables 1 through 4**.

Pearson's Corner Road/Lockwood Chapel Road (Activated October 2010)

The intersection of Pearson's Corner Road (K101) at Lockwood Chapel Road (K171) and West Denney's Road (K100) is located west of the City of Dover in Kent County, Delaware. According to DelDOT's archives, this intersection was a 2009 Hazard Elimination Program Site (Site I). In order to improve safety at the intersection, DelDOT installed Oversized STOP signs, Oversized Stop Ahead signs, Cross Traffic Does Not Stop signs, and raised pavement markings at the intersection. A follow-up study revealed that the signing and striping improvements had minimal impact on angle crashes at the intersection. As a result, DelDOT installed Oversized STOP signs and Oversized Crossroad Warning signs. DelDOT also installed an ICB at this intersection, which consist of red flashing beacons mounted over the STOP signs and yellow flashing beacons mounted above the Crossroad Warning signs.

Summary of crash data before installation of flashing beacons

- There were eight (8) angle crashes.
- Four (4) crashes involved vehicles disregarding the STOP sign and four (4) crashes involved motorist stopping for the STOP sign but failing to remain stopped.

Summary of crash data after installation of flashing beacons

- There were five (5) angle crashes
- Three (3) of the angle crashes were attributable to a motor vehicle stopping for the STOP sign but failing to remain stopped. The motorists noted that they didn't see the approaching motorists.
- Two (2) of the angle crashes were attributable to a motor vehicle completely disregarding the STOP sign. The police report noted that both motorists saw the STOP signs and flashing beacons but were confused by the ICBs meaning.
- There was one (1) left-turn crash.

ICB Effectiveness Study **June 2019**

Table 1:
Comparison of Pre ICB/Post ICB Crash Data
Pearson's Corner Road at Lockwood Chapel Road

	Severity				Crash Type				Crash Rate
	Fatal	Injury	PDO	Total	Angle	Left-turn	Rear-end	Total	
Pre ICB	0	5	3	8	8	0	0	8	3.27
Post ICB	0	6	0	6	5	1	0	6	2.69
Change	0	+1	-3	-2	-3	+1	0	-2	**-0.58**

Based on the before crash data, the majority (75%) of angle crashes were caused by vehicles from the westbound West Denney's Road approach. Of those crashes, 50% involved vehicles failing to stop for the STOP sign on West Denney's Road approach, which indicated the need to increase visibility of the intersection.

The after data shows that the number of angle crashes decreased (improved) to five (5) crashes, from eight (8) crashes before installation. The number of angle crashes involving vehicles from westbound West Denney's Road decreased by 50%, from six (6) to three (3) crashes. More significantly, the number of angle crashes involving vehicles completely disregarding the STOP signs decreased (improved) to two (2) crashes, from four (4) crashes.

SR 30 at Sand Hill Road (Activated December 2008)

The intersection of SR 30 (S248, Gravel Hill Road) at Sand Hill Road (S319) is located west of the City of Milton in Sussex County, Delaware. According to DelDOT's archives, this intersection was a 2007 Hazard Elimination Program (HEP) site (Site F). In order to improve safety at the intersection, DelDOT installed 36"x36" STOP signs and Oversized (48"x48") Stop Ahead signs on the Sand Hill Road approaches. DelDOT also installed mast arm mounted beacons (ICB) at the intersection and yellow flashing beacons mounted above the Stop Ahead Warning signs.

Summary of crash data before installation of flashing beacons

- There were thirteen (13) angle crashes, and one (1) angle crash resulted in a fatality.
- Nine (9) angle crashes involved vehicles disregarding the STOP sign and four (4) angle crashes involved motorists stopping for the STOP sign but failing to remain stopped.
- There was one (1) left-turn crash.
- There was one (1) rear-end crash.

Summary of crash data after installation of flashing beacons

- There were eight (8) angle crashes.
- Two (2) angle crashes involved vehicles disregarding the STOP sign and six (6) crashes involved motorist stopping for the STOP sign but failing to remain stopped.
- The police reports for the two (2) angle crashes resulting from a motor vehicle disregarding the STOP sign noted that the motorists saw the STOP signs and flashing beacons but were confused by the ICBs meaning.
- There were two (2) left-turn crashes.
- There was one (1) rear-end crash.

ICB Effectiveness Study **June 2019**

Table 2:
Comparison of Pre ICB/Post ICB Crash Data
SR 30 at Sand Hill Road

	Severity				Crash Type				Crash Rate
	Fatal	Injury	PDO	Total	Angle	Left-turn	Rear-end	Total	
Pre ICB	1	7	7	15	13	1	1	15	5.02
Post ICB	0	4	7	11	8	2	1	11	3.80
Change	-1	-3	0	-4	-5	+1	0	-4	**-1.22**

The results from **Table 2** show that the frequency of angle crashes decreased (13 to 8) after the ICB was installed. Significantly, the frequency of fatal and injury crashes decreased (-1 fatal and -3 personal injury crashes). It should be noted that the rumble strips on one of the approaches was paved over around the time the ICB was installed.

SR 30 at Morris Mill Road (Activated June 7, 2007)

The intersection of SR 30 (S248, Gravel Hill Road) and Morris Mill Road (S297) is located north of the City of Millsboro in Sussex County, Delaware. According to DelDOT's archives, this intersection was a 2006 HSIP Site (Site H). In order to improve safety at the intersection, DelDOT installed Oversized STOP signs and Oversized Crossroad Warning signs. DelDOT also installed an ICB at this intersection which consisted of red flashing beacons mounted over the STOP signs and yellow flashing beacons mounted above the Crossroad Warning signs. The 2006 report noted that rumble strips were previously on the minor street approaches at this intersection, but they had been removed because of complaints from local residents. This location was studied again in 2011 as part of the High Risk Rural Roads Program (HRRRP). A review of the crash data showed no reduction in the frequency of angle crashes, or the frequency of crashes resulting in fatal and injury crashes. As a result, DelDOT converted the intersection to All-Way Stop Control (AWSC).

Summary of crash data before installation of flashing beacons

- There were seven (7) angle crashes.
- Two (2) angle crashes involved vehicles disregarding the STOP sign and five (5) crashes involved motorists stopping for the STOP sign but failing to remain stopped.

Summary of crash data after installation of flashing beacons

- There were ten (10) angle crashes and one (1) of these crashes resulted in a fatality.
- Three (3) angle crashes involved vehicles disregarding the STOP sign and seven (7) crashes involved motorists stopping for the STOP sign, but then entering the intersection.
- There were two (2) rear-end crashes.

ICB Effectiveness Study **June 2019**

Table 3:
Comparison of Pre ICB/Post ICB Crash Data
SR 30 at Morris Mill Road

	Severity				Crash Type				Crash Rate
	Fatal	Injury	PDO	Total	Angle	Left-turn	Rear-end	Total	
Pre ICB	0	2	5	7	7	0	0	7	2.98
Post ICB	1	7	4	12	10	0	2	12	6.55
Change	+1	+5	-1	+5	+3	0	+2	+5	**+3.57**

The results from **Table 3** show that the frequency of angle crashes increased (7 to 10) after the ICB was installed. Significantly, the frequency of fatal and injury crashes also increased (+1 fatal and +5 injury crashes). In addition, a review of the police reports revealed that there was an increase in the number of angle crashes attributable to motor vehicles completely disregarding the STOP signs. It should be noted that the rumble strips on one of the approaches was paved over around the time the ICB was installed.

SR 30 at Zoar Road (Activated in 2008)

The intersection of SR 30 (S248, Gravel Hill Road) and Zoar Road (S048) is located north of the Town of Millsboro in Sussex County, Delaware. According to DelDOT's archives, this intersection was studied as part of the 2007 High Risk Rural Roads Program (Site 13). In order to improve safety at the intersection, DelDOT installed Oversized STOP signs, Oversized Stop Ahead signs, and Oversized Crossroad Warning signs. DelDOT also installed mast arm mounted beacons (ICB) at the intersection in May 2008. This location was studied again in 2011, and a review of the crash data showed no reduction in the frequency of angle crashes. As a result, DelDOT converted the intersection to All-Way Stop Control (AWSC).

Summary of crash data before installation of flashing beacons

- There were six (6) angle crashes.
- There were four (4) rear-end crashes.

Summary of crash data after installation of flashing beacons

- There were ten (10) angle crashes.
- There were two (2) left-turn crashes.

ICB Effectiveness Study **June 2019**

Table 4:
Comparison of Pre ICB/Post ICB Crash Data
SR 30 at Zoar Road

	Severity				Crash Type				Crash Rate
	Fatal	Injury	PDO	Total	Angle	Left-turn	Rear-end	Total	
Pre ICB	0	5	5	10	6	0	4	10	3.61
Post ICB	0	5	7	12	10	2	0	12	5.18
Change	**0**	**0**	+2	+2	+4	+2	-4	+2	**+1.57**

The results from **Table 4** showed an increase (6 to 10) in the frequency of angle crashes after the ICB was installed. It should be noted that the 2007 HRRRP Report mentioned that the transverse rumble strips at the intersection were paved over sometime before 2007.

Before/After Crash Comparison Summary

The results of the before/after crash data analysis for the four (4) intersections listed above is inconclusive. Based on the results of the crash data, two (2) of the intersections experienced a reduction in the frequency of angle crashes after the ICB was installed, while the other two (2) intersections saw an increase in the frequency of angle crashes. At this time, it is difficult to determine if the increase or decrease of angle crashes at these intersections were attributable to the ICB or another change (e.g. rumble strip removal) at the intersections.

B. Predictive Crash Method

Due to the limited number of intersections with crash data from the "before" period, DelDOT asked RK&K to use the *Highway Safety Manual* methodology to calculate the predicted crash rate for all of the existing ICB locations throughout Delaware. After a review of available data for existing ICB locations (i.e. traffic volumes), there were a total of 19 intersections (13 rural and 6 urban locations) that could be evaluated with the predicted crash rate. The results for ICBs at rural intersections are provided in **Tables 5 and 6**, and the results for urban intersections are provided in **Table 7 and 8**. A summary of the predicted crash rate for each location is provided in **Appendix A**.

ICBs at Rural Intersections

RK&K calculated the predicated (non-ICB) crash rate for 13 intersections in rural areas. The predicted crash rate for each intersection was compared with the average crash rate for a five-year period (2013 – 2017). The intent of this comparison is to determine if the actual crash rate was lower than, theoretically, it would have been without an ICB. In order to compare similar intersections, the ICBs were grouped by other existing countermeasures at the intersection:

- Group 1 – Intersection has an ICB.
- Group 2 – Intersection has an ICB and Oversized STOP Signs (48"x48")
- Group 3 – Intersection has an ICB and transverse rumble strips
- Group 4 – Intersection has an ICB, transverse rumble strips, and Oversized STOP signs (48"x48")

ICB Effectiveness Study **June 2019**

Table 5:
Average Crash Rate (2013-2017) with ICB vs. Predicted Crash Rate without ICB
Rural Intersections: Angle Crashes

	# of intersections with angle crash rate (2013-2017) lower or higher than the HSM Predicted Crash Rate				
	# of sites	Lower than predicted crash rate		Higher than predicted crash rate	
Group 1	4	1	25%	3	75%
Group 2	5	2	40%	3	60%
Group 3	2	0	0%	2	100%
Group 4	2	1	50%	1	50%

Based on the results from **Table 5**, the majority (9 of 13) of intersections in rural areas had a higher frequency of angle crashes than expected.

ICB Effectiveness Study					June 2019
Table 6: **Average Crash Rate (2013-2017) with ICB vs. Predicted Crash Rate without ICB** Rural Intersections: Rear-end Crashes					
	# of intersections with rear-end crash rate (2013-2017) lower or higher than the HSM Predicted Crash Rate				
	# of sites	**Lower than predicted crash rate**		**Higher than predicted crash rate**	
Group 1	4	2	50%	2	50%
Group 2	5	5	100%	0	0%
Group 3	2	2	100%	0	0%
Group 4	2	2	100%	0	0%

Based on the results from **Table 6**, the majority (11 of 13) of intersections in rural areas had a lower frequency of rear-end crashes than expected.

ICBs at Urban Intersections

RK&K determined the predicated (non-ICB) crash rate for six (6) intersections in urban areas. The predicted crash rate for each intersection was compared with the average crash rate for a five-year period (2013 – 2017). In order to compare similar scenarios, the ICBs in urban locations were grouped together based on the stop condition at the intersection (AWSC vs. TWSC).

- Group 1 – ICB with stop control on minor street approaches
- Group 2 – ICB with All-Way Stop Control

ICB Effectiveness Study					June 2019
Table 7: **Average Crash Rate (2013-2017) with ICB vs. Predicted Crash Rate without ICB** Angle Crashes at Urban Intersections					
	# of intersections with crash rate (2013-2017) lower or higher than the HSM Predicted Crash Rate				
	# of sites	**Lower than predicted crash rate**		**Higher than predicted crash rate**	
Group 1	4	0	0%	4	100%
Group 2	2	1	50%	1	50%

Based on the results from **Table 7**, the majority (5 of 6) of intersections in urban areas had a higher frequency of angle crashes than expected.

ICB Effectiveness Study					June 2019
Table 8: **Average Crash Rate (2013-2017) with ICB vs. Predicted Crash Rate without ICB** Rear-end Crashes at Urban Intersections					
	# of intersections with crash rate (2013-2017) lower or higher than the HSM Predicted Crash Rate				
	# of sites	**Lower than predicted crash rate**		**Higher than predicted crash rate**	
Group 1	4	0	0	4	100%
Group 2	2	1	50%	1	50%

The results from **Table 8** showed that all of the intersections that only have stop control on the minor street approaches had a higher frequency of rear-end crashes than expected.

IV. National Research

RK&K reviewed existing research for ICBs from FHWA, ITE, and other state agencies. A summary of national research related to ICBs is provided in **Appendix B** and some of the key findings are listed below.

When are ICBs effective/warranted:

- When the crash rate shows there is safety issue/special need [10, 11, 14].
- Where there is a history of angle crashes where the motorists violated the STOP sign [10,12].
- Where there is a STOP condition that has STOP signs that are not easily visible to approaching motorists [7].
- Where there are long stretches of road between STOP-controlled intersections [12].
- Where there is a history of nighttime crashes [11,12].
- Where the intersection is located on a crest vertical curve [11].

FHWA and NCHRP Report 500 both note that there have been instances of motorists believing the overhead ICBs indicate that the intersection was AWSC (e.g., motorists assume all approaches are STOP controlled). This resulted in the motorists failing to remain stopped on the minor street approaches, because they assumed the vehicles on the uncontrolled approach also had a STOP sign. A survey completed by Stackhouse and Cassidy in 1996, cited by several of the research studies, supports this theory. The results of this survey showed that approximately 38% of inexperienced motorists (young) and 46% of older motorists thought that the ICB indicated that every approach to the intersection had a STOP sign [2].

Findings from previous research:

- California: A study found no significant reduction in fatal crashes after overhead ICBs were installed [5].
- Florida: A study found that ICBs were not very effective, but actuated ICBs were moderately effective [4].

- IOWA: Unable to determine the influence of ICBs or rumble strips based on crash data from 223 intersections in Iowa [2].
- Ohio: A study found that ICBs were not effective in improving STOP sign compliance or in reducing the frequency of angle crashes at the study intersections [8,9].
- Minnesota: The Minnesota Department of Transportation (MnDOT) determined that ICBs were not effective in reducing the frequency of angle crashes, and their research also found that some motorists believed the ICB indicated that all of the approaches were stop controlled. As a result, MnDOT removed all of the overhead span mounted ICBs from the state between 2008 and 2010[6].
- Michigan: A study found that the total number of crashes didn't change, but the severity of crashes went down after the ICBs were activated. There was a greater reduction in nighttime crashes and crashes at intersections located on a crest vertical curve[11].
- Michigan: The University of Michigan found that ICBs should not be installed when the major-road approach is flat, and the flasher is visible for more than 20 seconds[11].
- North Carolina: A study found that the installation of ICBs resulted in a significant reduction in total crashes, angle crashes, and fatal/ serious injury crashes[13].
- South Carolina: A study found no significant reduction in crashes after ICBs were activated [13].
- NCHRP Report 500 stressed the fact that installing ICBs at locations without a history of applicable crashes (right-angle, rear-end, and turning crashes) or overusing ICBs will reduce their effectiveness [8].

Actuated Flashing Beacons: States have been installing flashing beacons that only flash when a vehicle approaches the intersection. For example, the Florida Department of Transportation (FDOT) has installed flashing beacons mounted on top of STOP signs that only activate when a vehicle drives over a loop detector. FDOT found that actuated flashing beacons were more effective than ICBs that always flash [4]. FDOT provided a case study where they installed an actuated flashing beacon. Before the beacon was installed there were a total of twelve (12) crashes with three (3) fatal crashes. After the actuated flashing beacons were installed there were a total of six (6) crashes, a 50% reduction, and no (0) fatalities, a 100% reduction[4].

IOWA installed flashing beacons mounted on STOP signs that only activates if a vehicle approaches the intersection at a high rate of speed and/or does not start to decelerate in advance of the STOP sign. Specifically, a radar detector measures the speed of approaching vehicles and only activates if the vehicle travels over 40 MPH at a set distance from the STOP sign. IOWA State University conducted a before and after study at several intersections with the actuated beacons, and the results showed that after their installation, vehicles began breaking earlier and the devices resulted in increased compliance of the STOP sign [3].

Automatic Dimming Device: The MUTCD provides the option of installing an automatic dimming device on the ICBs, which will reduce the brilliance of flashing beacons during night operation.

V. DelDOT Archives

The majority of the ICBs in Delaware were installed before 2005, which is currently the earliest date of available crash data in Delaware. This made it impossible for RK&K to find pre-installation crash data for most of the intersections in the state with ICBs. Therefore, RK&K reviewed DelDOT's archives to get

background information for many of the ICBs that were installed before 2005. A summary of information related to ICBs is provided in **Appendix C** and some of the key findings are listed below.

- **ICBs were installed for qualitative rather than quantitative reasons:** Intersection control beacons have been installed at locations where there was a perceived safety issue, but there wasn't necessarily a history of angle crashes. In the case of Marrows Road and Chaucer Drive, a local legislator and local residents requested an ICB. DelDOT reviewed this location and an ICB was not warranted based on the crash history. However, the ICB was installed anyway based on qualitative reasons.
- **ICBs installed because of a fatal crash:** Intersection control beacons have been installed at intersections following a single fatal crash even though the locations had been studied previously and a flashing beacon was not warranted. In the case of Milltown Road (N280) at Pecksniff Road, DelDOT recommended against flashing beacons after completing a study of the intersection between 1998 and 2001. However, when a fatal crash occurred at the intersection in 2003, resulting in the death of a State Representative's family member, a flashing beacon was approved and installed the following year (2004).
- **ICBs did not satisfy the requestor's concerns:** In several cases, after they are installed, residents don't feel like the ICBs are effective. Within a couple of years of the ICB being activated at the intersection of Marrows Road and Chaucer Drive, DelDOT received multiple request to have the intersection converted to a full traffic signal. Similarly, within a year of DelDOT installing an ICB at the intersection of Milltown Road at Pecksniff Road, DelDOT received a request to upgrade the traffic signal to a full traffic signal.
- **ICBs create a light pollution problem:** In 2011, DelDOT received a request to remove the flashing beacons at the intersection of Milltown Road and Pecksniff Drive because the light from the flashing beacons bothered the residents on the corner of the intersection.
- **ICBs were a stepping stone to a full traffic signal:** A review of DelDOT's archives revealed that span mounted Intersection Control Beacons were installed at several intersections where a full traffic signal or All-Way Stop Control were not warranted. The archives showed that in multiple locations, almost immediately after the intersection control beacons were installed, residents and/or the area legislator requested a study to convert the flashing beacon to a full traffic signal.
- **ICBs can be confusing:** Consistent with national research, a review of DelDOT's archives revealed that residents can become confused with the Intersection Control Beacon. In some cases, they didn't understand what it signified, or they assumed it meant that the intersection was a four-way stop.
- **ICBs were installed instead of other countermeasures:** ICBs have been installed at intersections where DelDOT Traffic recommended other countermeasures such as rumble strips or AWSC. For example, DelDOT Traffic recommended installing AWSC at the intersections of Hollett's Corner Road at Longridge Road, SR 5 at Hollymount Road, and SR 12 (Whites Lane) at SR 15 (Whiteleysburg Road) instead of an ICB. DelDOT Traffic felt those safety countermeasures were the most appropriate for these locations based on the crash data and intersection characteristics. However, the ICBs were ultimately installed based primarily on input from area legislators and residents who felt AWSC would have a negative impact on their commute and community.

VI. Conclusions

This report summarizes the results of this research effort looking at crash history and the predicted crash method. A review of the before and after crash data was inconclusive. Two (2) of the intersections experienced a significant decrease in angle crashes following the installation of the ICB, whereas the remaining two (2) intersections saw a significant increase in the frequency of angle crashes after the ICBs were activated. At this time, it is difficult to determine if the changes at these intersections are solely a result of the ICB, or if changes to the surrounding area (e.g. rumble strips removal/installation) played a role in the increase and decrease of crashes at these intersections.

The results from the predicted crash method showed that the majority of intersections with ICBs in rural locations (9 of 13) and urban locations (5 of 6) have had a higher frequency of angle crashes than predicted by the HSM predicted crash rate method. The results showed that rural intersections had a lower frequency of rear-end crashes than predicted. However, urban intersections had a higher frequency of rear-end crashes than predicted.

A review of existing research from other states and municipalities showed that overhead ICBs do not appear to be very effective. Research conducted in California, Florida, IOWA, Minnesota, and South Carolina found no significant reduction in angle crashes after the ICBs were activated. In addition, the majority of the studies noted that some motorists are confused by the overhead ICBs. They may assume it indicates that all approaches to the intersection have stop control. Because of this issue, some states are replacing the overhead ICBs with flashing beacons mounted on the STOP sign [(6)] and Stop Ahead Warning sign.

DelDOT's archives revealed that several ICBs in Delaware have been installed by Delaware's General Assembly at locations where there wasn't an existing safety issue or where other countermeasures may have been a better solution. The archives also revealed three (3) issues with ICBs that DelDOT should consider prior to installing ICBs in the future.

- ICBs can serve as a stop gap for local legislators and residents to get a full traffic signal. In many cases residents were not satisfied with the ICBs (thinking they didn't work) and immediately requested DelDOT to upgrade the ICBs to full traffic signals.
- ICBs can be confusing for motorists, which may lead to an increase in property damage crashes.
- ICBs create light pollution for residents living nearby to the intersections, which is similar to the noise pollution from rumble strips.

Based on the limited information available for this study, combined with the majority of existing research from other states, ICBs do not appear to effective at reducing angle crashes. It should be noted that the majority of DelDOT's ICBs are mounted over the intersection, by either span wire or mast arm. Based on a review of crash data from the existing ICBs in Delaware and research from FHWA and other states, overhead ICBs have also been found to be confusing for motorists and may result in vehicles failing to remain stopped, because they assume the other approaches are also stop controlled.

VII. Recommendations

Based on the limited information available for this study, combined with the majority of existing research from other states, ICBs do not appear to effective at reducing angle crashes. Therefore, DelDOT may want to reconsider their current policies regarding the use of ICBs, potentially discontinuing the use of overhead ICBs as a countermeasure for reducing angle crashes and instead establishing guidance to install ground mounted flashing beacons or actuated flashing beacons as a safety countermeasure. DelDOT may also want to consider installing Hazard Identification Beacons (HIBs) on the Stop Ahead signs at locations with existing overhead ICBs.

VIII. References

1) American Association of State Highway and Transportation Officials. (2010). 1st Edition Highway Safety Manual. AASHTO, Washington, D.C.

2) Center for Transportation Research and Education. Iowa State University. *Strategies to Address Nighttime Crashes at Rural, Unsignalized Intersections*, February 2008. IHRB Project TR-540, CTRE Project 05-220. Retrieved from http://publications.iowa.gov/19982/

3) Center for Transportation Research and Education. Iowa State University. *Evaluation of Rural Intersection Treatments*, May 2018. Retrieved from https://intrans.iastate.edu/research/completed/evaluation-of-rural-intersection-treatments/

4) Freeman, John R., Bansen, Justin A., Wemple, Beth, and Spinks, Richard. *Innovative Operational Safety Improvements at Unsignalized Intersections*. Kittleson & Associates, Florida Department of Transportation Contract No. C8K2, 2008. Retrieved from https://www.fdot.gov/traffic/doc-library/doc-library.shtm

5) Hammer, J.B., and E.J. Tye. *Overhead Yellow-Red Flashing Beacons*, Report No. FHWA/CA/TE-87/01, Federal Highway Administration, 1987.

6) Minnesota Department of Transportation. Engineering Services Division. *Removal of Overhead Red/Yellow Intersection Control Beacons*. *Development of Guidelines for Installation of Intersection Control Beacons*, Technical Memorandum No 08-12-T-03, June 19, 2008.

7) Missouri Department of Transportation. *MoDOT Engineering Policy Guide. 902.12 Flashing Beacons. Web. Retrieved from* http://epg.modot.org/index.php/902.12_Flashing_Beacons_(MUTCD_Chapter_4L)

8) *NCHRP Report 500. Guidance for Implementation of the AADSHTO Strategic Safety Plan. Volume 5: A Guide for Addressing Unsignalized Intersection Collisions*, Transportation Research Board of the National Academies, 2003. Retrieved from http://www.trb.org/Main/Blurbs/152859.aspx

9) Pant, P.D., Y. Park, and S.V. Neti. *Development of Guidelines for Installation of Intersection Control Beacons*, Report No. FHWA/OH-93/006, Federal Highway Administration, 1992. Web. Retrieved from https://catalog.hathitrust.org/Record/005515051

10) Tennessee Department of Transportation (December 2003). *Tennessee Department of Transportation Traffic Design Manual (Section 5.2.1)*

11) University of Michigan, Michigan Department of State Highways and Transportation (December 1977). *A Study of Accident Experience at Michigan Trunkline Intersection Control Beacon Installations.* Retrieved from https://www.michigan.gov/mdot/0,4616,7-151-9622_11045_24249_76865_76877---,00.html

12) U.S. Department of Transportation. Federal Highway Administration. Office of Safety (January 2011). *Intersection Safety: A Manual for Local Rural Road Owners*. Retrieved from *https://safety.fhwa.dot.gov/local_rural/training/fhwasa1108/*

13) U.S. Department of Transportation. Federal Highway Administration. Office of Safety Research and Development. *Safety Evaluation of Flashing Beacons at STOP-Controlled Intersections*. VA: Turner-Fairbank Highway Research Center, March 2008. Print. Publication No. FHWA-HRT-08-044. Retrieved from https://www.fhwa.dot.gov/publications/research/safety/08044/index.cfm

14) Delaware Department of Transportation. *2011 Delaware Manual of Uniform Traffic Control Devices.* Web. Retrieved from https://deldot.gov/Publications/manuals/de_mutcd/index.shtml

Appendix A – Summary of Predicted Crash Rate

Frequency of Angle Crashes (2013 - 2017) vs. Expected Angle Crash Rate Rural Locations												
	County	Crash History (# of Total Crashes 2013 - 2017)			Crash Frequency (2013 - 2017)			Predicted Crash Rate			Crash Frequency vs. Predicted Crash Rate		
		FI	PDO	Total	FI	PDO	Total	FI	PDO	Total	FI	PDO	Total
Holletts Corner Rd at Longridge Rd	Kent	1	1	2	0.20	0.20	0.40	0.12	0.11	0.23	0.08	0.10	0.18
SR 18 (Seashore Hwy) at Coverdal Rd (S042)	Sussex	10	10	20	2.00	2.00	4.00	1.32	1.16	2.48	0.68	0.84	1.53
North Main St. at Duck Creek Parkway	Kent	0	0	0	0.00	0.00	0.00	0.24	0.25	0.49	-0.24	-0.25	-0.49
US 13 at Blackbird Forest Rd	NCC	7	5	12	1.40	1.00	2.40	0.20	0.21	0.41	1.20	0.79	1.99
Pearsons Corner Rd at Lockwood Chapel Rd	Kent	3	4	7	0.60	0.80	1.40	0.56	0.49	1.05	0.04	0.31	0.35
SR 404 (Seashore Hwy) at SR 36 (S032, Scotts Store Rd)	Sussex	1	0	1	0.20	0.00	0.20	0.32	0.34	0.66	-0.12	-0.34	-0.46
Woodland Ferry Rd at Bethel Rd	Sussex	6	3	9	1.20	0.60	1.80	0.43	0.38	0.81	0.77	0.22	1.00
SR 16 (Hickman Rd) at SR 36 (S032, Scotts Shore Rd)	Sussex	0	5	5	0.00	1.00	1.00	0.07	0.08	0.15	-0.07	0.92	0.85
SR 8 (N. Little Creek Rd) at SR 9 (Bayside Drive)	Kent	0	0	0	0.00	0.00	0.00	0.06	0.07	0.13	-0.06	-0.07	-0.13
SR 30 (Gravel Hill Rd) at Sand Hill Rd	Sussex	8	17	25	1.60	3.40	5.00	0.72	0.63	1.36	0.88	2.77	3.64
SR 6 (Millington Rd) at SR 42 (Longridge Rd)	Kent	5	2	7	1.00	0.40	1.40	0.63	0.56	1.19	0.37	-0.16	0.21
SR 12 (Whites Ln/Burnite Mill Rd) at Whiteleysburg Rd	Kent	0	1	1	0.00	0.20	0.20	0.22	0.19	0.41	-0.22	0.01	-0.21
SR 18 (Cannon Rd) at Wesley Church Rd (S561)	Sussex	8	15	23	1.60	3.00	4.60	0.42	0.37	0.79	1.18	2.63	3.81

Frequency of Rear-end Crashes (2013 - 2017) vs. Expected Rear-end Crash Rate Rural Locations												
	County	Crash History (# of Total Crashes 2013 - 2017)			Crash Frequency (2013 - 2017)			Predicted Crash Rate			Crash Frequency vs. Predicted Crash Rate		
		FI	PDO	Total	FI	PDO	Total	FI	PDO	Total	FI	PDO	Total
Holletts Corner Rd at Longridge Rd	Kent	0	0	0	0.00	0.00	0.00	0.05	0.08	0.13	-0.05	-0.08	-0.13
SR 18 (Seashore Hwy) at Coverdal Rd (S042)	Sussex	1	8	9	0.20	1.60	1.80	0.52	0.87	1.39	-0.32	0.73	0.41
North Main St. at Duck Creek Parkway	Kent	0	2	2	0.00	0.40	0.40	0.22	0.35	0.57	-0.22	0.05	-0.17
US 13 at Blackbird Forest Rd	NCC	3	0	3	0.60	0.00	0.60	0.19	0.30	0.48	0.41	-0.30	0.12
Pearsons Corner Rd at Lockwood Chapel Rd	Kent	0	0	0	0.00	0.00	0.00	0.22	0.37	0.59	-0.22	-0.37	-0.59
SR 404 (Seashore Hwy) at SR 36 (S032, Scotts Store Rd)	Sussex	0	1	1	0.00	0.20	0.20	0.30	0.47	0.77	-0.30	-0.27	-0.57
Woodland Ferry Rd at Bethel Rd	Sussex	0	1	1	0.00	0.20	0.20	0.17	0.28	0.45	-0.17	-0.08	-0.25
SR 16 (Hickman Rd) at SR 36 (S032, Scotts Shore Rd)	Sussex	0	0	0	0.00	0.00	0.00	0.07	0.11	0.18	-0.07	-0.11	-0.18
SR 8 (N. Little Creek Rd) at SR 9 (Bayside Drive)	Kent	0	0	0	0.00	0.00	0.00	0.06	0.09	0.15	-0.06	-0.09	-0.15
SR 30 (Gravel Hill Rd) at Sand Hill Rd	Sussex	0	3	3	0.00	0.60	0.60	0.29	0.48	0.76	-0.29	0.12	-0.16
SR 6 (Millington Rd) at SR 42 (Longridge Rd)	Kent	1	0	1	0.20	0.00	0.20	0.25	0.42	0.67	-0.05	-0.42	-0.47
SR 12 (Whites Ln/Burnite Mill Rd) at Whiteleysburg Rd	Kent	0	0	0	0.00	0.00	0.00	0.09	0.14	0.23	-0.09	-0.14	-0.23
SR 18 (Cannon Rd) at Wesley Church Rd (S561)	Sussex	0	2	2	0.00	0.40	0.40	0.17	0.28	0.44	-0.17	0.12	-0.04

Frequency of Angle Crashes (2013 - 2017) vs. Expected Angle Crash Rate Urban Locations												
	County	Crash History (# of Total Crashes 2013			Crash Frequency (2013 - 2017)			Predicted Crash Rate			Crash Frequency vs. Predicted Crash		
		FI	PDO	Total	FI	PDO	Total	FI	PDO	Total	FI	PDO	Total
Brackenville Rd at Millcreek Rd	NCC	9	23	32	1.80	4.60	6.40	0.28	0.41	0.69	1.52	4.19	5.71
Marsh Rd at Hillcrest Ave	NCC	0	2	2	0.00	0.40	0.40	0.09	0.16	0.25	-0.09	0.24	0.15
S. Chapel St. at E. Park Place	NCC	0	0	0	0.00	0.00	0.00	0.04	0.07	0.11	-0.04	-0.07	-0.11
SR 9 at Hamburg Rd	NCC	1	10	11	0.20	2.00	2.20	0.03	0.04	0.07	0.17	1.96	2.13
SR 18 at Del Tech (Carmean Way)	Sussex	6	10	16	1.20	2.00	3.20	0.26	0.33	0.59	0.94	1.67	2.61
SR 18 at Vaughn Rd	Sussex	1	2	3	0.20	0.40	0.60	0.04	0.05	0.09	0.16	0.35	0.51

Frequency of Rear-end Crashes (2013 - 2017) vs. Expected Rear-end Crash Rate Urban Locations												
	County	Crash History (# of Total Crashes 2013			Crash Frequency (2013 - 2017)			Predicted Crash Rate			Crash Frequency vs. Predicted Crash		
		FI	PDO	Total	FI	PDO	Total	FI	PDO	Total	FI	PDO	Total
Brackenville Rd at Millcreek Rd	NCC	1	9	10	0.20	1.80	2.00	0.10	0.14	0.24	0.10	1.66	1.76
Marsh Rd at Hillcrest Ave	NCC	0	0	0	0.00	0.00	0.00	0.03	0.06	0.09	-0.03	-0.06	-0.09
S. Chapel St. at E. Park Place	NCC	1	2	3	0.20	0.40	0.60	0.10	0.23	0.33	0.11	0.17	0.27
SR 9 at Hamburg Rd	NCC	0	4	4	0.00	0.80	0.80	0.06	0.14	0.20	-0.06	0.66	0.60
SR 18 at Del Tech (Carmean Way)	Sussex	0	3	3	0.00	0.60	0.60	0.10	0.11	0.21	-0.10	0.49	0.39
SR 18 at Vaughn Rd	Sussex	1	4	5	0.20	0.80	1.00	0.10	0.17	0.26	0.10	0.63	0.74

Appendix B – Summary of National Research

Agency	Report Name	Date Published	Key Information
AASHTO	Highway Safety Manual - 1st Edition	2010	Provides predicted crash rate methodology
CALTRANS	CAMUTCD Part 4: Intersection Control Beacons	November 2014	Provides guidance (CALTRANS specific) for installing yellow flashing beacons in advance of traffic signals
Center for Transportation Research and Education, IOWA Highway Research Board	Strategies to Address Nighttime Crashes at Rural, Unsignalized Intersections	February 2008	Reviewed safety at 223 intersections, to compare effectiveness of intersection lighting, rumble strips, and intersection control beacons. Reviewed crash data from 2003 to 2005. Unable to detect the influence of rumble strips or overhead beacons based on data (Page 37). Provides a summary of four (4) research efforts conducted in 1991, 1992, 1996, and 2004.
Center for Transportation Research and Education, IOWA Highway Research Board	Evaluation of Rural Intersection Treatments	May 2018	Evaluated the effectiveness of inexpensive countermeasures for rural intersections.
Delaware Department of Transportation (DelDOT)	2011 Delaware Manual of Uniform Traffic Control Devices	Accessed June 2019	The DEMUTCD provides information on ICBs and flashing beacons
FHWA	Low Cost Safety Enhancements for Stop Controlled and Signalized Intersections	May 2009	Crash Reduction Factors for several countermeasures ICB CRF (Advanced Warning signs and STOP signs) - 10% (13% for right angle crashes)
FHWA Office of Safety	Intersection Safety: A Manual for Local Rural Road Owners	January 2011	Provides conditions when ICBs may be effective. This includes history of nighttime crashes, long stretches between stop controlled intersections, and a history of angle crashes where the motorists blew through the stop sign.
FHWA Office of Safety Research and Development	Safety Evaluation of Flashing Beacons at STOP-Controlled Intersections	April 2008	Analyzed crash history for North Carolina and South Carolina. • Reduction of 4 percent for angle crashes and 1 percent for fatal and injury crashes • Safety effect may be larger for STOP sign mounted beacons, than span mounted beacons. • Intersections in North Carolina experienced a significant reduction in total crashes, angle crashes, and injury and fatal crashes • Intersections in South Carolina experienced very little change following the installation of ICBs
FHWA, IOWA DOT, IOWA State University	Evaluating the Relationship between the Driver and Roadway to Address Rural Intersection Safety using the SHRP 2 Naturalistic Driving Study Data	February 2016	Model was developed to analyze driver braking behavior at rural intersections. A proof of concept gap acceptance model for rural intersections, was also created. Based on the results, overhead flashing beacons caused motorists to react earlier and activate the brakes sooner
Florida Department of Transportation (FDOT)	Innovative Operational Safety Improvements at Unsignalized Intersections	August 2008	Post Mounted Flashing Beacons estimated effectiveness -Continuous flashing beacons low effectiveness, vehicle actuated flashing beacons are moderately effective
Hammer, J.B, E.J. Tye, and FHWA	Overhead Yellow-Red Flashing Beacons	1987	This study was cited by other studies
ITE	Unsignalized Intersection Improvement Guide	Website 2015	Provides a brief overview of targeted crash types, problems addressed, conditions addressed, considerations, and references
Kittleson & Associates, Florida Department of Transportation (FDOT)	Innovative Operational Safety Improvements at Unsignalized Intersections	August 2008	Case Study - SR 20 (Alachua County, Florida) Actuated flashing beacons were used after initial improvements didn't work. Pre improvements - 12 crashes and three (3) fatal crashes. After improvements - six (6) crashes and no (0) fatalities
Minnesota Department of Transportation	Development of Guidelines for Installation of Intersection Control Beacons, Technical Memorandum No 08-12-T-03	June 19, 2008	The director of Minnesota's Department of Transportation Engineering Services Division sent a memorandum changing the policy for overhead ICBs. Overhead ICBs with red/yellow flashing beacons would no longer be installed at intersections with two-way stop control (TWSC). Existing overhead ICBs at intersections with TWSC would be removed by the end of 2010.
Missouri Department of Transportation (MoDOT)	MoDOT Engineering Policy Guide. 902.12 Flashing Beacons	Website 2013 Accessed in June 2019	Provides conditions for installing ICBs: • A required stop after a long period of uninterrupted speed • A required stop on a long tangent section of roadway where cross-street traffic may have trouble judging the distance and speed of an oncoming vehicle
Pant, P.D., Y. Park, and S.V. Neti, FHWA	Development of Guidelines for Installation of Intersection Control Beacons	1992	This study was cited by other studies
Tennessee Department of Transportation	Tennessee MUTCD	December 2003	Stop beacons are justified when • Violations - A significant number of vehicles violate the stop condition
Texas Transportation Institute	Modern Traffic Control Devices to Improve Safety at Rural Intersections	December 2011	Part of the study evaluated the effectiveness of different LED arrangements on STOP signs. Study showed no difference between overhead flashings beacons, and ground-mounted signs with embedded LEDs
TRB	NCHRP Report 500: Volume 5: A guide for Addressing Unsignalized Intersection Collisions	2003	Provides strategies for installing flashing beacons at stop-controlled intersections
University of Michigan	Study of Accident Experience at Michigan ICBs	December 1977	Compared before/after crash data for 77 intersections where ICBs were installed. • Provides warrants for installing ICBs • Provides guidance for locations where ICBs should not be installed

Appendix C – DelDOT Archives

Location	Roadway	Sight distance issues?	On a curve?	History of site	Did the ICB improve safety?	Other notes
Pearson's Corner Rd and Lockwood Chapel Rd/ W. Denney's Rd	Pearson's Corner Rd (K101) Lockwood Chapel Rd/ W. Denney's Rd (K171)	Yes, trees and corn fields	Yes, the intersection is located on a smooth right-hand curve on Pearson's Corner Road. It can be safely driven at 50 MPH	**2009 HEP Site I (The following changes were made)** -Installed Oversized Stop signs -Installed Oversized Crossroad Warning signs -Installed Cross Traffic Does not stop plaques -Installed raised pavement markers on Pearson's Corner Rd **2010 follow-up study - still issues** -Installed red flashing beacons on top of Stop signs -Installed yellow flashing beacons on Crossroad Warning signs	Yes, the crash rate went down Crashes involving vehicles completely disregarding STOP signs decreased (improved) by 50% following installation of ICB	
SR 30 at Sandhill Rd	SR 30 (S248, Gravel Hill Rd) Sand Hill Rd (S319)	Yes, there are trees on the NW and SW quadrants of the intersection, which may obstruct sight distance	Yes, based on google aerial it appears that the intersection is located on a smooth right-hand curve on SR 30 There are additional curves north and south of the intersection on SR 30, and there are curves to the east and west of the intersection on Sand Hill Rd	There were rumble strips on EB and WB Sand Hill Rd approaches prior to installation of the ICB **2007 HSIP Site F (The following changes were made)** -Installed 48x48 Stop signs -Installed ICBs with STOP signs (On mast arm) -Installed Oversized Stop Ahead signs -Installed HIB's (yellow) with Stop Ahead signs -Installed HIBs (yellow) on Gravel Hill Road, which is an uncontrolled approach(on mast arm) The Villages of Elizabethtown signal agreement was supposed to provide funding for the ICB until a signal was warranted. **2007 HSIP - Task 2 Meeting**	**Yes**, the following trends were identified -Crash rate decreased (improved) -Frequency of angle crashes caused by vehicles completely disregarding the stop signs decreased (improved) to two (2) crashes after ICB installed, from nine (9) crashes - Frequency of fatal/injury crashes decreased by 50%	There are separate right-turn lanes on two (2) approaches The ICB was installed with the idea that a full traffic signal would be installed once it was warranted by traffic volumes. Other options were a roundabout or AWSC
SR 30 at Morris Mill Rd	SR 30 (S248, Gravel Hill Rd) Morris Mill Rd (S297)/ Mount Joy Road	Yes, prior and during 2008, there was a house on the NE quadrant of the intersection, which may have obstructed sight distance The house was demolished after 2008	Yes, the intersection appears to be located in the middle of a curve on Morris Mill Rd. There are curves east of the intersection on Mount Joy Rd	Rumble strips may have been removed around the time the flashing beacons were installed **2006 HSIP Site H (The following changes were made)** -Installed Oversized STOP signs -Installed Oversized Crossroad Warning signs -Installed ICBs with the STOP signs -Installed HIBs with the Crossroad Warning signs **2011 HRRRP Study** -Changes made in 2007, as a result of 2006 HSIP, did not work. -WRA recommended converting intersection to AWSC -DelDOT converted intersection to AWSC in February 2012	No, the crash rate went up 2011 HRRRP review recommended converting intersection to AWSC The number of fatal and injury crashes increased significantly following the installation of the ICB in 2007. However, this may be partially attributable to the removal of rumble strips around that same time.	Long-term solution under 2011 Transparency Report is a roundabout

Location	Roadway	Sight distance issues?	On a curve?	History of site	Did the ICB improve safety?	Other notes
SR 30 at Zoar Road	SR 30 (S248, Gravel Hill Rd) Zoar Road (S048)			**2007 HRRRP Site 13 (The following changes were made)** -Installed Oversized Stop signs -Installed Oversized Crossroad Warning signs -Installed ICBs (Mast arm mounted) in 2008 **2011 DelDOT Study** -Found that improvements hadn't reduced crash rate -Converted intersection to AWSC in 2012	No, the crash rate went up Converted to AWSC in 2012	
SR 12 at Butler Road	SR 14 (K036) Butler Rd/ Old Airport Rd (K429)				No, the crash rate went up and rear-end crashes doubled	
Milltown Rd at Pecksniff Drive	Milltown Road (N280) Pecksniff Drive	No, based on 1993 study completed by DelDOT	There are curves on Milltown Rd, east and west of the intersection	Fatal car crash occurred at the intersection in 2003 -The crash involved a state representatives mother and it occurred on 6/19/2003. Disregarded STOP sign -There were two (2) angle crashes and a left-turn crash prior to the installation of the ICB -As a result of the crash, an intersection control beacon was installed in 2004	Crash data was not analyzed because of its age DelDOT's archives contain older studies with crash data prior to the ICB installation	DelDOT received a request to upgrade the ICB to a full traffic signal in 2005 DelDOT received a request to turn off the flashing beacons in 2011. A resident who lived at the intersection didn't think they worked and the light bothered him
Marrows Rd at Chaucer Drive	Marrows Rd (N351) Chaucer Drive			Flashing beacons installed in 1989 -Traffic signal was not warranted -Safety was not an issues at this location -DelDOT said ICB could be installed if Rep. Amick wanted to pay for it (June 27, 1989) -Rep. Amick funded the ICB and it was installed	No, there wasn't an existing safety issue when the ICB was installed	Residents complained that ICB did nothing DelDOT received requests to convert the ICB to a full traffic signal in the following years -1993 - Representative Amick -1995 - Representative Ulbrich
Old County Rd at Frazer Rd	Old County Rd (N395) Fazer Rd (N391)	Yes, there was a row of trees, which may have obstructed sight distance for motorists	Yes, the intersection is located on a slight right-hand curve	In 1996, there were three (3) fatal crashes at the intersection. As a result, DelDOT made the following improvements at the intersection: -Installed dual oversized STOP signs -Installed flashing beacons on top of the STOP signs -Installed dual STOP Ahead signs with flashing beacons -Removed a row of trees to improve sight distance	Yes, there was a decrease in the frequency and severity -1996: 3 fatal crashes -1997-2000: 3 crashes (2 injury and 1 pdo)	The police asked for rumble strips and ICBs. Members of the local community did not want rumble strips, so flashing beacons were installed
SR 9 (N378) at Hamburg Rd	SR 9 (N378, River Road) Hamburg Rd (N381)	Yes, 1997 HSIP Report notes that the horizontal and vertical curves on SR 9 restrict sight distance	Yes, the intersection is located within the middle of a curve on SR 9	**1997 HSIP Site M** -15 crashes between 1993 and 1995 -Installed intersection control beacons (span wire) -Made additional signing and striping changes	N/A	

Location	Roadway	Sight distance issues?	On a curve?	History of site	Did the ICB improve safety?	Other notes
SR 6 at SR 42	SR 6 (Millington Rd)			**ICB installed in 1991** -ICB resolution dated May 15, 1990 -Resident requested flashing beacon following several close calls at the intersection The resolution cited the following reasons for ICB: -Long distance between this intersection and nearest stop controlled intersection -8 crashes between 1987 and 1989	**Pre Crash Data** -8 crashes between 1987-1989 **After Crash Data** -12 crashes, 1996-1998 -11 angle crashes (1 fatal, 5 injury, and 5 PDO) -1 rear-end (PDO)	Rumble strips were considered, but they weren't supported by the community or DelDOT Traffic. They were pushed through by legislator Rumble strips installed in 1996 Lighting installed in 1996
	SR 42 (Longridge Rd) Blackiston Rd					
Holletts Corner Road at Longridge Road	Holletts Corner Rd (K126)			**1995 Warrant Study for ICB** -Requested by Representative Welch -DelDOT Traffic felt that flashing beacons wouldn't have any measurable impact on safety at the intersection. This intersection didn't have a crash issue at the time, according to the Chief Traffic Engineer (Memo 8/7/1995) -Representative Welch replied to that letter, that he understood that it wasn't warranted, but he still wanted it installed and would pay for it **1999 Signal Warrant Study** -Representative Welch requested the intersection control beacon be converted to a full traffic signal -Representative Welch later requested the intersection be converted to AWSC -Review determined that full signal wasn't warranted	N/A	
	Longridge Rd (K129)					
US 13 at Brickyard Rd	US 13 Brickyard Rd (S481)	No, sight distance is adequate, per 1997 HSIP Review	No	**1997 HSIP Site I** -27 rear-end crashes occurred on NB US 13 (1993-1995) -One of the crashes was a fatal crash The following improvements made, following HSIP -Installed yellow flashing beacons on top of Signal Ahead signs on northbound US 13 -Installed an additional three-section head on NB US 13	N/A	
SR 5 at Hollymount Rd	SR 5 (S022, Harbeson Rd)			**ICB installed in 2001** -AWSC had been warranted, but residents had DelDOT remove AWSC -Flashing beacons installed, because residents didn't want AWSC -Funded by four (4) area legislators	Pre Crash Data (1994-1997) -5 angle crashes -4 attributable to vehicles failing to remain stopped -1 attributable to ice	
	Hollymount Rd (S048)					

Location	Roadway	Sight distance issues?	On a curve?	History of site	Did the ICB improve safety?	Other notes
SR 24 at Camp Arrowhead Rd	SR 24 (John J. Williams Hwy) Camp Arrowhead Rd (S279)			Intersection had high crash rate during the summer months, because of beach traffic. Motorists were unfamiliar with the area (on way to beach), and they frequently ran stop sign. A fatal crash resulted in an ICB being installed. Flashing beacon warrants were applied and met. "Where side street delay and backups are not critical, but restricted sight or accidents are a problem, the flashing beacon signal warrants are applied". (1/3/1980)	Pre Crash Data (1976-1979) -5 angle crashes -1 fatal crash -3 crashes in July -2 crashes involved vehicles failing to stop at stop sign	The area was developing at the time, and the report specifically mentions developments being built on nearby roadways The ICB was constructed so that it could be converted to a full traffic signal when traffic volumes increased
Woodland Ferry Rd at Bethel Rd	Woodland Ferry Rd (S078) Bethel Rd (S493)			In 1988, DelDOT initiated a study because of the high frequency of stop sign violations As a result of the study, DelDOT recommended converting the intersection to all-way stop control. DelDOT Traffic believed AWSC would be the safest solution to prevent serious angle crashes and it wouldn't have that much of an impact on traffic. Area residents were against AWSC, because the residents thought it would be a hardship for tractor trailers traveling through this intersection. ICB installed in place of an AWSC	Pre crash data (1984-1987) -2 angle crashes (Both ran stop signs) -1 left-turn crash	DelDOT's review in 1988 showed that the volumes at the intersection were low, the sight distance were sufficient, and the accident rate was relatively low. (4/6/1988)
Redmill Rd at Mary Ella Drive	Red Mill Rd (N352) at Mary Ella Drive (Mill Race Development)		Yes, located in the middle of a curve on Red Mill Road	**Letter from Ray Pusey Chief Traffic Engineer 8/27/1990** -There wasn't a history of crashes at the intersection and DelDOT Traffic determined that flashing beacons would not improve safety -The warrants for a flashing beacon were not met and Mr. Pusey was concerned about funding an unwarranted ICB, because it would set a bad precedent. **Flashing beacons (span wire) were installed in 1990** -A local legislator and area residents supported the installation of an ICB -The local legislator funded the ICB and it was installed	No, there wasn't a documented safety issue	

Location	Roadway	Sight distance issues?	On a curve?	History of site	Did the ICB improve safety?	Other notes
Duck Creek Pkwy at North Main Street	Duck Creek Parkway (K134) North Main Street (K065)		The intersection is located northeast of a reverse curve	**DelDOT Traffic Study completed in 1987** -There were no crashes related to the intersection -All of the crashes occurred on curve (ROR/HFO crashes) -AWSC or a traffic signal were not warranted by traffic volumes or crash history -It was requested by Representative Ennis **ICB (Flashing beacons) were still installed** -Representative Ennis used special appropriation bill to fund the project -His main reason for installing the ICB was the intersections close proximity to Smyrna High School and the resulting high frequency of young/ inexperienced motorists.	No, there wasn't a documented safety issue	
SR 12 at SR 15	SR 12 (Midstate Rd) SR 15 (Canterbury Rd)	During the summer, crops in nearby fields can obstruct sight distance for motorists		**DelDOT Study (January 29, 1986)** -The ICB (flashing beacon) had already been installed and this was an after study -18 crashes (1982-1985) -Significant decrease in frequency of vehicles completely disregarding STOP signs -There was still an issue of vehicles misjudging gaps on the southbound approach -Didn't meet the warrants for a traffic signal **Intersection converted to AWSC in 1990** -The flashing beacons hadn't solved the safety issues at the intersection. -All of the angle crashes involved vehicles misjudging gaps on SB SR 15 approach	Based on DelDOT's review in 1986 and 1990, the flashing beacons eliminated the issue of vehicles completely disregarding the stop sign. However, it did not solve the issue of vehicles stopping and then failing to remain stopped. As a result, the intersection was converted to AWSC.	