November 2022

# Washington County, Tennessee Corridor Safety Analyses and Recommendations Final Report

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# Introduction

In 2021, the Federal Highway Administration (FHWA) sought participating agencies who may be interested in technical assistance to address their specific road safety challenges. To identify potential participating agencies, FHWA considered if a State was a Focus State as identified in the Focus Approach to Safety [1] ; proportion of Statewide public road mileage that is locally owned; and, proportion of statewide fatalities on local roads. In addition, FHWA prioritized States that have not received or have had few technical assistance projects or programs. FHWA and the project team coordinated with FHWA Division Office Safety Specialists in potential States as well as the State Department of Transportation to determine interest and to identify interested local agencies.

Tennessee fit several of the criteria and subsequently Washington County and its Highway Department was identified in July 2021 as the participating agency. Through an analysis of data collected from the State and discussions with the Highway Department, the project team identified key contributing factors to crashes across the county and determined a High Injury Network (HIN), which is a smaller subset of roadways in the county that experiences the majority of fatal and serious injury crashes.

Based on the data analysis and discussions with the project team, the Highway Department identified their desired technical assistance which was to conduct safety corridor studies that can help inform applications for project funding grants. The project team then identified three corridors on the HIN that showed a notable frequency of crashes when compared to the rest of the roadway network. These corridors and their geographic extents, were:

- Gray Station Road
    - North extent: Kingsport Highway; South extent: Suncrest Drive;
- Old Gray Station Road
    - West extent: Gray Station Road; East extent: Harwood Road; and,
- Greenwood Drive
    - North extent: Johnson City municipal limits; South extent: Tennessee State Route 81.

The project team then conducted additional data analysis focused on the three corridors and determined contributing factors to crashes. On December 7, 2021, a team consisting of the contractor team, the Highway Department, and the Johnson City Metropolitan Planning Organization (JCMPO) met and drove the corridors to observe physical conditions and driver behavior and to correlate these observations against the crash data analysis results. On March 8, 2022, a team consisting of the contractor team and FHWA again visited the corridor to note the physical characteristics and to video record the corridors for reference. After the site visits, the next task was to develop a set of safety recommendations to address the identified road safety issues. This report summarizes the recommendations along with a summary of the data analyses conducted as part of this effort.

[1] https://safety.fhwa.dot.gov/fas/

# Selection of Technical Assistance Type

The document review and data analysis informed the type of technical assistance of interest to the county. The Highway Department chose to receive technical assistance that would focus on corridor analysis – identifying safety issues and the development of safety countermeasures to address them. The agency is expected to use the findings as the base for applications for future funding to implement the strategies to improve safety in the corridors. The results of the document review and data analysis were presented to the county via a virtual meeting on December 15, 2021 at which time the county agreed on pursuing corridor analysis technical assistance. The sections below briefly describe the document review and initial data analysis efforts.

## Document Review

The project team reviewed pertinent planning and safety documents to support the local road safety focus approach for the county. The documents were obtained from TDOT, the county, and JCMPO. The information from the documents gave the project team a better understanding of the dynamics and trends in the region and were used to guide the development of the safety technical assistance for the county.

Among the documents was the Tennessee Strategic Highway Safety Plan (SHSP) which identified emphasis areas, strategies, and performance measures for reducing fatalities and serious injuries on all public roads. The SHSP is intended to coordinate traffic safety programs and help identify roadway safety priorities and strategies. The emphasis areas were used to guide some of the data analysis and later to inform potential countermeasures.

## Data Analysis

Soon after the county's decision to pursue technical assistance from FHWA, the Tennessee Department of Transportation (TDOT) provided crash data for all county-owned roads in the county. This crash data covered the period between 2016 and 2020.

The project team examined the crash data to identify trends and proportions in the types of crashes and the conditions in which they occurred. This provided a high-level look at crash data with a view to inform the discussion of road safety priorities and potential activities that could be undertaken through technical assistance. During the five-year analysis period, a total of 2,925 crashes were reported on these county-owned roads, of which 501 involved an injury, and 82 of which involved a fatal or serious injury. The emphasis areas of interest in the county and taken from the Tennessee SHSP were distracted driving, impaired driving, intersection crashes, roadway departure crashes, older drivers, young drivers, aggressive/speeding drivers, motorcycles, bicycles, pedestrians, heavy trucks, and unrestrained occupants.

In reviewing the emphasis areas in the SHSP and correlating them with the county road crash data, it was determined that the State's three emphasis areas of lane and roadway departure, unrestrained occupants, and aggressive drivers/speeding are overrepresented on county roads. There was a notable proportion of impaired and senior driver crashes which could also inform other technical assistance efforts in the county. The data analysis also showed potential for improvements in the county on minor collector roads, on curves, and undivided roads.

Figure 1 shows a HIN for the county. The HIN is comprised of 19 percent of the road miles in the county and accounts for 64 percent of the county's fatal and serious injury crashes and 58 percent of all injury crashes.

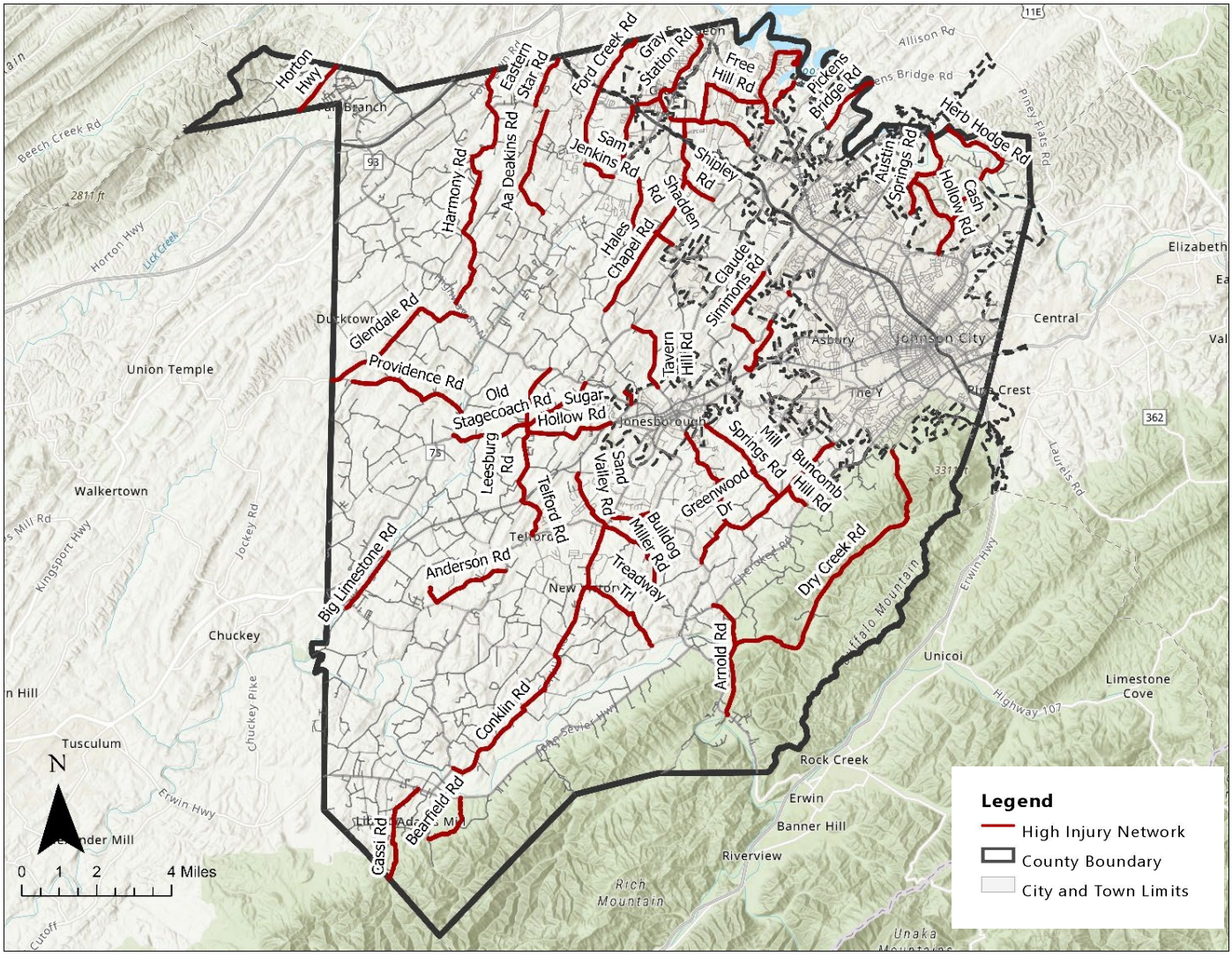



*Figure 1: High Injury Network of Roads in Washington County, TN (Source: Tennessee DOT, Washington County, TN, 2022)*

## Corridor Selection

After the December 2021 meeting, the project team proceeded to identify the corridors for further investigation during this technical assistance effort. Three corridors were selected in the county based on high proportions of injury crash data, planned Long-Range Transportation Plan improvements, and through conversations with local representatives. Table 1 shows the proportion of the county's fatal and serious injury crashes and fatal and injury crashes by road. In this table, those roads where the share of the county's fatal and serious injury crashes was over 3.0 percent or the share of fatal and injury crashes was over 2.9 percent are bolded. These bolded routes were shared with the county and three corridors were selected in January 2022 for future investigation.

Figure 2 shows these three corridors. The extents of the three corridors are as follows:

- Old Gray Station Road, from Harwood Road to Gray Station Road.
- Gray Station Road, from Suncrest Drive to Kingsport Highway.
- Greenwood Drive, from Tennessee State Route 81 to the point where South Greenwood Drive meets Johnson City, near Willow Spring Drive.

Old Gray Station Road and Gray Station Road both rank in the top five highest proportions of injury crashes, with 4.30 percent and 2.92 percent of the county's injury crashes, respectively. Old Gray Station Road is also identified for improvements in the 2045 Long-Range Transportation Plan. Greenwood Drive accounts for 3.66 percent of fatal and serious injury crashes. All three corridors are also located on the high injury network.

The corridors are typically adjoined by residential land uses. Greenwood Drive is the most rural of the three, consisting of a large-lot residential development pattern. Gray Station Road and Old Gray Station Road are adjoined by more diverse development including rural, suburban, multi-family residential, low-density commercial, civic, and institutional uses.

*Table 1: Roadway Representation in Crash Data (Source: Tennessee DOT, 2022)*

| Road | % of Locality Fatal and Serious Injury Crashes | % of Locality Fatal and Injury Crashes | % of Locality Miles |
|---|---|---|---|
| Conklin Road | **8.54%** | **3.95%** | 1.09% |
| Greenwood Drive | **3.66%** | **2.92%** | 0.71% |
| Cash Hollow Road | **3.66%** | 2.58% | 0.33% |
| Dry Creek Road | **3.66%** | 2.41% | 1.76% |
| Claude Simmons Road | **3.66%** | 1.89% | 0.44% |
| Gray Station Road | 2.44% | **2.92%** | 0.55% |
| Mill Springs Road | 2.44% | 1.37% | 0.36% |
| Sugar Hollow Road | 2.44% | 1.37% | 0.56% |
| Oak Grove Road | 2.44% | 1.20% | 0.59% |
| Aa Deakins Road | 2.44% | 0.86% | 0.41% |
| Ford Creek Road | 2.44% | 0.86% | 0.43% |
| Arnold Road | 2.44% | 0.52% | 0.64% |
| Bacon Branch Road | 2.44% | 0.52% | 0.12% |
| Cassi Road | 2.44% | 0.34% | 0.22% |
| John France Road | 2.44% | 0.34% | 0.09% |
| Old Gray Station Road | 1.22% | **4.30%** | 0.35% |
| Treadway Trail | 1.22% | 2.23% | 0.33% |
| Leesburg Road | 1.22% | 1.72% | 0.50% |
| Pickens Bridge Road | 1.22% | 1.37% | 0.70% |

| Road | % of Locality Fatal and Serious Injury Crashes | % of Locality Fatal and Injury Crashes | % of Locality Miles |
|---|---|---|---|
| Shadden Road | 1.22% | 1.37% | 0.42% |
| Austin Springs Road | 1.22% | 1.20% | 0.71% |
| Eastern Star Road | 1.22% | 0.86% | 0.18% |
| Rockingham Road | 1.22% | 0.86% | 0.12% |
| Big Limestone Road | 1.22% | 0.69% | 0.24% |
| Glendale Road | 1.22% | 0.69% | 0.59% |
| Mapleswamp Road | 1.22% | 0.69% | 0.14% |
| Bulldog Miller Road | 1.22% | 0.52% | 0.20% |
| Providence Road | 1.22% | 0.52% | 0.43% |
| Sand Valley Road | 1.22% | 0.52% | 0.22% |
| Hales Chapel Road | 0.00% | **3.09%** | 0.72% |
| Old Stagecoach Road | 0.00% | 1.72% | 0.53% |
| Harmony Road | 0.00% | 1.37% | 0.96% |
| Jim Range Road | 0.00% | 1.20% | 0.14% |
| Old Embreeville Road | 0.00% | 1.20% | 0.36% |
| Telford Road | 0.00% | 1.20% | 0.17% |
| Free Hill Road | 0.00% | 1.03% | 0.34% |
| Herb Hodge Road | 0.00% | 0.86% | 0.35% |
| Buncomb Hill Road | 0.00% | 0.69% | 0.09% |
| Mosier Road | 0.00% | 0.69% | 0.12% |
| Tavern Hill Road | 0.00% | 0.69% | 0.28% |
| Horton Highway | 0.00% | 0.52% | 0.21% |
| Phillips Road | 0.00% | 0.52% | 0.13% |
| Sam Jenkins Road | 0.00% | 0.52% | 0.11% |
| Shipley Road | 0.00% | 0.52% | 0.25% |
| Anderson Road | 0.00% | 0.34% | 0.49% |
| Bearfield Road | 0.00% | 0.34% | 0.22% |

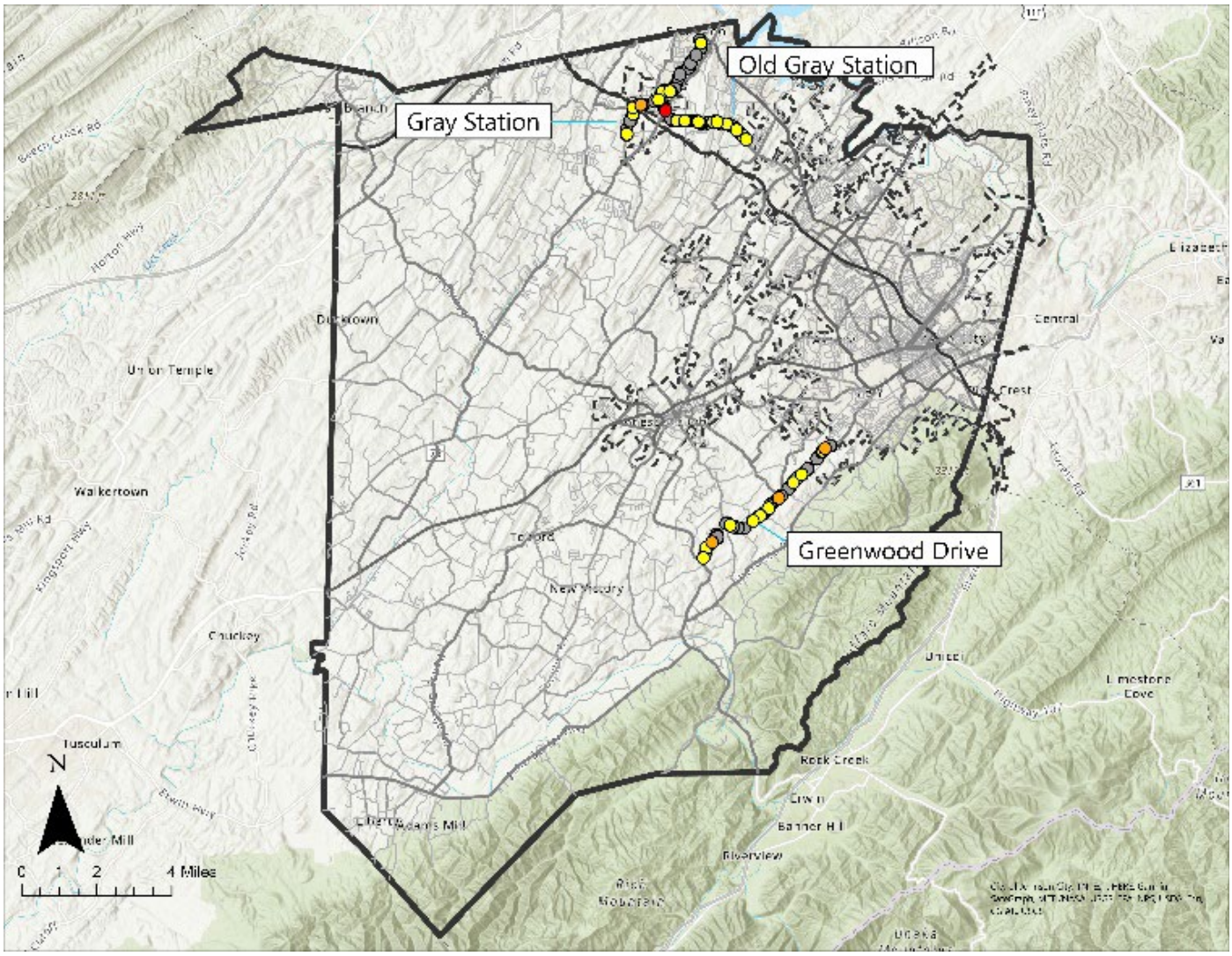



*Figure 2: Study Corridors and Crash Data (Source: Tennessee DOT, 2022)*

## Site Visits

A team consisting of the contractor team, the county and JCMPO made a site visit on December 7, 2021 led by the Washington County Highway Superintendent. The group toured various corridors throughout the county and Johnson City by car. On March 8, 2022, the contractor team and FHWA staff again visited the three selected corridors and took video while driving through the three corridors. The videos were narrated, acknowledging points of safety concern, areas for improvement, and crash cluster locations.

# Study Corridors

The following sections describe the three corridors analyzed during the technical assistance.

## Old Gray Station Road

Old Gray Station Road (figure 3) is in the northeast portion of the county and runs east-west, parallel to Interstate 26 (I-26). The eastern extent of the corridor study area lies just outside of Johnson City and is intersected by Harwood Road. Traveling west, Old Gray Station Road is mostly residential until it is intersected by Bobby Hicks Highway where the corridor briefly sits within Johnson City. This intersection provides access to restaurants, grocery stores, banks, offices, and a connection to I-26. The western extent of the study area ends at the intersection of Gray Station Road.

Intersection crashes account for the highest percentage of all severe crashes within the studied emphasis areas on this corridor, at 47 percent. This is followed by roadway departure and speeding/aggressive driving, which account for 37 percent and 34 percent of all crashes, respectively.


*Figure 3: Old Gray Station Road Corridor Overview (Source: FHWA, 2022)*

## Gray Station Road

Gray Station Road (Figure 4) is in the northern part of the county and is oriented in a north-south direction. South of I-26, large-lot rural residential is the prevailing land use. Gray Station Road takes an east-west orientation just north of I-26 where there are a mix of rural, suburban, multi-family residential, and small commercial uses. Gray Elementary School lies between I-26 and Old Gray Station Road. Near the intersection of Gray Station Road and Roy Martin Road there is a neighborhood with commercial and multi-family residential land use. East of the railroad tracks, Gray Station Road returns to its north-south orientation and the remainder of the corridor is a mixture of multi-family, rural, and suburban residential uses. The study corridor ends/begins at the intersection with Kingsport Highway (Tennessee State Route 36) in the north.

For Gray Station Road, intersection, speeding/aggressive driving, and roadway departure account for the three highest percentages of crashes at 53, 44, and 28 percent, respectively.

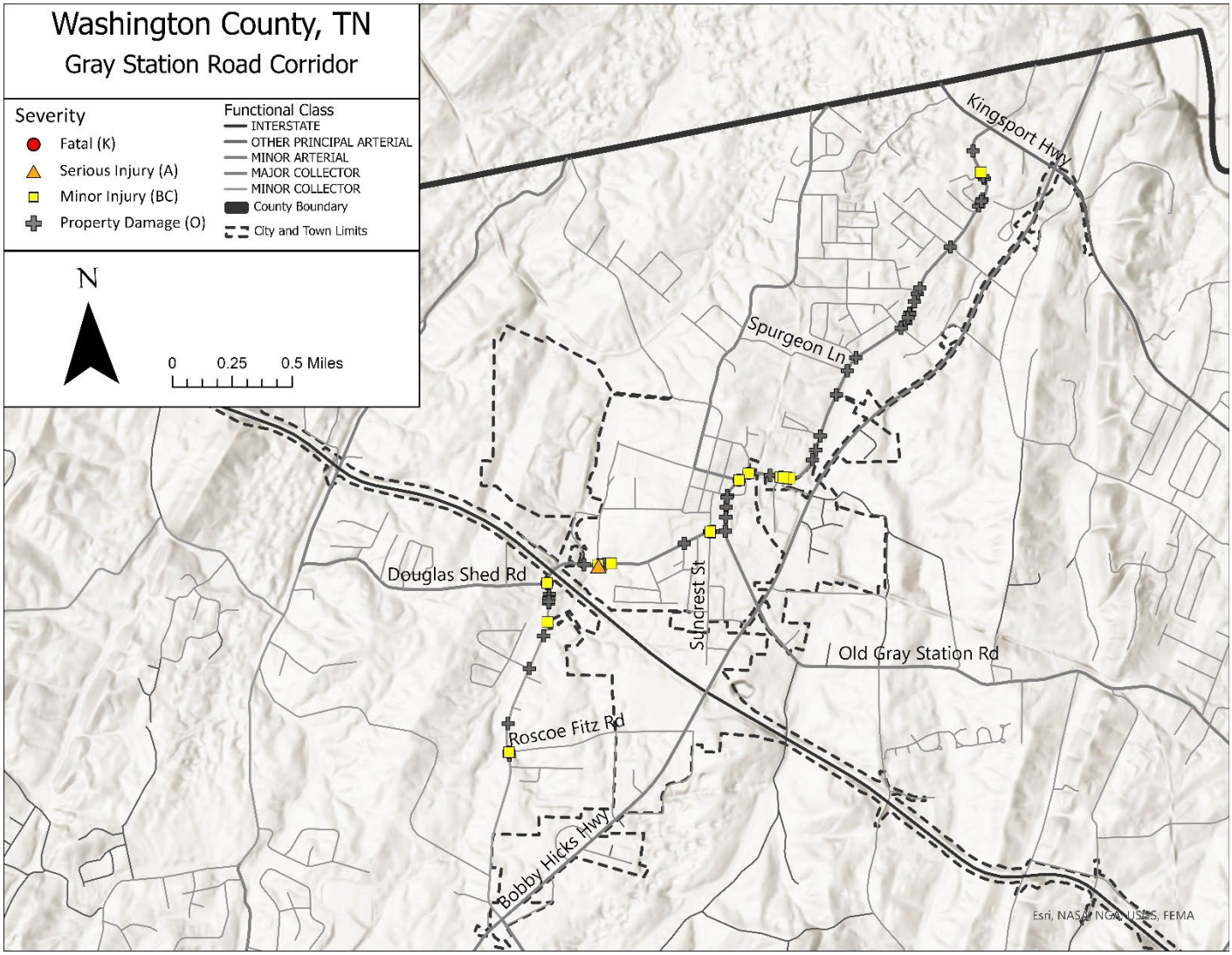



*Figure 4: Gray Station Road Corridor Overview (Source: FHWA, 2022)*

## Greenwood Drive

Greenwood Drive runs northeast to southwest in the southeastern part of the county and has both rural and suburban land uses. The land use adjacent to the two-lane roadway is large-lot suburban residential to the north and farms to the south. The study corridor ends at Tennessee State Route 81 in the southwest and at the border of Johnson City in the northeast near Willow Springs Drive.

The overrepresented county emphasis areas of roadway departure and speeding/aggressive driving account for two of the highest percentages of crashes along this corridor at 29 and 25 percent, respectively. In addition, teen drivers also account for 26 percent of crashes in this corridor.

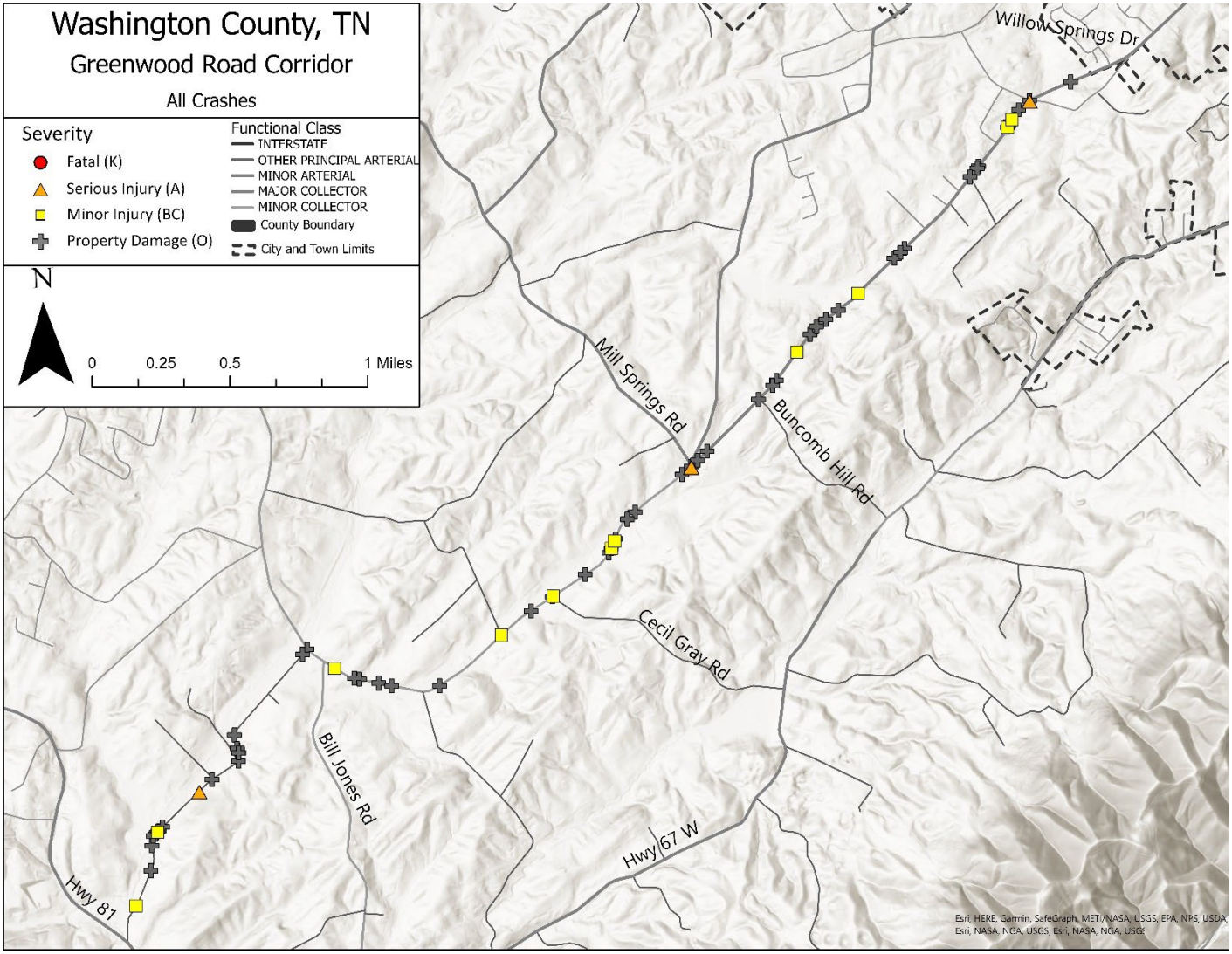



*Figure 5: Greenwood Drive Corridor Overview (Source: FHWA, 2022)*

# Crash Characteristics Highlights

The following pages summarize the documented crashes for each corridor in a graphical format.

## Old Gray Station Road

The descriptions of crashes on the Old Gray Station Road corridor are divided across five figures (figures 6 to 12). Each figure shows the location and severity of the crashes and a brief description of each crash.

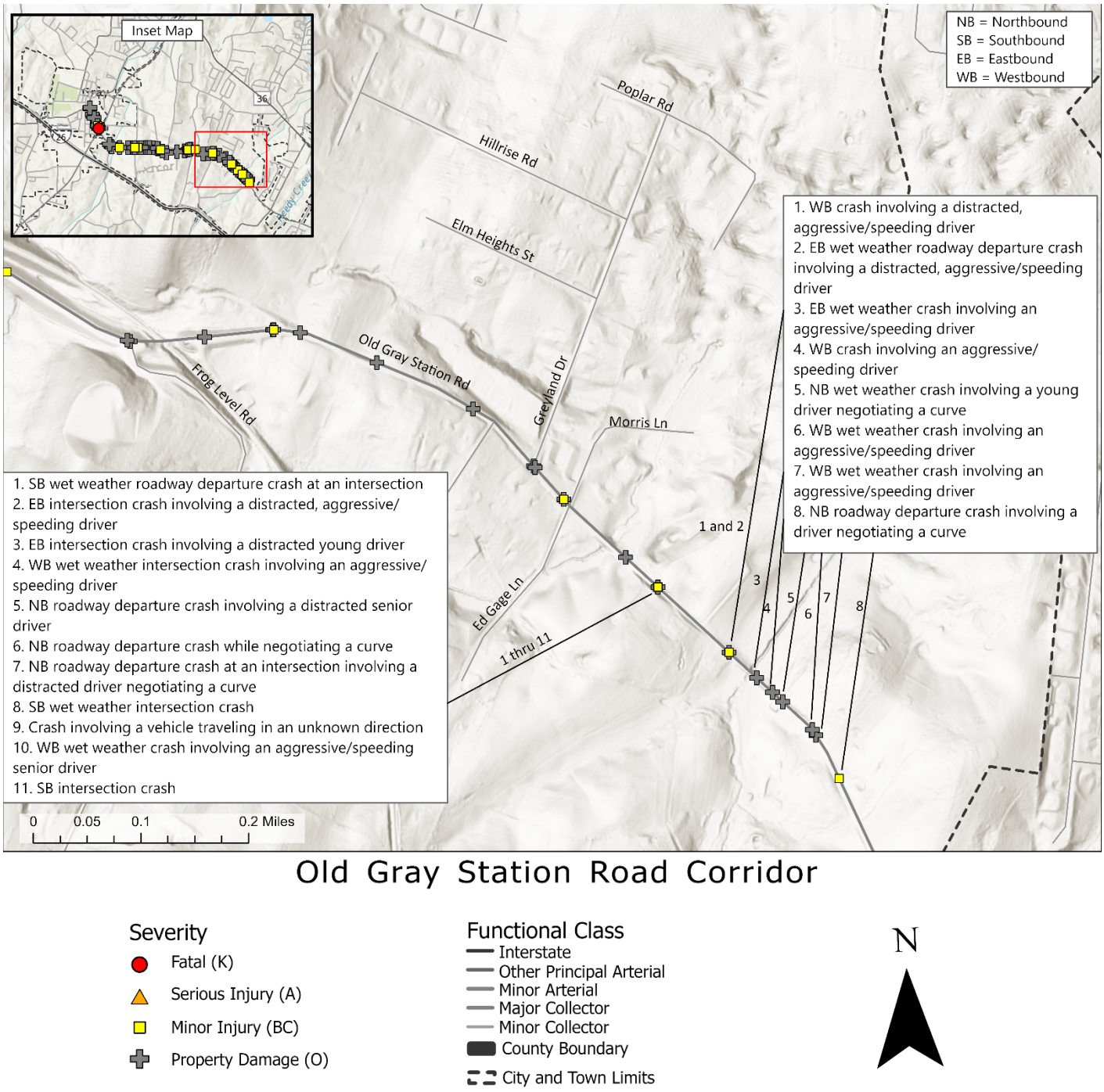
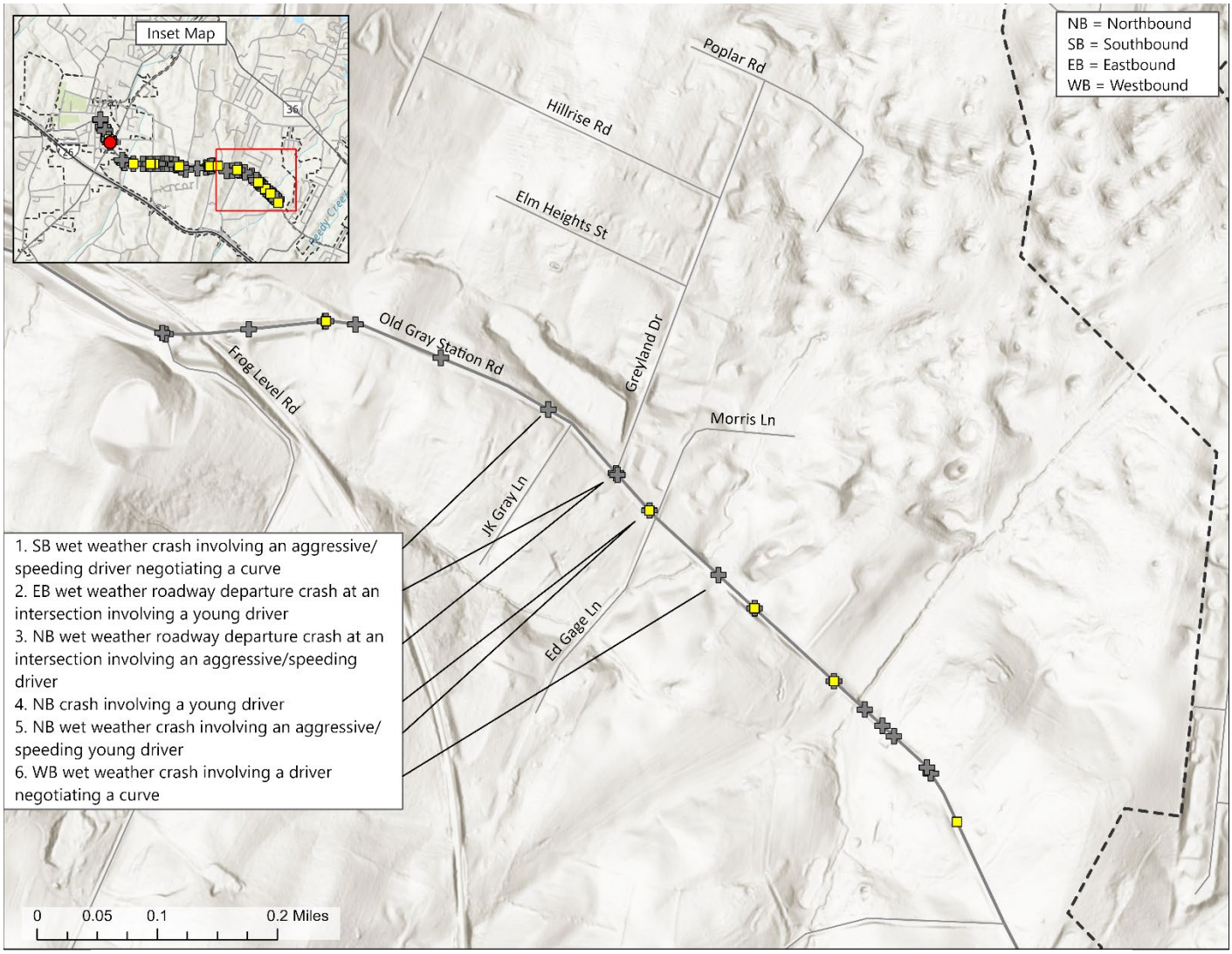



*Figure 6: Old Gray Station Road Crash Descriptions, Southeastern Segment (Source: FHWA, 2022)*




Old Gray Station Road Corridor

Severity
- Fatal (K)
- Serious Injury (A)
- Minor Injury (BC)
- Property Damage (O)

Functional Class
- Interstate
- Other Principal Arterial
- Minor Arterial
- Major Collector
- Minor Collector
- County Boundary
- City and Town Limits

N

*Figure 7: Old Gray Station Road Crash Descriptions, Central-Eastern Segment (Source: FHWA, 2022)*

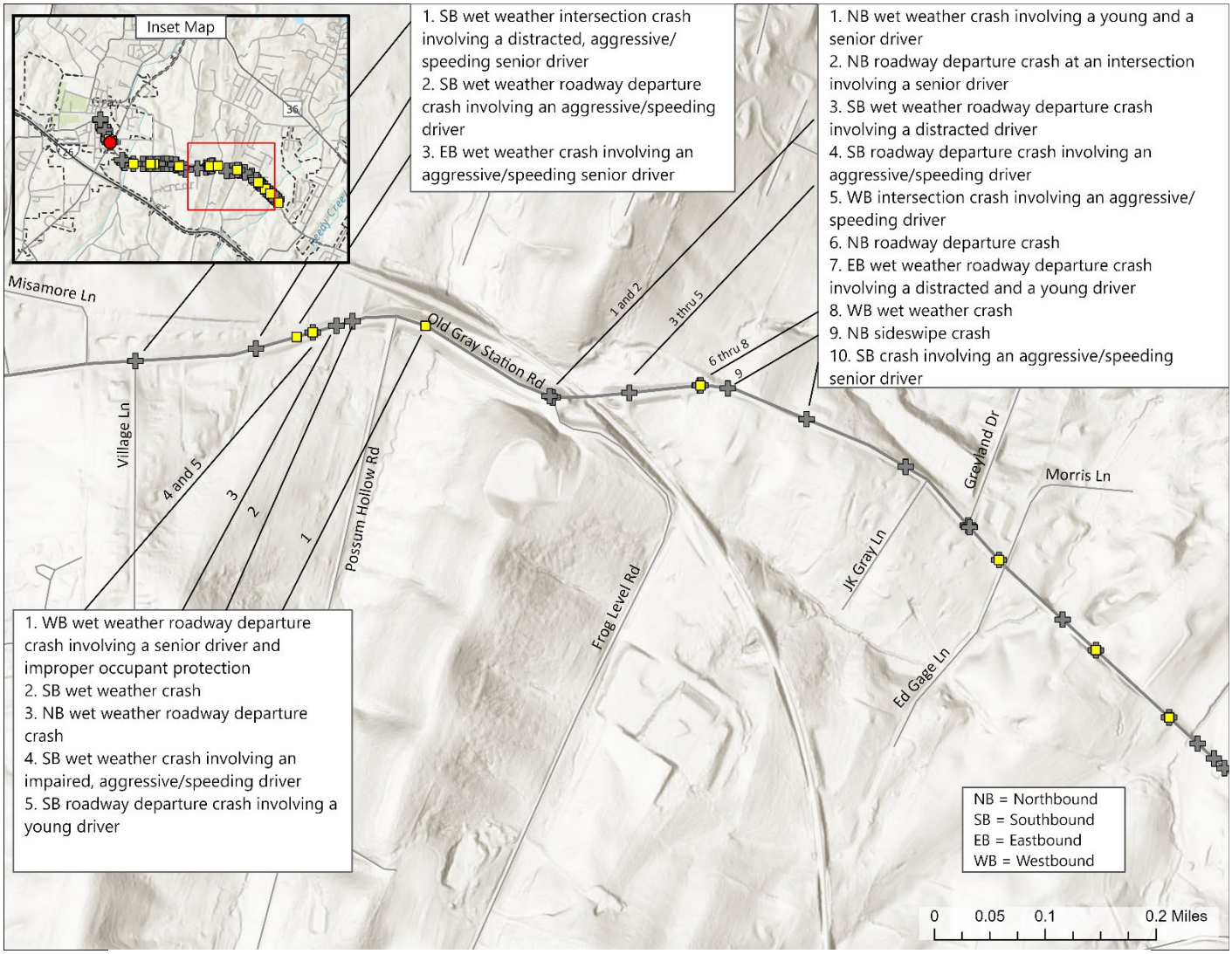



*Figure 8: Old Gray Station Road Crash Descriptions, Central-Western Segment (Source: FHWA, 2022)*

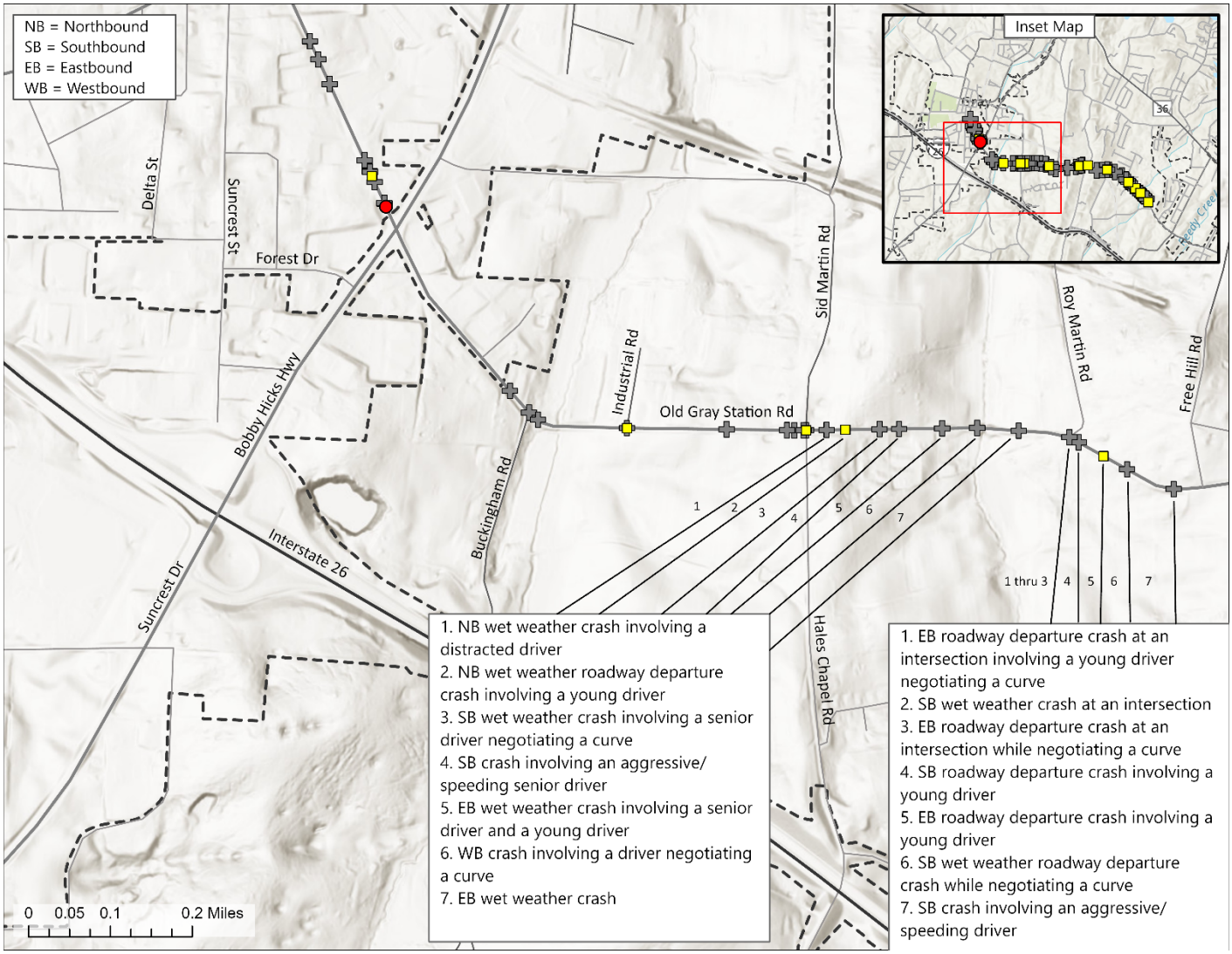



*Figure 9: Old Gray Station Road Crash Descriptions, Western Segment (1 of 3)(Source: FHWA, 2022)*

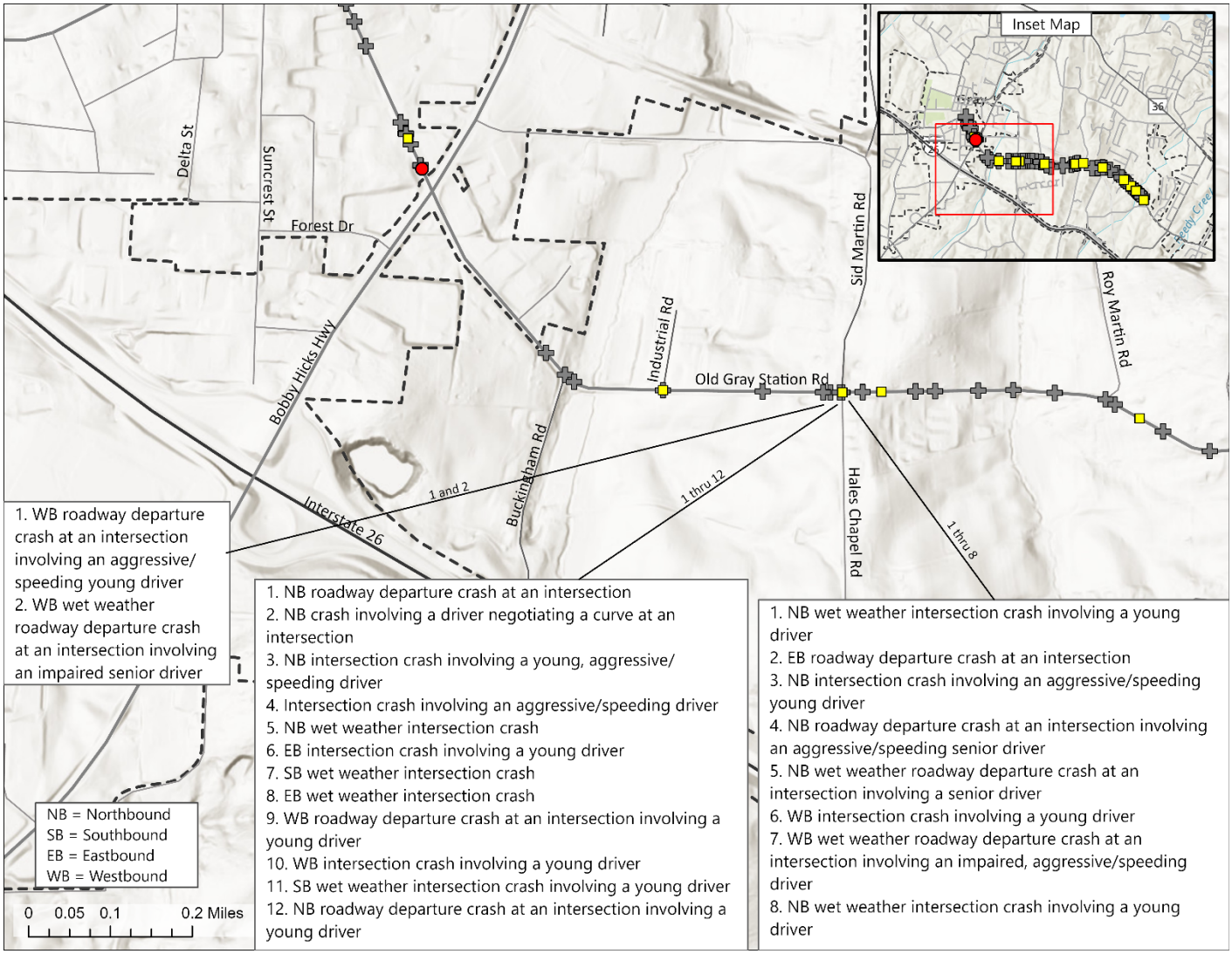
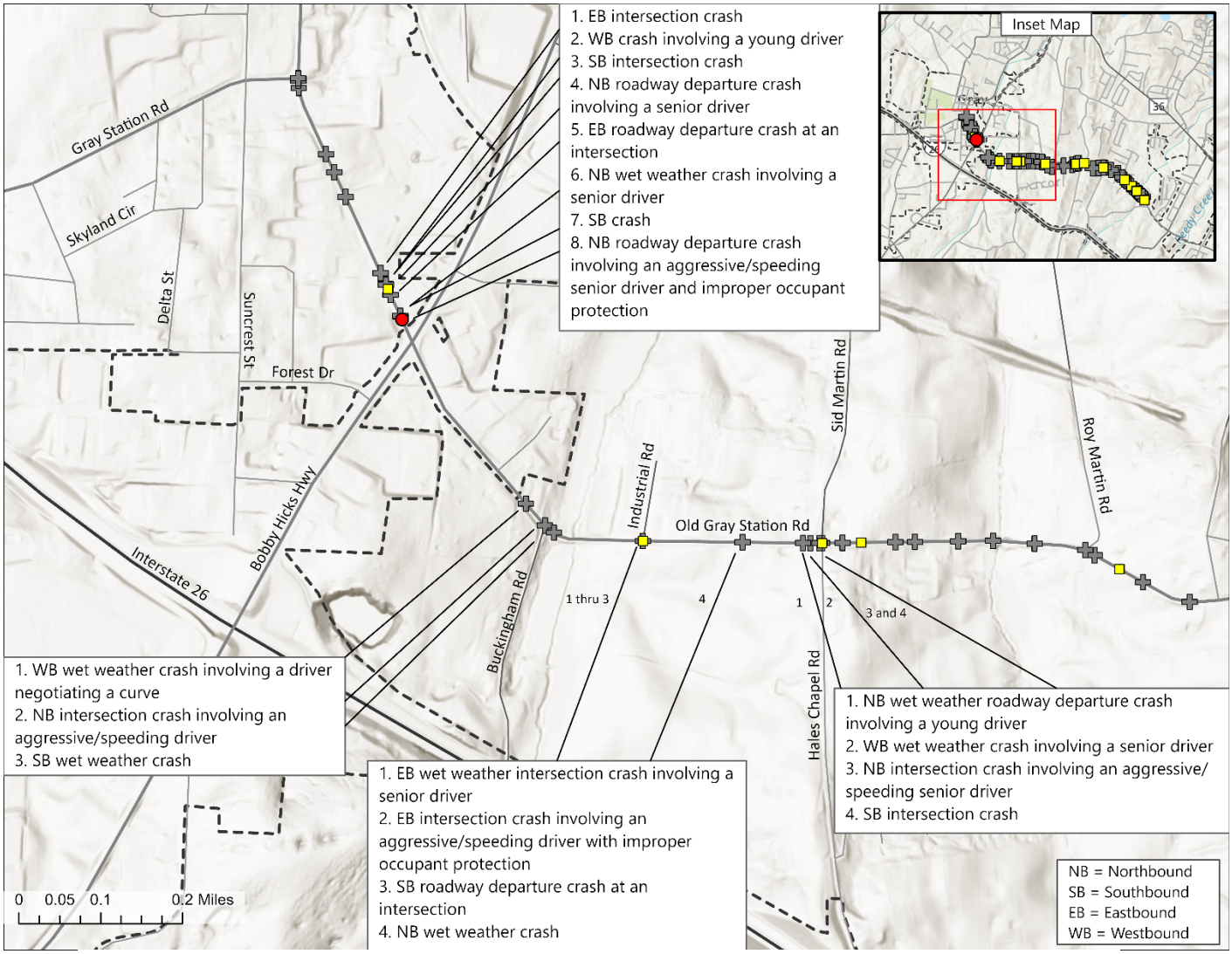



*Figure 10: Old Gray Station Road Cash Descriptions, Western Segment (2 of 3) (Source: FHWA, 2022)*




# Old Gray Station Road Corridor

**Severity**

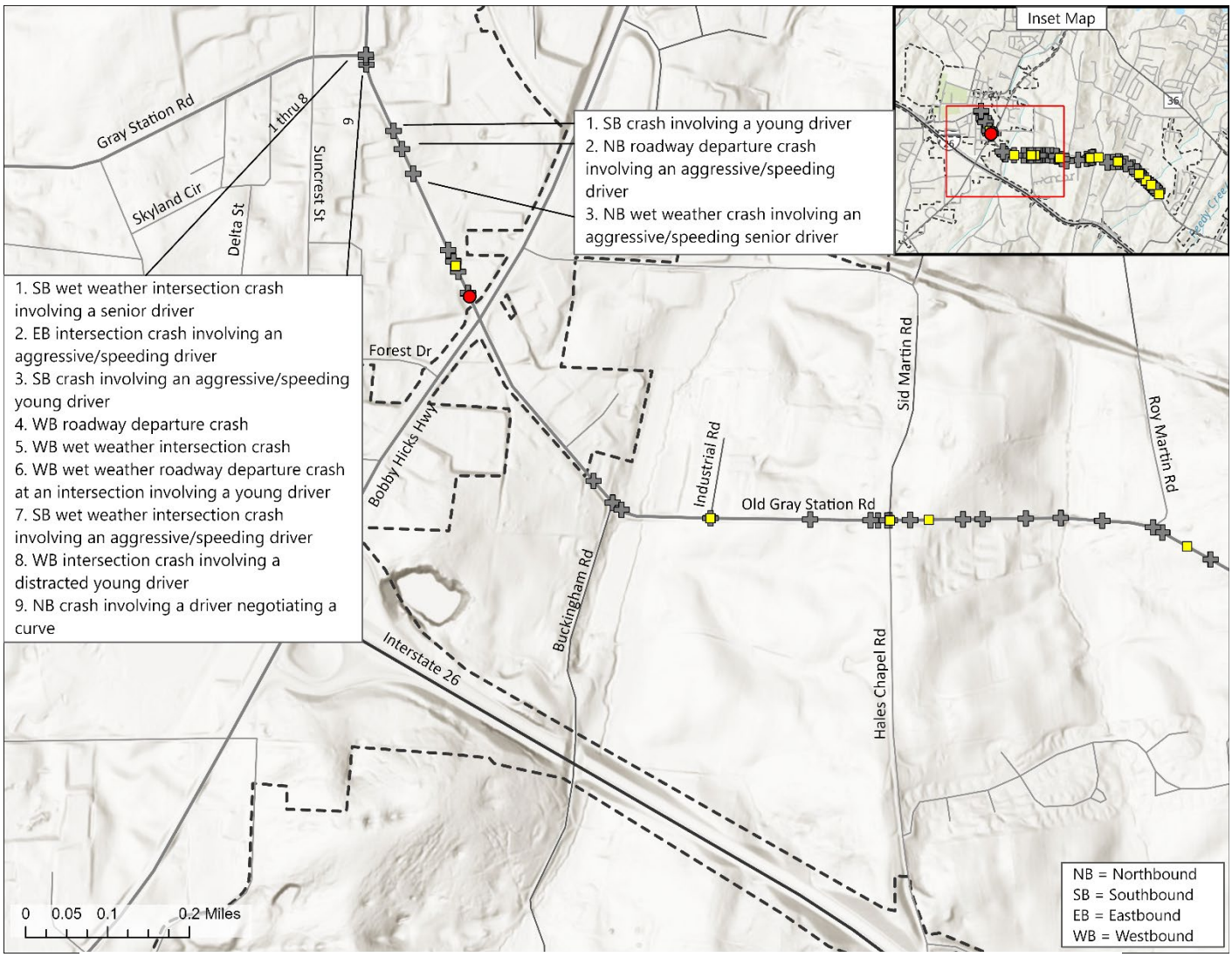
- Fatal (K)
- Serious Injury (A)
- Minor Injury (BC)
- Property Damage (O)

**Functional Class**

- Interstate
- Other Principal Arterial
- Minor Arterial
- Major Collector
- Minor Collector
- County Boundary
- City and Town Limits

N

*Figure 11: Old Gray Station Road Crash Descriptions, Western Segment (3 of 3) (Source: FHWA, 2022)*




Old Gray Station Road Corridor

Severity
- Fatal (K)
- Serious Injury (A)
- Minor Injury (BC)
- Property Damage (O)

Functional Class
- Interstate
- Other Principal Arterial
- Minor Arterial
- Major Collector
- Minor Collector
- County Boundary
- City and Town Limits

N

*Figure 12: Old Gray Station Crash Descriptions, Northwestern Segment (Source: FHWA, 2022)*

## Gray Station Road

The descriptions of crashes on the Gray Station Road corridor are divided across three figures (figures 13 to 15).

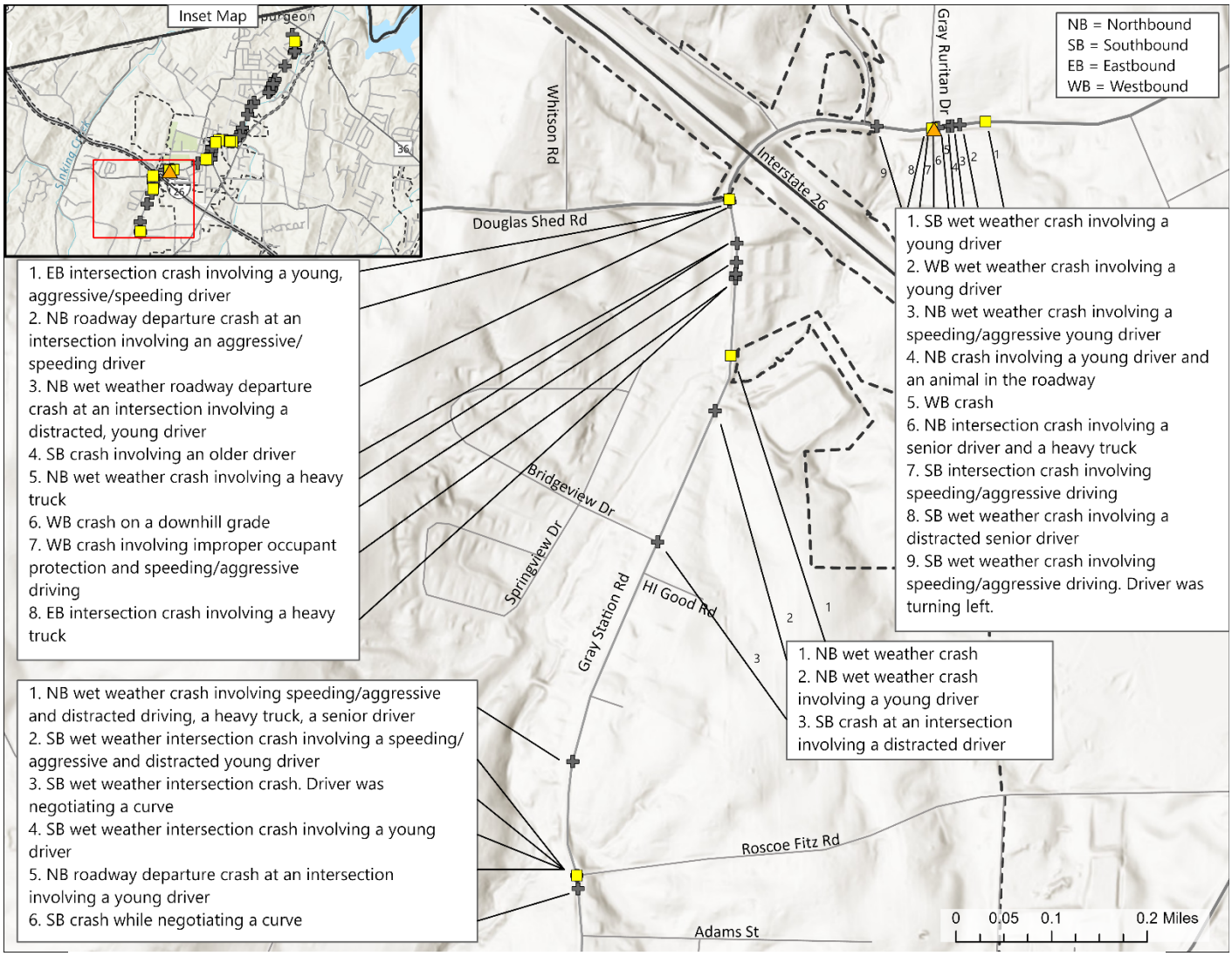
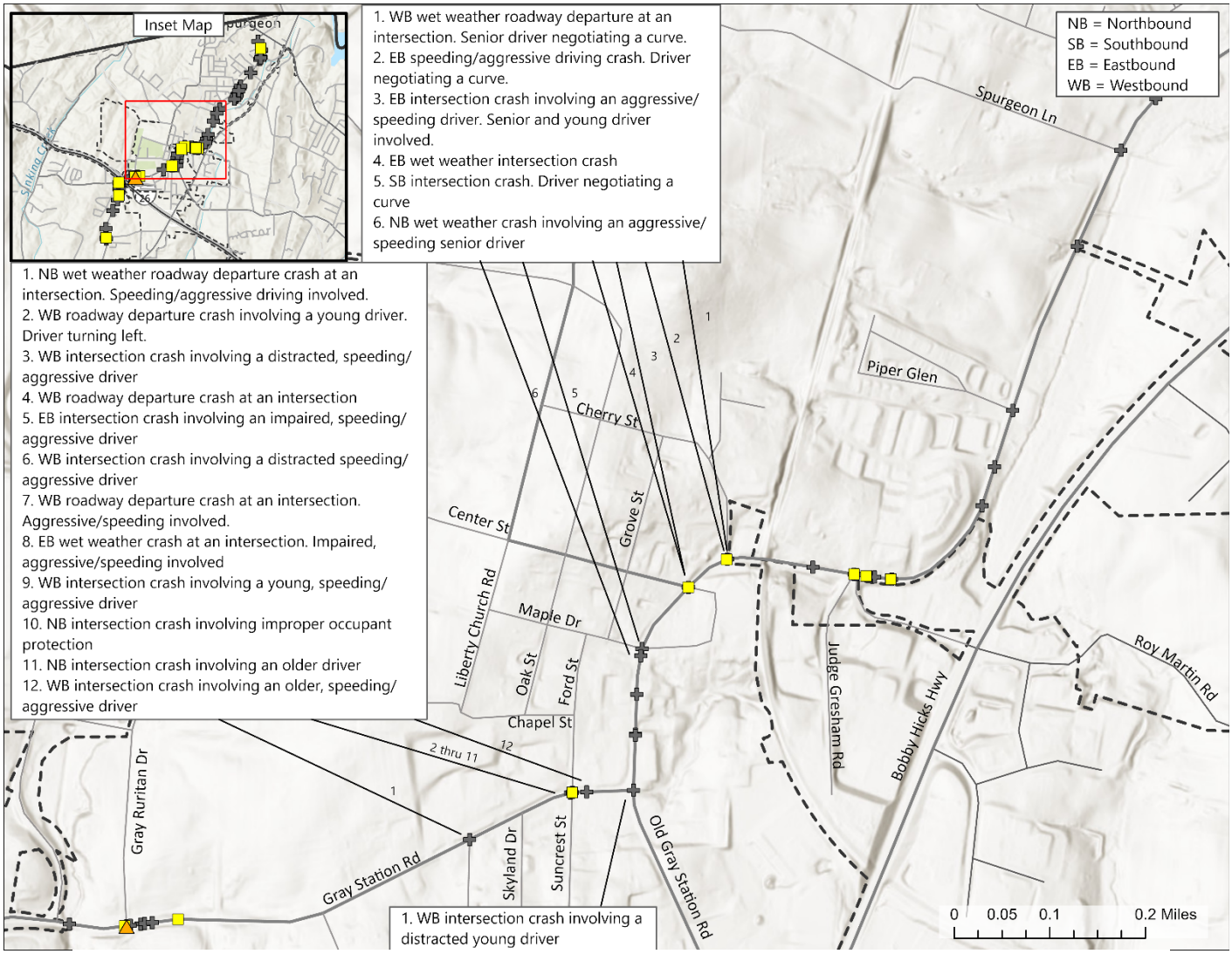



*Figure 13: Gray Station Road Crash Descriptions, Southern Segment (Source: FHWA, 2022)*




# Gray Station Road Corridor

## Severity

- Fatal (K)
- Serious Injury (A)
- Minor Injury (BC)
- Property Damage (O)

## Functional Class

- Interstate
- Other Principal Arterial
- Minor Arterial
- Major Collector
- Minor Collector
- County Boundary
- City and Town Limits

N

*Figure 14: Gray Station Road Crash Descriptions, Central Segment (1 of 2) (Source: FHWA, 2022)*

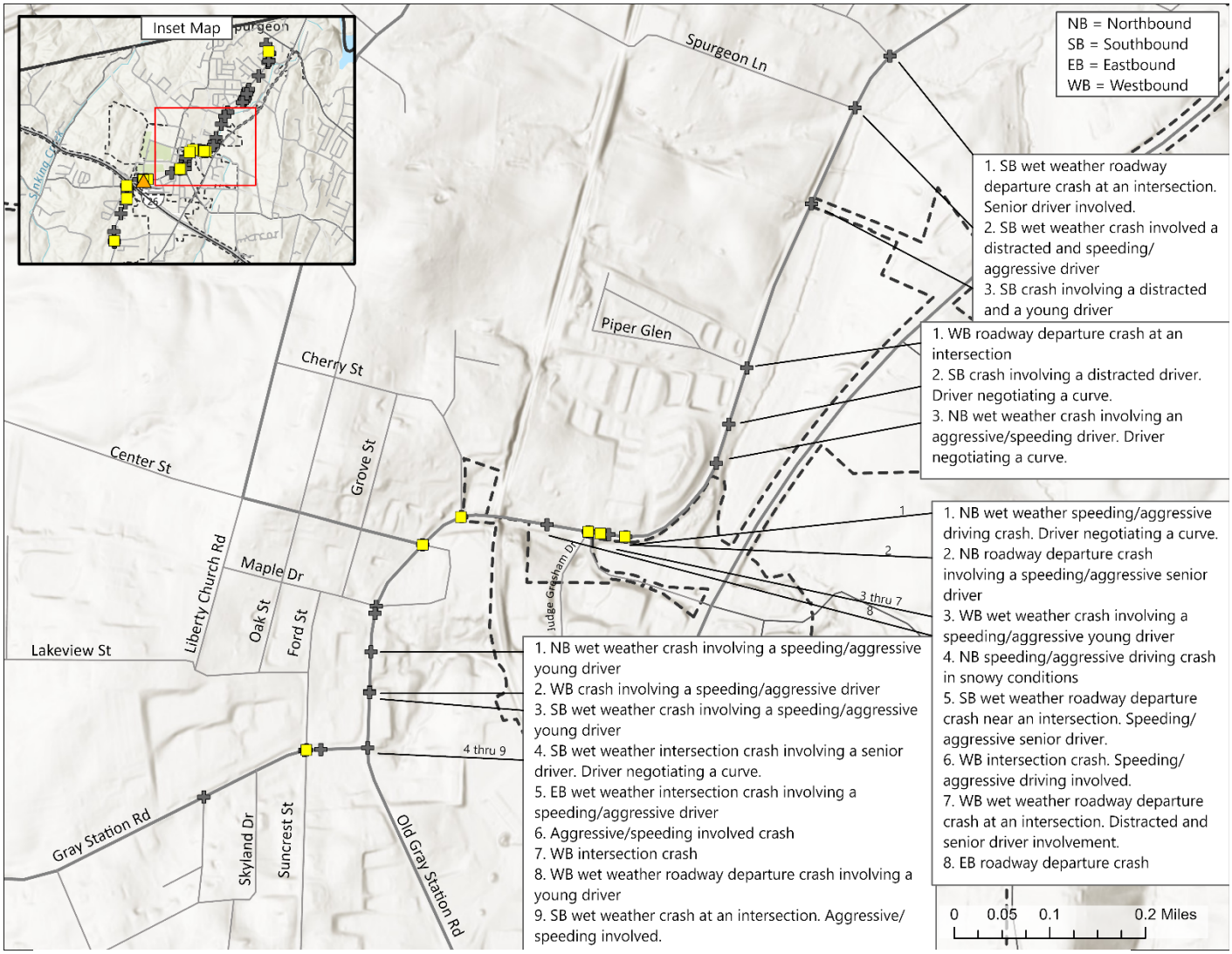



*Figure 15: Gray Station Road Crash Descriptions, Central Segment (2 of 2) (Source: FHWA, 2022)*

## Greenwood Drive

The descriptions of crashes on the Greenwood Drive corridor are divided across four figures (figures 16 to 20).

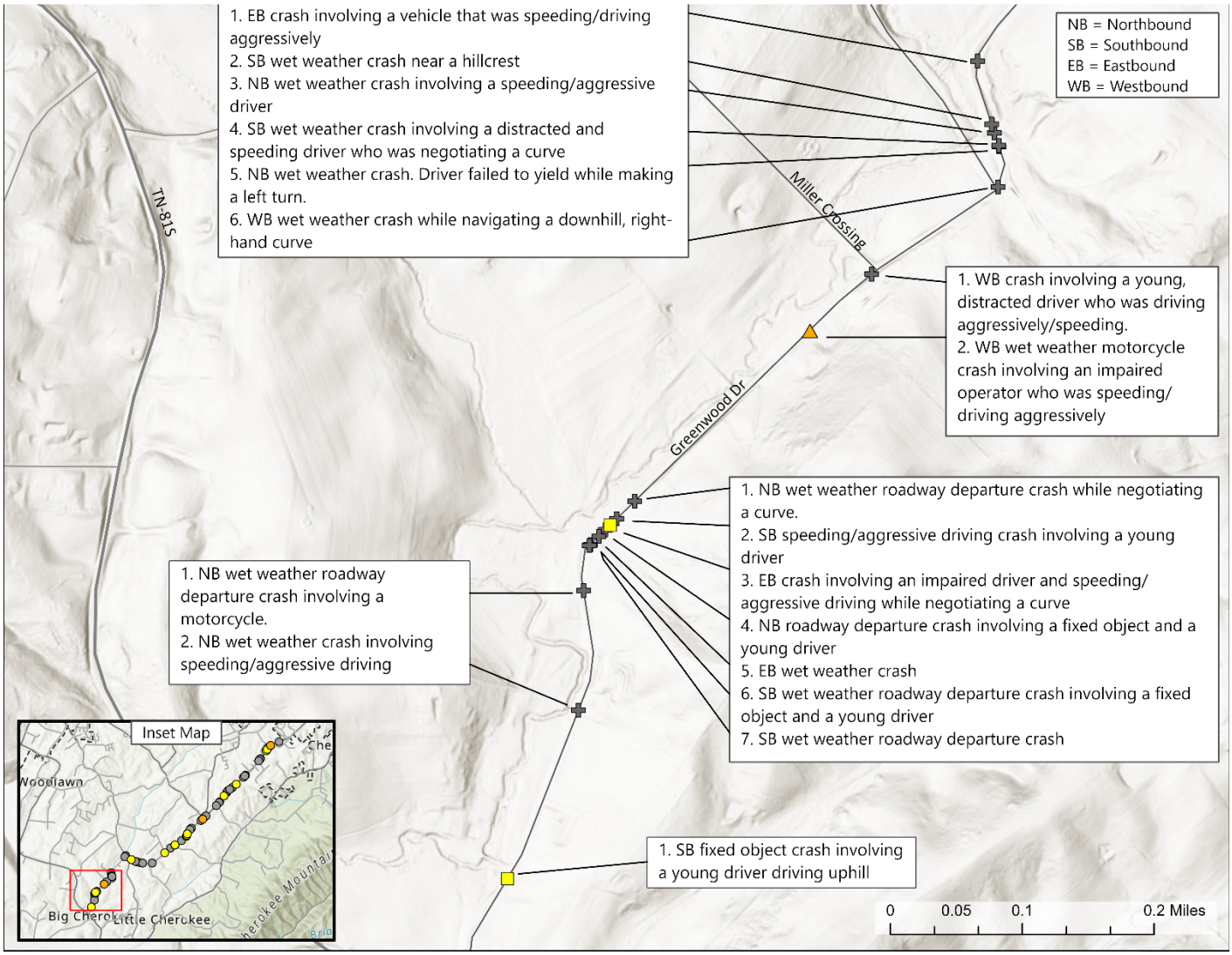
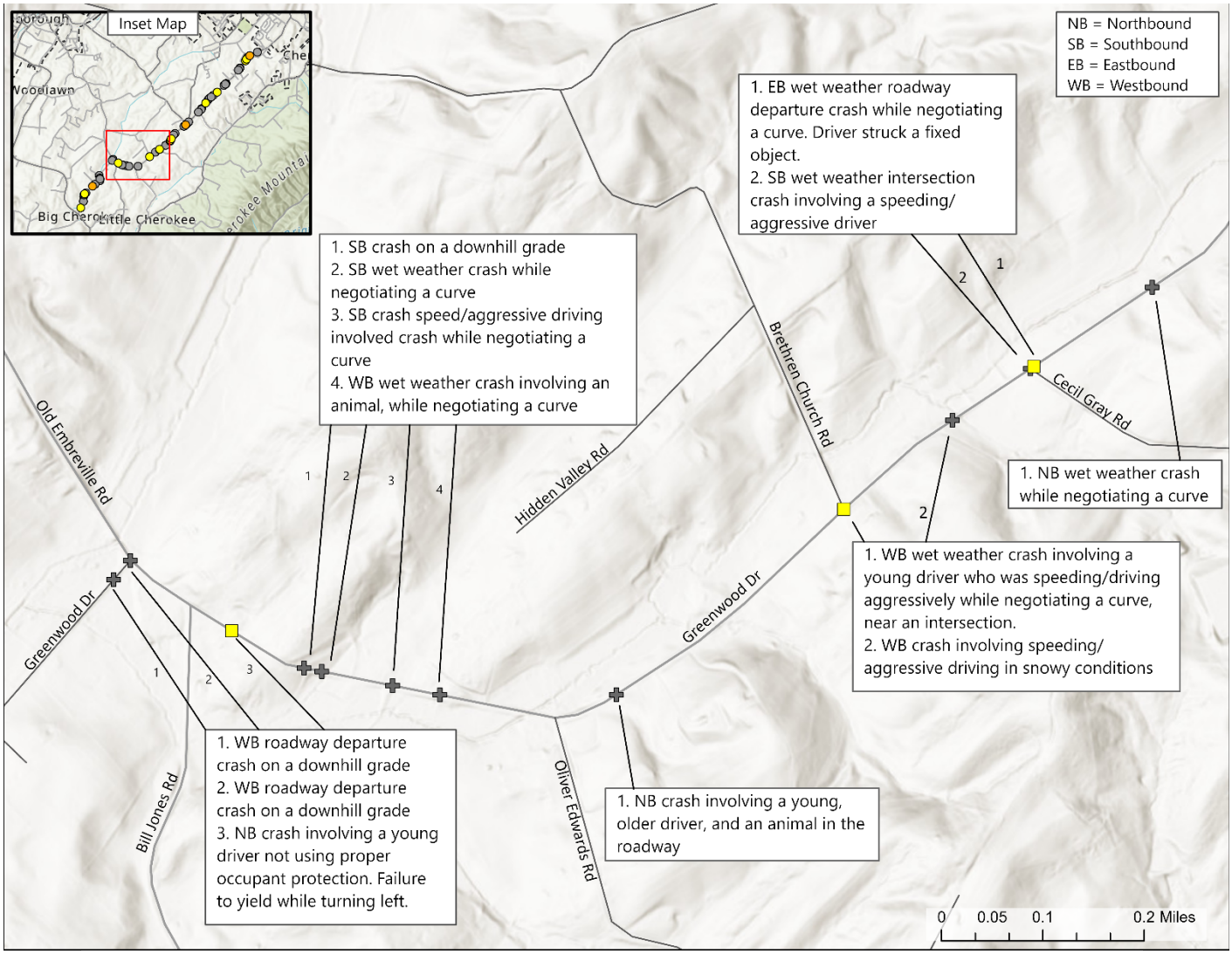



*Figure 16: Greenwood Drive Crash Descriptions, South Segment (Source: FHWA, 2022)*




## Greenwood Drive Corridor

**Severity**
- Fatal (K)
- Serious Injury (A)
- Minor Injury (BC)
- Property Damage (O)

**Functional Class**
- Interstate
- Other Principal Arterial
- Minor Arterial
- Major Collector
- Minor Collector
- County Boundary
- City and Town Limits

N

*Figure 17: Greenwood Drive Crash Descriptions, South-Central Segment (Source: FHWA, 2022)*

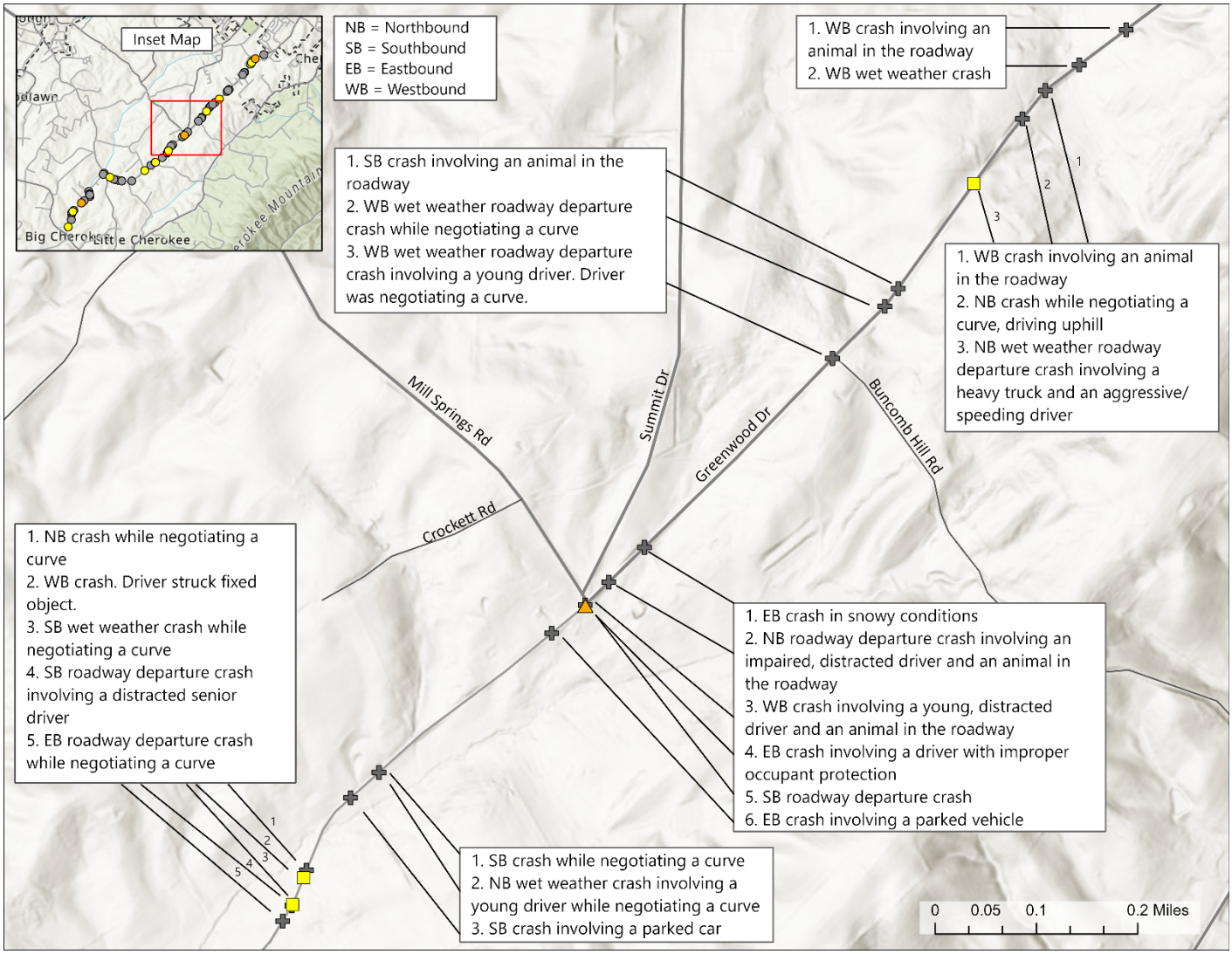



*Figure 18: Greenwood Drive Crash Descriptions, North-Central Segment (Source: FHWA, 2022)*

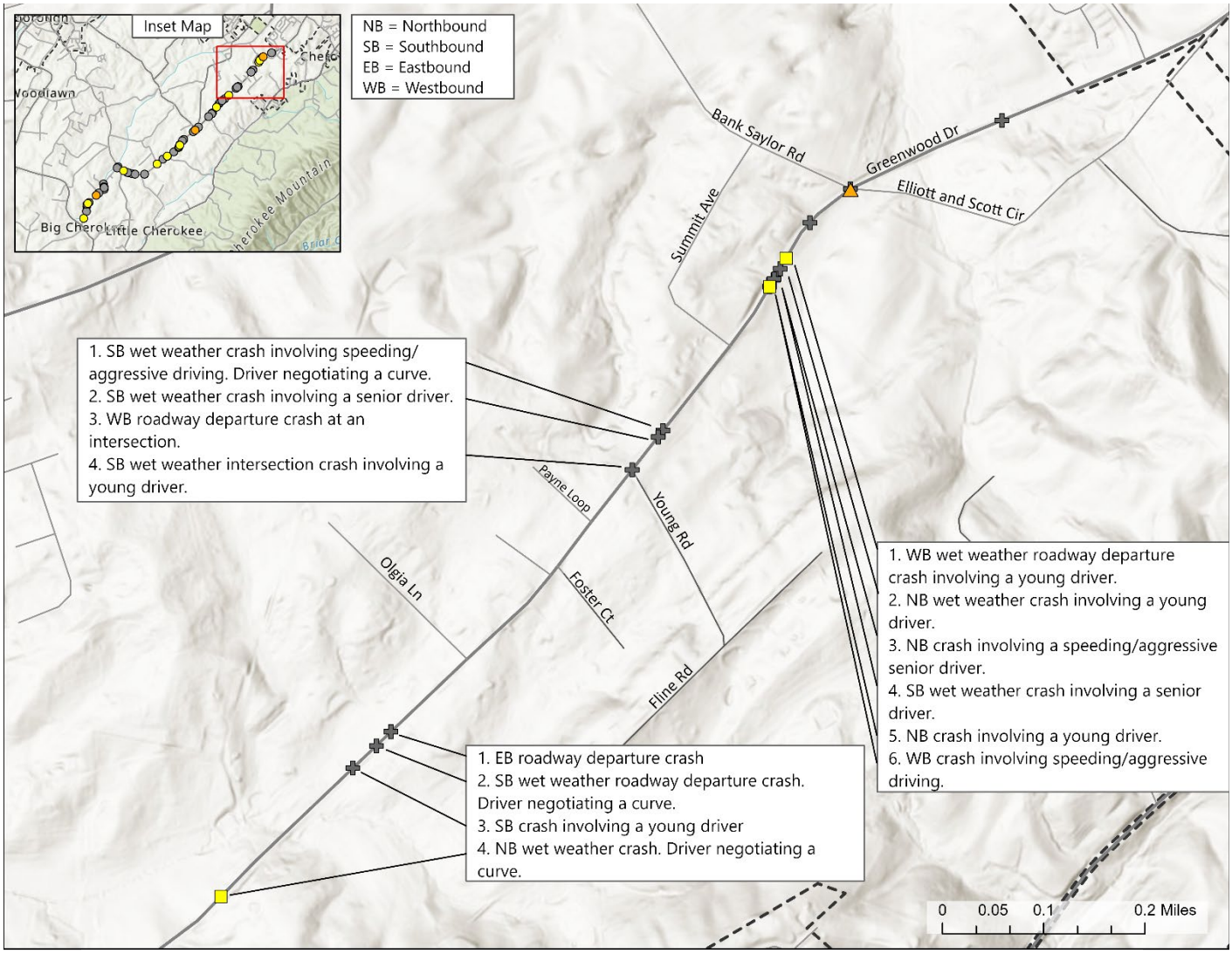



*Figure 19: Greenwood Drive Crash Descriptions, North Segment (Source: FHWA, 2022)*

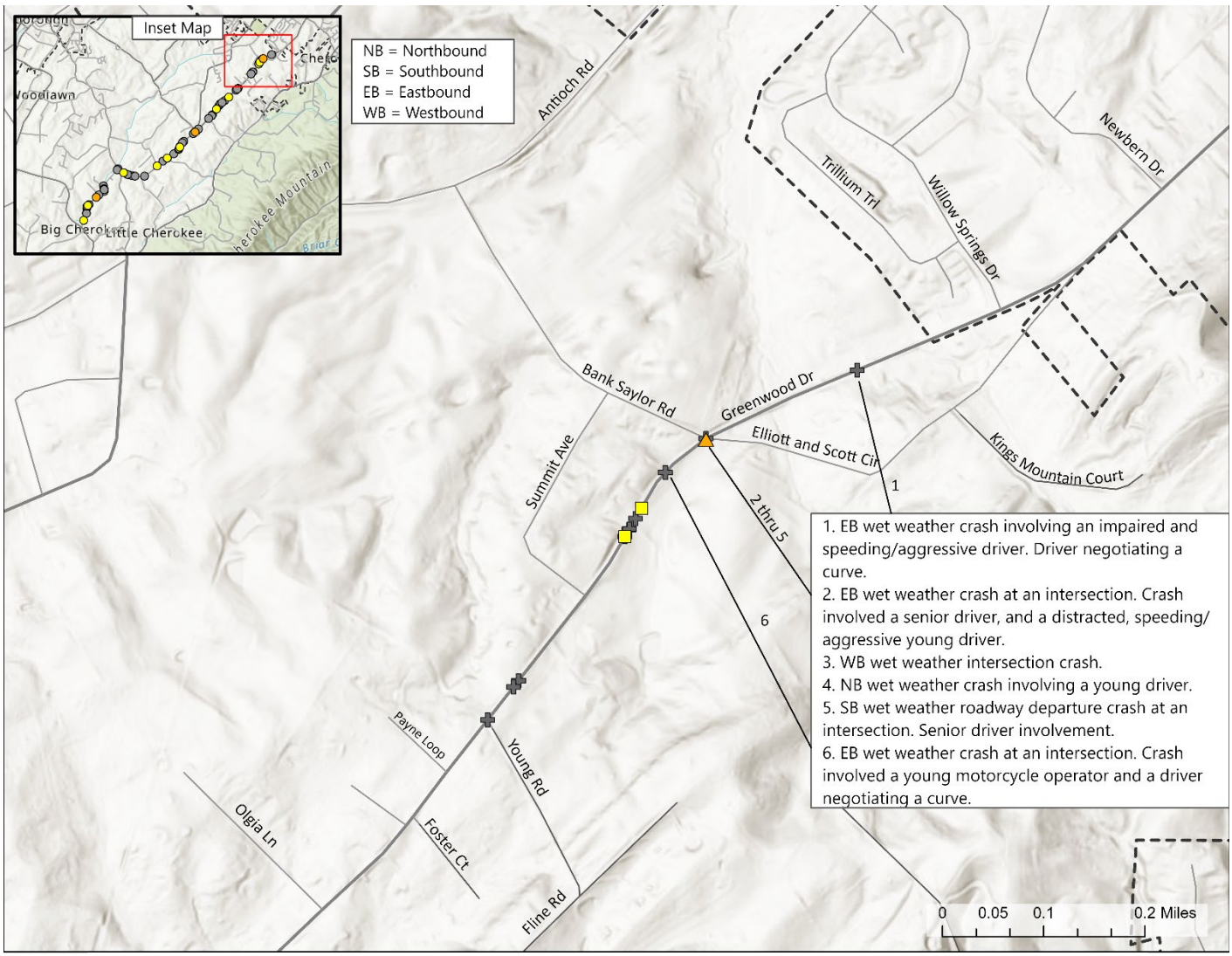



*Figure 20: Greenwood Drive Crash Descriptions, Northeastern Segment (Source: FHWA, 2022)*

# Identified Safety Issues and Recommendations

The data analysis and subsequent site visits revealed a variety of potential opportunities to improve safety in each corridor. Several resources were used to inform the types of treatments or countermeasures that could be implemented to address safety concerns. These resources included FHWA's Proven Safety Countermeasures (https://safety.fhwa.dot.gov/provencountermeasures/index.cfm), the National Highway Traffic Safety Administration (NHTSA) Countermeasures That Work (CTW) (https://www.nhtsa.gov/sites/nhtsa.gov/files/2021-09/Countermeasures-10th_080621_v5_tag.pdf), and FHWA's Crash Modification Factors (CMF) Clearinghouse (https://www.cmfclearinghouse.org/).

The following pages provide recommendations on treatments that could be applied at the corridor level for each of the three study corridors. This is followed by recommendations at specific locations in each corridor. In each section, there are descriptions of the recommended treatments followed by a summary table that lists the treatments, the emphasis areas addressed, the relative cost, a star rating, an applicable CMF identification (ID) number from the CMF Clearinghouse, and the source of the recommendation. The star rating is based on the quality of the research behind the CMF listed in the CMF Clearinghouse or the effectiveness of the countermeasure listed in NHTSA's CTW.

# Corridor-Wide Treatments

The following sections describe identified issues and recommendations for each corridor at the corridor-wide level.

## Old Gray Station Road

The county will not be able to implement all recommendations in the short-term, therefore prioritizing solutions that are cost-effective and provide the best safety benefits is recommended. Solutions that address intersection, roadway departure, and speeding/aggressive driving crashes should be prioritized. Below is a list of recommendations which are ordered based on cost from lowest to highest. The paragraphs that follow explain each solution greater detail and a subsequent table provides information on CMFs and their ratings.

### Recommendations

- Install enhanced delineation at horizontal curves -- curve warning and chevron signage.
    - Paint curve warning pavement markings.
    - Install center/edgeline rumble strips.
    - Widen edge lines, repaint existing faded edge lines.
    - Install SafetyEdge$^{SM}$.
- Install larger signage and enhance signs with retroreflectivity measures.
- Install intersection ahead warning signs and markings.
- Replace damaged metal-beam guardrails and install proper end treatments.
- Implement traffic calming measures.
    - Install transverse rumble strips.
    - Install dynamic speed displays.
- Apply Pavement Friction Management treatments.
- Conduct high visibility enforcement for speeding/impaired driving.
- Establish license screening and testing for older drivers.
- Roadway Design Improvements
    - Improve sight distance at intersections.
    - Widen shoulders and flatten sideslopes.
    - Remove fixed objects and maintain vegetation in the clear zone.
- Participate in Click It or Ticket national campaign.

**Implement Improvements and Enhanced Delineation at Horizontal Curves**

*Figure 21: Edge and centerline rumble strips (Source: FHWA)*

Old Gray Station Road has several horizontal curves. For example, at Old Gray Station Road and Roy Martin Road, there have been four crashes, three of which involved roadway departure. Strategies to keep the vehicles on the roadway on a curve or to reduce the severity of a crash once the vehicle leave the road include: widening shoulders, flattening sideslopes, maintaining the clear zone, installing curve warning and chevron signage, implementing retroreflective pavement markings, installing center and edgeline rumble strips, widening edgelines and applying SafetyEdge$^{SM}$ treatments. Location of rumble strip implementation will also depend on proximity to residential properties due to noise from their operation.

**Install Signage Warning of Upcoming Intersections**

47 percent of crashes on Old Gray Station Road were at an intersection, which is the highest percentage of all emphasis areas. Increasing the visibility of intersections by adding intersection ahead warning signage, transverse rumble strips on minor approaches, and/or pavement word markings (e.g., STOP AHEAD) are recommended.

**Replace damaged metal-beam guardrails and install proper end treatments**

Throughout this corridor there are locations where metal-beam guardrails have been damaged and not replaced. Sections that have been damaged are unable to provide the level of safety that a guardrail in good condition provides. An example of such a site is found at the intersection of Old Gray Station Road and Possum Hollow Road. There are also guardrails that have no, or improper, end treatments – a map is provided showing these locations. High visibility end treatments help warn drivers of the presence of a guardrail, and blunted ends help maintain the effectiveness and safety if a vehicle strikes that section of the guardrail.

**Implement Traffic calming**

34 percent of crashes on Old Gray Station Road include speeding and/or aggressive driving. Traffic calming measures are effective at reducing speed. Some of the traffic calming measures and devices include dynamic speed displays and chicanes.

*Figure 22: High Friction Surface Treatment (Source: Meritt et al. 2020a)*

**Apply Pavement Friction Management Treatments**

Of the 15 wet-weather crashes that occurred on Old Gray Station Road, four of them also involved roadway departure. High Friction Surface Treatment (HFST) is effective in reducing run-off-road and wet weather crashes but has also been shown to reduce dry weather and head-on sideswipe opposite direction crashes. HFST locations are

typically selected based on high crash rates, although HFST has also been used as a systemic treatment countermeasure. FHWA research shows that HFST has a lifecycle of approximately 10 years.[2]

**Conduct High Visibility Enforcement/Saturation Patrols**

The Old Gray Station Road corridor had three impaired driving crashes during the data analysis period between 2016 and 2020. Highly publicized saturation patrols are effective means of deterrence for impaired driving. The patrols increase the potential to identify and stop an impaired driver before involvement in a crash. Highly publicized enforcement operations help raise the perceived risk of impaired driving[3].

**Conduct License Screening and Testing -- Upgrade and Enhance Signage**

There were 22 crashes involving a driver aged 65 and older. Five of these crashes resulted in an injury, four of which were of a minor severity, and one resulted in a fatality. License screening can be an effective way of measuring a driver's ability to safely operate a motor vehicle. Though age is not a determinant of ability, a study in Alabama evaluating a screening tool found that drivers aged 65 and older performed significantly worse than drivers younger than 65 years old, and older drivers with a crash history performed worse than those who had no crash history[4]. Upgrading and enhancing signage by adding reflective materials and increasing the size of the signage will increase visibility of traffic control devices for drivers.

**Improve Intersection Sightlines**

Poor visibility at stop-controlled intersections reduces a driver's ability to determine if it is safe to proceed from the intersection. Reducing and/or flattening vertical crests, if possible, and removing vegetation that reduces sight distance is recommend. The intersection of Sid Martin Road/Hales Chapel Road and Old Gray Station Road is an example of a location with poor sightlines.

**Participate in Communications and Outreach: National Campaigns - Click It or Ticket**

There were four crashes involving a motorist without proper occupant protection during the study period. Motorists who do not use proper occupant protection are more likely to be severely injured or killed in a crash. Three of the crashes resulted in minor injuries and one involved a fatality. High-visibility communication can be an effective way of encouraging and reminding the public to wear their seatbelts when operating a motor vehicle and to wear proper safety gear when operating a motorcycle. Costs vary, and paid advertising can be expensive[5]. Effective plans require four to six months to implement but are considered highly effective[6].

### Summary of Old Gray Station Road Corridor-Wide Treatments

| Corridor Wide Treatment | Relevant Emphasis Area(s) | Cost (Low/ Medium/ High) | CMF Rating/ CTW Rating | CMF ID | Source (e.g., Proven Safety Countermeasure) |
|---|---|---|---|---|---|
| Enhanced Delineation for Horizontal Curves – Pavement Markings | Roadway Departure | Low | ★★★★ | 10314 | |
| Enhanced Delineation for Horizontal Curves – Chevrons | Roadway Departure | Low | ★★ | 9726 | FHWA Proven Safety Countermeasures |

[2] https://safety.fhwa.dot.gov/roadway_dept/pavement_friction/high_friction/
[3] https://www.nhtsa.gov/sites/nhtsa.gov/files/2021-09/Countermeasures-10th_080621_v5_tag.pdf, page 1-25
[4] https://www.nhtsa.gov/sites/nhtsa.gov/files/2021-09/Countermeasures-10th_080621_v5_tag.pdf, page 7-14
[5] https://www.nhtsa.gov/sites/nhtsa.gov/files/2021-09/Countermeasures-10th_080621_v5_tag.pdf, page 2-30
[6] https://www.nhtsa.gov/sites/nhtsa.gov/files/2021-09/Countermeasures-10th_080621_v5_tag.pdf, page 2-30

| Corridor Wide Treatment | Relevant Emphasis Area(s) | Cost (Low/ Medium/ High) | CMF Rating/ CTW Rating | CMF ID | Source (e.g., Proven Safety Countermeasure) |
|---|---|---|---|---|---|
| Enhanced Delineation for Horizontal Curves – Warning Signs | Roadway Departure | Low/Medium | -- | -- | |
| Wider edge lines; Repainting existing faded edge lines | Roadway Departure | Low/Medium | ★★ | 1944 | FHWA Proven Safety Countermeasures |
| Larger signage and updated/increased retroreflectivity | Older Drivers | Low/Medium | -- | -- | FHWA Desk Reference for Designing Roadways for the Aging Population |
| Replace damaged metal-beam guardrails and install proper end treatments | Roadway Departure | Low/Medium | ★★★ | 10306 | FHWA Proven Safety Countermeasures |
| Centerline rumble strips | Roadway Departure | Medium | ★★★ | 10386 | FHWA Proven Safety Countermeasures |
| Edgeline rumble strips | Roadway Departure | Medium | ★★★ | 3390 | |
| SafetyEdge$^{SM}$ | Roadway Departure | Medium | ★★★★★ | 8661 | FHWA Proven Safety Countermeasures |
| Traffic calming - Transverse Rumble Strips | Speeding | Medium | ★★★★ | 2702 | FHWA Proven Safety Countermeasures |
| Traffic Calming – Dynamic Speed Displays | Speeding | Medium | ★★★★ | 6885 | |
| Pavement Friction Management | Roadway Departure | Medium | ★★★ | 7900 | FHWA Proven Safety Countermeasures |
| High Visibility Enforcement/Saturation Patrols | Speeding, Impaired Driving, Distracted Driving | Medium | ★★★★ | - | Countermeasures That Work, 10$^{th}$ edition (measure 2.2) |
| License Screening and Testing | Older Drivers | Medium | ★★ | - | Countermeasures That Work, 10$^{th}$ edition (measure 2.2) |
| Roadway Design Improvements at Horizontal Curves -- Widened Shoulder | Roadway Departure | Medium | ★★★★ | 6659 | FHWA Proven Safety Countermeasures |
| Roadway Design Improvements at Horizontal Curves – Flatten Sideslope | Roadway Departure | Medium | -- | -- | FHWA Proven Safety Countermeasures |

| Corridor Wide Treatment | Relevant Emphasis Area(s) | Cost (Low/ Medium/ High) | CMF Rating/ CTW Rating | CMF ID | Source (e.g., Proven Safety Countermeasure) |
|---|---|---|---|---|---|
| Roadway Design Improvements at Horizontal Curves – Clear Zone | Roadway Departure | Medium/High | ★★★/★★★ | 6403 and 1024 | FHWA Proven Safety Countermeasures |
| Communications and Outreach: Seatbelts (e.g., Click It or Ticket campaign) | Unrestrained Occupant Crashes | Varies | ★★★★★ | - | Countermeasures That Work, 10th edition (measure 3.1) |

## Gray Station Road

Implementing all these recommendations in the short-term is cost-prohibitive, therefore, prioritizing solutions that are cost-effective and provide the best safety benefits is recommended. Solutions that address intersection, speeding/aggressive driving, and roadway departure crashes should be prioritized. Below is a list of recommendations which are ordered based on cost from lowest to highest. The paragraphs that follow explain some of the solutions in more depth for this corridor and a subsequent table provides CMF/CTW ratings.

- Install enhanced delineation at horizontal curves -- curve warning and chevron signage
    - Paint curve warning pavement markings
    - Install center/edgeline rumble strips
- Install intersection ahead warning signs and markings
- Improve pedestrian and bicycle infrastructure
    - Install Rectangular Rapid Flashing Beacons (RRFB)
    - Enhance existing crosswalks
    - Add sidewalks
- Replace damaged guardrail and upgrade end treatments
- Implement traffic calming measures
    - Install dynamic speed displays
    - Install transverse rumble strips
- Apply Pavement Friction Management treatments
- Conduct high visibility enforcement for speeding/impaired driving
- Roadway Design Improvements
    - Improve sight distances at intersections
    - Widen shoulders and flatten side slopes
    - Remove fixed objects and maintain vegetation in the clear zone
- Engage in communications and public outreach campaigns – speeding/aggressive driving

**Implement Roadway Design Improvements – Horizontal Curves**

Roadway departure crashes make up 28 percent of the crashes in this corridor. There are several locations where chevron and advance curve warning signage already indicate horizontal curvature, but there may be opportunities to improve these warnings by decreasing the distance between signs or enhancing the visibility of signage at night and in other low-light conditions by affixing reflective materials to them. There are also many locations on Gray Station Road where the roadside clear zones have fixed objects (often telephone poles) located in them. Relocating these poles outside of the clear zone would provide a safety benefit. If the fixed object cannot be relocated, consider installing guardrails to lessen the severity of a crash if one occurs. Other strategies to improve safety at horizontal

curves, include widening shoulders, flattening sideslopes, painting pavement markings, installing center and edgeline rumble strips, widening edgelines, and introducing SafetyEdge[SM] treatments. Location of rumble strip implementation will also depend on proximity to residential properties due to noise from their operation.

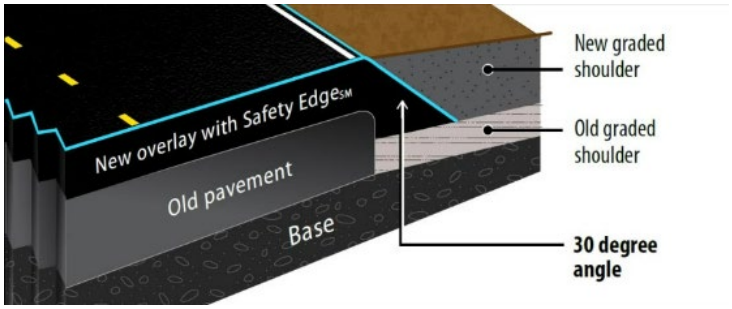



*Figure 23: SafetyEdge[SM] (Source: FHWA-SA-17-044)*

**Improve and Install New Pedestrian and Bicycle Infrastructure**

Gray Station Road winds through diverse environments for the extent of the corridor. Some areas have distinct rural characteristics while others are more urban. Even in the urban surroundings, the road design does not provide pedestrians with infrastructure where they can travel safely. Strategies to encourage safe pedestrian and bicycle travel include sidewalks, crosswalks, and rectangular rapid flashing beacons (RRFB).

*Figure 24: Rectangular Rapid Flashing Beacon (Source: FHWA MUTCD)*

**Replace Damaged Guard Rail and Upgrade End Treatments**

28 percent of the crashes in this corridor involved roadway departure. There are several locations throughout the corridor where guardrails have been damaged or are lacking proper end treatments. A map of such locations is provided later in this document. Ensuring that guardrails are in place is of high importance and may help reduce the severity of roadway departure crashes. High visibility end treatments help warn drivers of the presence of a guardrail, and blunted ends help maintain the effectiveness and safety if a vehicle strikes that section of the guardrail.

**Implement Traffic Calming**

44 percent of crashes on Gray Station Road involved speeding and/or aggressive driving. Traffic calming measures are effective at reducing speed. Recommended measures and devices include dynamic speed displays and chicanes.

**Apply Pavement Friction Management Treatments**

Of the 48 wet-weather crashes that have occurred on Gray Station Road, 16 also involved roadway departure. Five of the 16 wet-weather roadway departure crashes involved a driver negotiating a curve. HFST is most effective in reducing run-off-road and wet weather crashes but has also been shown to reduce dry weather and head-on sideswipe opposite direction crashes. HFST locations are typically selected based on high crash rates, although HFST has also been used as a systemic treatment countermeasure.

**Conduct Communications and Outreach Supporting Enforcement/High Visibility Enforcement – Speed Management**

44 percent of the crashes in the Gray Station Road corridor have involved speeding and aggressive driving. Six of those crashes have involved a minor injury. The middle portion of the corridor, near the intersection of Old Gray Station Road has a cluster of those crashes. This section of the corridor is more urban with Gray Elementary School close by with the potential for pedestrian and bicyclist traffic. There are no pedestrian involved crashes during the study period, however, the introduction of pedestrian infrastructure strategies will prevent future pedestrian crashes considering the proximity to the school and pedestrian activity in the area. Enforcement will be necessary to encourage drivers to obey the school zone speed limit. Pedestrians and bicyclists are considered vulnerable users and

are more likely to be seriously injured or killed when struck by a vehicle. The severity of injury and likelihood of a death also increase as vehicle speed increases[7].

Paid advertising programs have been shown to be effective for seat belt use, which suggests they may be effective against speeding. A high visibility campaign has the potential outcome of raising the perceived risk of speeding. Advertising must be tied to rigorous enforcement to ensure an effective campaign.

### Summary of Gray Station Road Corridor-Wide Treatments

| Corridor Wide Treatment | Relative Emphasis Area(s) | Cost (Low/ Medium/ High) | CMF Rating/ CTW Rating | CMF ID | Source (e.g., Proven Safety Countermeasure) |
|---|---|---|---|---|---|
| Enhanced Delineation for Horizontal Curves – Warning Signs | Roadway Departure | Low | -- | -- | FHWA Proven Safety Countermeasures |
| Enhanced Delineation for Horizontal Curves - Chevrons | Roadway Departure | Low | ★★ | 9726 | FHWA Proven Safety Countermeasures |
| Enhanced Delineation for Horizontal Curves – Pavement Markings | Roadway Departure | Low | ★★★★ | 10314 | FHWA Proven Safety Countermeasures |
| Improved pedestrian and bicycle infrastructure – Crosswalks | Pedestrians, Intersections, Bicyclists | Low/Medium | ★★ | 4123 | FHWA Proven Safety Countermeasures |
| Improved pedestrian and bicycle infrastructure – Rectangular Rapid Flashing Beacons (RRFB) | Pedestrians, Intersections, Bicyclists | Medium | ★★★ | 9024 | FHWA Proven Safety Countermeasures |
| Traffic Calming - Transverse Rumble Strips | Speeding | Medium | ★★★★ | 2702 | FHWA Proven Safety Countermeasures |
| Traffic Calming – Dynamic Speed Displays | Speeding | Medium | ★★★★ | 6885 | FHWA Proven Safety Countermeasures |
| Pavement Friction Management | Roadway Departure | Medium | ★★★ | 7900 | FHWA Proven Safety Countermeasures |

[7] https://nacto.org/wp-content/uploads/2017/11/2011PedestrianRiskVsSpeed.pdf, page 9

| Corridor Wide Treatment | Relative Emphasis Area(s) | Cost (Low/ Medium/ High) | CMF Rating/ CTW Rating | CMF ID | Source (e.g., Proven Safety Countermeasure) |
|---|---|---|---|---|---|
| High-Visibility Enforcement | Speeding, Impaired Driving, Unrestrained Occupants | Medium | ★★★★ | - | Countermeasures That Work, 10th edition |
| Roadway Design Improvements: Metal-Beam Guardrail - Replace damaged guardrail and upgrade end treatments | Roadway Departure | Medium | ★★★ | 10306 | FHWA Proven Safety Countermeasures – Reduce Crash Severity |
| Roadway Design Improvements for Horizontal Curves – Clear Zone | Roadway Departure | Medium | ★★★/★★★ | 6403 and 1024 | FHWA Proven Safety Countermeasures |
| Roadway Design Improvements for Horizontal Curves -- Widened Shoulder | Roadway Departure | Medium/High | ★★★★ | 6659 | FHWA Proven Safety Countermeasures |
| Roadway Design Improvements for Horizontal Curves – Flatten Sideslope | Roadway Departure | Medium/high | -- | -- | FHWA Proven Safety Countermeasures |
| Improved pedestrian and bicycle infrastructure – Sidewalks | Pedestrians, Intersections, Bicyclists | Varies | -- | -- | FHWA Proven Safety Countermeasures |
| Communications and Outreach Supporting Enforcement | Speeding | Varies | ★★★★★ | - | Countermeasures That Work, 10th edition |

## Greenwood Drive

Implementing all these recommendations in the short-term is cost-prohibitive, therefore, prioritizing the recommendations that are cost-effective and provide the most safety benefit is recommended. The county should prioritize solutions that address roadway departure, speeding/aggressive driving, and young driver crashes. A list is provided below that identifies the recommended prioritization based on cost from lowest to highest. The paragraphs that follow examine solutions in greater depth in the context for this corridor and the subsequent table shows the associated CMF/CTW rating.

- Install enhanced delineation at horizontal curves -- curve warning and chevron signage
    - Paint curve warning pavement markings
    - Install center/edgeline rumble strips
    - Widen edge lines, repaint existing faded lines
    - Install SafetyEdge$^{SM}$ treatments
- Implement traffic calming measures
    - Install dynamic speed displays
    - Install transverse rumble strips
- Apply Pavement Friction Management treatments
- Conduct high visibility enforcement – speeding/impaired driving
- Roadway Design Improvements
    - Remove fixed objects and maintain vegetation in the clear zone
    - Widen shoulders and flatten side slopes
- Engage in communications and public outreach campaigns – speeding/young drivers

**Implement Roadway Design Improvements – Horizontal Curves**

Roadway departure crashes account for 29 percent of crashes in the Greenwood Drive corridor. A hot spot for these crashes is between TN-81S and Miller Crossing. Recommendations for enhancing delineation of horizontal curves include installing reflective materials to signage and adding in-lane curve warning pavement markings. Additional methods include widening shoulders, flattening sideslopes, maintaining vegetation in the clear zone, installing SafetyEdge$^{SM}$, and implementing center and edgeline rumble strips. All these methods are effective by themselves but implementing multiple methods would provide redundancy. Location of rumble strip implementation will also depend on proximity to residential properties due to noise from their operation.

**Implement Traffic Calming Measures**

25 percent of crashes on Greenwood Drive involved speeding and/or aggressive driving. Traffic calming measures are effective at reducing speed. Recommendations include installing transverse rumble strips and dynamic speed displays.

**Apply Pavement Friction Management Treatments**

Of the 45 wet-weather crashes that have occurred on Greenwood Drive, 14 of them have also involved roadway departure. Six of the 14 wet-weather roadway departure crashes involved a driver negotiating a curve. HFST is most effective in reducing run-off-road and wet weather crashes but has also been shown to reduce dry weather and head-on sideswipe opposite direction crashes. HFST locations are typically selected based on high crash rates, although HFST has also been used as a systemic treatment countermeasure.

**Conduct High-Visibility Enforcement (HVE)/Communications and Outreach – Speeding and aggressive driving, impaired and distracted driving**

Speeding and aggressive driving make up 25 percent of the crashes in the Greenwood Drive corridor. Impaired and distracted driving make up an additional 5 percent and 8 percent, respectively. A hotspot for speeding/aggressive driving crashes is the portion of Greenwood Drive between TN-81S and Old Embreeville Road. High-visibility campaigns can be effective at reducing these behaviors by increasing the perceived consequences of operating a vehicle in an unsafe manner. Paid advertising can increase the visibility of a campaign, but it must be paired with enforcement to be effective**.**


*Figure 25: Dynamic speed feedback sign (Source: FHWA)*

## Summary of Greenwood Drive Corridor-Wide Treatments

| Corridor Wide Treatment | Relevant Emphasis Area(s) | Cost (Low/ Medium/ High) | CMF Rating/ CTW Rating | CMF ID | Source (e.g., Proven Safety Countermeasure) |
|---|---|---|---|---|---|
| Enhanced Delineation for Horizontal Curves - Chevrons | Speeding, Roadway Departure | Low | ★★ | 9726 | FHWA Proven Safety Countermeasures |
| Enhanced Delineation for Horizontal Curves – Pavement Markings | Speeding, Roadway Departure | Low | ★★★★ | 10314 | FHWA Proven Safety Countermeasures |
| Enhanced Delineation for Horizontal Curves – Warning Signs | Speeding, Roadway Departure | Low/Medium | - | - | FHWA Proven Safety Countermeasures |
| Wider edge lines; repainting existing faded edge lines | Roadway Departure | Low/Medium | ★★ | 1944 | FHWA Proven Safety Countermeasures |
| Centerline Rumble Strips | Roadway Departure | Medium | ★★★ | 10386 | FHWA Proven Safety Countermeasures |
| Edgeline Rumble Strips | Roadway Departure | Medium | ★★★ | 3390 | FHWA Proven Safety Countermeasures |
| SafetyEdge[SM] | Roadway Departure | Medium | ★★★★★ | 8661 | FHWA Proven Safety Countermeasures |
| Traffic Calming - Transverse Rumble Strips | Speeding | Medium | ★★★★ | 2702 | FHWA Proven Safety Countermeasures |

| Corridor Wide Treatment | Relevant Emphasis Area(s) | Cost (Low/ Medium/ High) | CMF Rating/ CTW Rating | CMF ID | Source (e.g., Proven Safety Countermeasure) |
|---|---|---|---|---|---|
| Traffic Calming – Dynamic Speed Displays | Speeding | Medium | ★★★★ | 6885 | FHWA Proven Safety Countermeasures |
| Pavement Friction Management | Roadway Departure | Medium | ★★★ | 7900 | FHWA Proven Safety Countermeasures |
| High-Visibility Enforcement (HVE) | Speeding, Impaired Driving, Distracted Driving | Medium | ★★★★ | - | Countermeasures That Work, 10th edition |
| Roadway Design Improvements for Horizontal Curves – Clear Zone | Roadway Departure | Medium | ★★★/★★★ | 6403 and 1024 | FHWA Proven Safety Countermeasures |
| Roadway Design Improvements for Horizontal Curves – Flatten Sideslope | Roadway Departure | Medium/High | -- | -- | FHWA Proven Safety Countermeasures |
| Roadway Design Improvements for Horizontal Curves -- Widen Shoulders | Roadway Departure | Medium/High | ★★★★ | 6659 | FHWA Proven Safety Countermeasures |
| Communications and Outreach Supporting Enforcement | Speeding Young Drivers | Varies | ★★★★★ | | Countermeasures That Work, 10th edition |

# Site-Specific Treatments

The following sections describe identified issues and site-specific recommendations for each corridor.

## Old Gray Station Road

The numbered improvements below correspond to the locations identified in the summary table at the end of these treatment descriptions.

1. **Roadway Design Improvements**

During the study period, twenty-four crashes occurred at the intersection of Old Gray Station Road and Hales Chapel Road/Sid Martin Road and three others occurred within 150 feet of the intersection. There are several contributing factors that may have caused this location to become a hotspot for crashes. The north-south connections, Sid Martin Road and Hales Chapel Road, are not aligned. The Sid Martin Road approach has poor visibility looking eastward due to vegetation, a utility pole, and a nearby crest on Old Gray Station Road. Traveling in a westerly direction along Old Gray Station Road, the exposed end treatment on the guardrail on the right side of the road presents a road departure hazards to motorists. Traveling in an easterly direction there is a utility pole on the right side of the road that likewise presents a roadway departure hazard for motorists.

Remediations include installing intersection ahead signs, establishing a four-way stop intersection, installing rumble strips on the mainline approaching the intersection, and reconfiguring the intersection so that the minor roads align. Having guardrails that are in place and well-maintained is also recommended.

*Figure 26: Intersection of Old Gray Station Road and Hales Chapel Road/Sid Martin Road (Source: FHWA)*

**2. Roadway Design Improvements**

Twenty-two of the 41 roadway departure crashes involved a driver negotiating a curve. This site has had three roadway departure crashes during the study period. Rumble strips that help delineate the edges and center of the roadway are recommended. Additional recommendations are to widen shoulders, flatten sideslopes, maintain the clear zone, and install additional chevron or advance curve warning signs.

*Figure 27: Horizontal curve at the intersection of Old Gray Station Road and Roy Martin Road (Source: FHWA)*

**3. Roadway Design Improvements**

The guardrail at this location does not properly protect motorists from striking the roadside utility pole. Extending the guardrail section closest to the utility pole and installing proper end treatments is recommended.

*Figure 28: Guardrail at the intersection of Old Gray Station Road and Free Hill Road (Source: FHWA)*

**4. Roadway Design Improvements**

Traveling west, the guardrail end treatment at this location does not properly protect motorists who strike that section of the guardrail. Adding proper guardrail end treatments is recommended. Enhancing the visibility of the curve by repairing existing chevron signage and adding additional chevron and curve warning signs is also recommended.

*Figure 29: Guardrail located at coordinates 36.40023925363636, -82.43532453803012 (Source: FHWA)*

## Old Gray Station Road – Site Specific Recommendations Table

| Site | Site-Specific Location (Geographic Coordinates) | Countermeasure | Cost (Low/ Medium/ High) | CMF Rating/ CTW Rating | CMF ID | Source (e.g., Proven Safety Countermeasure) | Timeline |
|---|---|---|---|---|---|---|---|
| 1 | Intersection of Old Gray Station Road and Hales Chapel Rd/Sid Martin Rd (Both directions. See Figure 26.) | Roadway Design Improvements: Metal-Beam Guardrail | Medium | ★★★ | 10306 | FHWA Proven Safety Countermeasures | Short-term |
| 1 | Intersection of Old Gray Station Road and Hales Chapel Road/Sid Martin Road (Both directions. See Figure 26.) | Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections | Low | Varies | -- | FHWA Proven Safety Countermeasures | Short-term |
| 2 | Intersection of Old Gray Station Road and Roy Martin Road | Center line Rumble Strips | Medium | ★★★ | 10386 | FHWA Proven Safety Countermeasures | Medium-term |

| Site | Site-Specific Location (Geographic Coordinates) | Countermeasure | Cost (Low/ Medium/ High) | CMF Rating/ CTW Rating | CMF ID | Source (e.g., Proven Safety Countermeasure) | Timeline |
|---|---|---|---|---|---|---|---|
| | (Both directions. See Figure 27.) | | | | | | |
| 2 | Intersection of Old Gray Station Road and Roy Martin Road (Both directions. See Figure 27.) | Edge Line Rumble Strips | Medium | ★★★ | 3390 | FHWA Proven Safety Countermeasures | Medium-term |
| 2 | Intersection of Old Gray Station Road and Roy Martin Road (Both directions. See Figure 27.) | Roadway Design Improvements for Horizontal Curves: Widened Shoulder | Medium/ High | ★★★★ | 6659 | FHWA Proven Safety Countermeasures | Medium-term |
| 2 | Intersection of Old Gray Station Road and Roy Martin Road (Both directions. See Figure 27.) | Roadway Design Improvements for Horizontal Curves: Flatten Sideslope | Medium/ high | -- | -- | FHWA Proven Safety Countermeasures | Medium-term |
| 2 | Intersection of Old Gray Station Road and Roy Martin Road (Both directions. See Figure 27.) | Roadway Design Improvements for Horizontal Curves: Clear Zone | Medium | ★★★ / ★★★ | 6403 and 1024 | FHWA Proven Safety Countermeasures | Short-term |
| 2 | Intersection of Old Gray Station Road and Roy Martin Road (Both directions. See Figure 27.) | Enhanced Delineation for Horizontal Curves: Warning Signs | Low | -- | -- | FHWA Proven Safety Countermeasures | Short-term |
| 2 | Intersection of Old Gray Station Road and Roy Martin Road (Both directions. See Figure 27.) | Enhanced Delineation for Horizontal Curves – Chevrons | Low | ★★ | 9726 | FHWA Proven Safety Countermeasures | Short-term |
| 2 | Intersection of Old Gray Station Road and Roy Martin Road (Both directions. See Figure 27.) | Enhanced Delineation for Horizontal Curves – Pavement Markings | Low | ★★★★ | 10314 | FHWA Proven Safety Countermeasures | Short-term |
| 3 | Intersection of Old Gray Station Road and Free Hill Road, (Eastbound, see Figure 28.) | Roadway Design Improvements: Metal-beam Guardrail extension and replacement | Low/Medium | ★★★ | 10306 | FHWA Proven Safety Countermeasures | Short-term |
| 4 | Old Gray Station Road, between | Roadway Design Improvements: | Low/Medium | ★★★ | 10306 | FHWA Proven Safety Countermeasures | Short-term |

| Site | Site-Specific Location (Geographic Coordinates) | Countermeasure | Cost (Low/ Medium/ High) | CMF Rating/ CTW Rating | CMF ID | Source (e.g., Proven Safety Countermeasure) | Timeline |
|---|---|---|---|---|---|---|---|
| | Harwood Road and Ed Gage Lane, (Westbound, see Figure 29.) | Replace Metal-beam guardrail | | | | | |
| 4 | Old Gray Station Road, between Harwood Road and Ed Gage Lane, (Westbound, see Figure 29.) | Enhanced Delineation for Horizontal Curves: Chevron Signs | Low | ★★ | 9726 | FHWA Proven Safety Countermeasures | Short-term |

Figure 30 shows locations where there are poor guardrail treatments:


*Figure 30: Poor guardrail treatments on Old Gray Station Road (Source: FHWA)*

## Gray Station Road

The numbered improvements also correspond to the locations identified in the summary table at the end of these treatment descriptions.

**1. Crosswalk Visibility Enhancements**

Upgrading the current crosswalk at Gray Elementary School (Figure 32) with high visibility design elements help it standout to motorists, like the example shown in Figure 31. Other enhancements in the vicinity of the crosswalk include pedestrian crossing signs, high-visibility treatments to existing school zone signage, flashing warning signs, and speed feedback signs. This can potentially provide a safer environment for children to cross Gray Station Road.


*Figure 31: High-visibility crosswalk (Source: FHWA)*

*Figure 32: Crosswalk on Gray Station Road, located at approximate coordinates 36.41595382316783, -82.47767720708008 (Source: FHWA)*

**2. Corridor Access Management**

This northbound location on Gray Station Road at the intersection with Judge Gresham Road and Roy Martin Road is a crash hotspot for multiple emphasis areas. Three crashes occurred at the intersection and four others occurred within 200 feet east of the intersection. Crash types include three rear-end, two angle, one opposite direction sideswipe, and one single car roadway departure crash. The layout of this intersection may be causing confusion for motorists. The proximity to a curve and poor sightlines may be contributing factors which have resulted in this intersection becoming a crash hotspot. In the long-term, access could be redesigned with consolidated approaches to improve safety at this intersection. Short-term solutions include warning signage, transverse rumble strips on the Gray Station Road approach, and introduction of a four-way stop. Location of rumble strip implementation will also depend on proximity to residential properties due to noise from their operation.

*Figure 33: Corner of Gray Station, Judge Gresham Road, and Roy Martin Road (Source: FHWA)*


*Figure 34: Intersection of Gray Station Road, Judge Gresham, and Roy Martin Road (Source: FHWA)*

### 3. Metal-Beam Guardrail

This southbound location on Gray Station Road, approximately 185 feet north of Roscoe Fitz Road, has two guardrails with improper end treatments. Without proper end treatments, guardrails can be less effective at preventing vehicles from running off the roadway and the existing end treatments present additional safety concerns to motorists. If a motorist were to strike the end of the guardrail head-on, the guardrail may not buckle and redirect as it is designed to, but instead impale the vehicle, potentially harming any occupants.

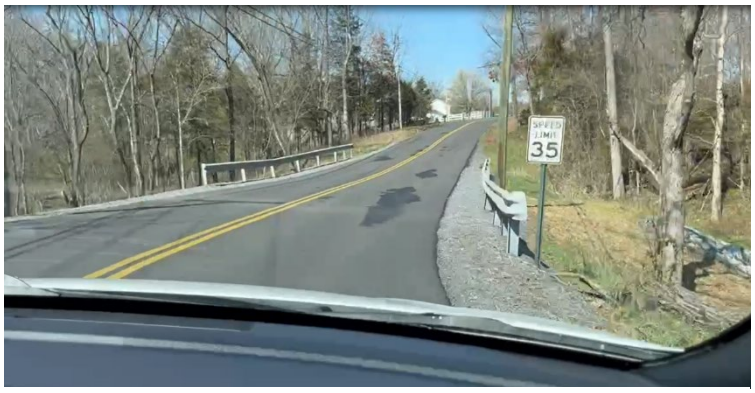



*Figure 36: Guardrails near the intersection of Gray Station Road and Roscoe Fitz Road, at coordinates 36.40401965354401, -82.49215650991447 (Source: FHWA)*

*Figure 35: Energy-absorbing end treatment (Source: FHWA, W-Beam Guardrail Repair)*

### 4. Pavement Friction Management and Speed Management

Four of the seven roadway departure crashes at this location, near the intersection of Gray Station Road and Crystal Springs Circle, have occurred during wet-weather conditions. High-friction surface treatment application is recommended to reduce instances of skidding off the roadway. Additional recommendations are slippery road warning signs, transverse rumble strips, and speed feedback signs. Location of rumble strip implementation will also depend on proximity to residential properties due to noise from their operation.

*Figure 37: Horizontal curve at the intersection of Gray Station Road and Crystal Springs Circle, at approximate coordinates 36.42842186393448, -82.46123884162745 (Source: FHWA)*

**5. Roundabout – Intersections**

This intersection of Gray Station Road and Old Gray Station Road has been a crash hotspot during the period studied with eight property damage crashes. Replacing the stop-controlled intersection with a roundabout is a long-term solution to reducing crashes at this site. Short term solutions include the installation of an all-way stop control.

*Figure 38: Corner of Old Gray Station Road and Gray Station Road (Source: FHWA)*

## Gray Station Road – Site Specific Recommendations Table

| Site | Site-Specific Location (Geographic Coordinates) | Countermeasure | CMF Rating/ CTW Rating | CMF ID | Cost (Low/ Medium/ High) | Source (e.g., Proven Safety Countermeasure) | Timeline |
|---|---|---|---|---|---|---|---|
| 1 | Gray Station Road, between Skyland Drive and Skyland Circle (Gray Elementary. See Figure 32.) | Crosswalk Visibility Enhancements | ★★ | 4123 | Low/Medium | FHWA Proven Safety Countermeasures | Short-term |
| 1 | Gray Station Road, between Skyland Drive and Skyland Circle (Gray Elementary. See Figure 32.) | Transverse rumble strips on crosswalk approach | ★★ | 3070 | Low/Medium | FHWA Proven Safety Countermeasures | Short-term |
| 1 | Gray Station Road, between Skyland Drive and Skyland Circle (Gray Elementary. See Figure 32.) | Retroreflective school signage | -- | -- | Low | | Short-term |

| Site | Site-Specific Location (Geographic Coordinates) | Countermeasure | CMF Rating/ CTW Rating | CMF ID | Cost (Low/ Medium/ High) | Source (e.g., Proven Safety Countermeasure) | Timeline |
|---|---|---|---|---|---|---|---|
| 1 | Gray Station Road, between Skyland Drive and Skyland Circle (Gray Elementary. See Figure 32.) | Rectangular Rapid Flashing Beacon (RRFB) | ★★★ | 9024 | Medium | FHWA Proven Safety Countermeasures | Short-term |
| 1 | Gray Station Road, between Skyland Drive and Skyland Circle (Gray Elementary. See Figure 32.) | Speed feedback signs | ★★★★ | 6885 | Low | - | Short-term |
| 2 | Intersection of Gray Station Road and Judge Gresham Road/Roy Martin Road (See Figure 33.) | Intersection reconfiguration | -- | -- | Low/High | FHWA Proven Safety Countermeasures | Long-term/Short-term |
| 2 | Intersection of Gray Station Road and Judge Gresham Road/Roy Martin Road (See Figure 33.) | Intersection ahead warning signage | -- | -- | Low | - | Short-term |
| 2 | Intersection of Gray Station Road and Judge Gresham Road/Roy Martin Road (See Figure 33.) | Transverse rumble strips | ★★★ | 138 | Low/medium | - | Medium-term |
| 2 | Intersection of Gray Station Road and Judge Gresham Road/Roy Martin Road (See Figure 33.) | Four-way stop | ★★★ | 3130 | Low/medium | FHWA Proven Safety Countermeasures | Medium - term |
| 3 | Gray Station Road between Roscoe Fitz Road and Hill Street (See Figure 36.) | Roadway Design Improvements: Replace/Install Metal-beam Guardrail end treatments | ★★★ | 10306 | Low/Medium | FHWA Proven Safety Countermeasures | Short-term |

| Site | Site-Specific Location (Geographic Coordinates) | Countermeasure | CMF Rating/ CTW Rating | CMF ID | Cost (Low/ Medium/ High) | Source (e.g., Proven Safety Countermeasure) | Timeline |
|---|---|---|---|---|---|---|---|
| 4 | Gray Station Road near the intersection with Crystal Springs Circle and Red Lane (See Figure 37.) | Intersection ahead sign, Transverse Rumble Strips, Additional Chevrons, Metal-beam Guardrail; Speed Feedback Sign | -- | -- | Medium | FHWA Proven Safety Countermeasures | Medium - term |
| 4 | Gray Station Road near the intersection with Crystal Springs Circle and Red Lane (See Figure 37.) | Transverse rumble strips | ★★★ | 138 | Medium | - | Medium - term |
| 4 | Gray Station Road near the intersection with Crystal Springs Circle and Red Lane (See Figure 37.) | Enhanced Delineation for Horizontal Curves – Chevrons | ★★ | 9726 | Low | FHWA Proven Safety Countermeasures | Short |
| 4 | Gray Station Road near the intersection with Crystal Springs Circle and Red Lane (See Figure 37.) | Roadway Design Improvements: Replace/Install Metal-beam Guardrail end treatments | ★★★ | 10306 | Medium | FHWA Proven Safety Countermeasures | Medium - term |
| 4 | Gray Station Road near the intersection with Crystal Springs Circle and Red Lane (See Figure 37.) | Install dynamic speed feedback sign | ★★★★ | 6885 | Medium | FHWA Proven Safety Countermeasures | Medium - term |
| 4 | Gray Station Road near the intersection with Crystal Springs Circle and Red Lane (See Figure 37.) | Pavement Friction Management | ★★★ | 7900 | Medium | FHWA Proven Safety Countermeasures | Medium - term |

| Site | Site-Specific Location (Geographic Coordinates) | Countermeasure | CMF Rating/ CTW Rating | CMF ID | Cost (Low/ Medium/ High) | Source (e.g., Proven Safety Countermeasure) | Timeline |
|---|---|---|---|---|---|---|---|
| 5 | Intersection of Old Gray Station and Gray Station Road (See Figure 38.) | Roundabout | ★★ | 10422 | High | FHWA Proven Safety Countermeasures | Long-term |

In addition, there are poor guardrail treatments which have been displayed on the following map:

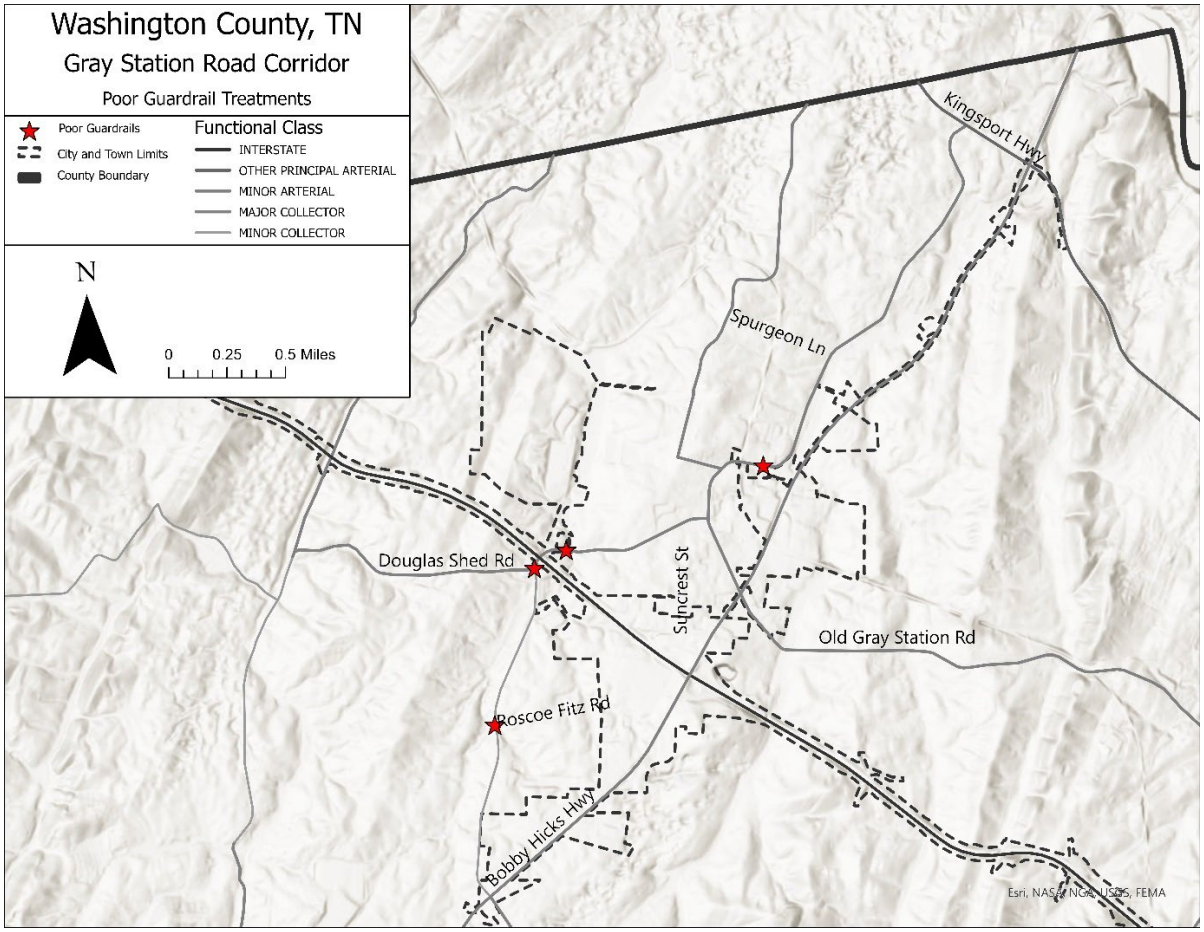



*Figure 39: Poor guardrail treatment locations on Gray Station Road (Source: FHWA)*

## Greenwood Drive

The numbered improvements also correspond to the locations identified in the summary table at the end of these treatment descriptions.

**1. Roadway design improvements**

This horizontal curve near 4490 Greenwood Drive has been the site of multiple roadway departure crashes. Five crashes were recorded at this location including a motorist striking a utility pole. Implementing the following countermeasures has the potential to improve safety at this location: Maintaining the vegetation in the clear zone, relocating utility poles outside the clear zone, installing chevrons to adequately delineate the curve, widening the shoulder in both directions, and installing SafetyEdge$^{SM}$ treatment.

*Figure 40: Horizontal curve located near coordinates 36.24745067319022, -82.45597961070588 (Source: FHWA)*

**2. Roadway Design Improvements**

There has been one crash at this location near 4670 Greenwood Drive involving a driver striking a utility pole. The utility pole in this location is located within the clear zone and if possible it should be relocated, or otherwise protected by a guard rail. Additionally, there are no curve warnings in the southbound direction, and only a curve-road sign in the northbound direction. Adding chevron signs further delineate the curve and it is also helpful to install advance curve warning signs in both directions.

*Figure 41: Horizontal curve located near coordinates 36.24136900224054, -82.46150468997978 (Source: FHWA)*

**3. Roadway Design Improvements at Curves- Clear Zone**

This southbound location on Greenwood Drive near Cecil Gray Road is the site of three crashes. Two have involved drivers striking the utility pole that is identified in figure 42. Removing and/or relocating the utility pole and any other fixed objects from the clear zone is recommended. If that is not possible, adding a guardrail -- like the one seen in the photo -- is recommended. Installing advance curve warning signs and chevrons help to delineate the curve and enhance driver awareness and visibility.

*Figure 42: Guardrail and horizontal curve located near coordinates 36.25772966043992, -82.43038290368362 (Source: FHWA)*

**4. Roadway Design Improvements**

Five crashes occurred within 180 feet of this curve near Rock Church Road. Two of those crashes involved speeding/aggressive driving. In the southbound direction, there is a lack of warning for this curve. Advance curve warning signs and/or pavement markings are recommended to help delineate the curve. Additional chevron signage is also recommended.

*Figure 43: Horizontal curve located near coordinates 36.246394061855256, -82.45570999655796 (Source: FHWA)*

**5. Roundabout- Access Management**

There have been three crashes at the intersection of Greenwood Drive and Mill Springs Road. Two others have occurred within 200 feet of the intersection. A sixth crash was recorded at the intersection of Summit Drive and Mill Springs Road. The current intersection design involves difficult sightlines and approaches that confuse motorists and increase the likelihood of crashes. A long-term goal of consolidating or reconfiguring the access to Greenwood Drive could reduce conflict points, simplify the approach, and improve safety at this intersection. Short-term recommendations include signage on Greenwood Drive to indicate the intersecting streets extending from the intersection.


*Figure 44: Corner of Greenwood Drive and Mill Springs Road (Source: FHWA)*

*Figure 45: Roundabout (Source: FHWA)*

## Greenwood Drive – Site Specific Recommendations Table

| Site | Site-Specific Location (Geographic Coordinates) | Countermeasure | CMF Rating/ CTW Rating | CMF ID | Cost (Low/ Medium/ High) | Source (e.g., Proven Safety Countermeasure) | Timeline |
|---|---|---|---|---|---|---|---|
| 1, 2 | Near 4490 Greenwood Drive (Northbound, see photo 40), Near 4670 Greenwood Drive (Northbound, see photo 41) | Roadway Design Improvements: Clear Zone | ★★★ | 1024 | Low/Medium | FHWA Proven Safety Countermeasures | Medium-term |
| 1, 2 | Near 4490 Greenwood Drive (Northbound, see photo 40), Near 4670 Greenwood Drive (Northbound, see photo 41) | Roadway Design Improvements – Chevrons | ★★ | 9726 | Low | FHWA Proven Safety Countermeasures | Short-term |
| 1, 2 | Near 4490 Greenwood Drive (Northbound, see photo 40), Near 4670 Greenwood Drive (Northbound, see photo 41) | Roadway Design Improvements – Reflective Strips on poles | -- | -- | Low | FHWA Proven Safety Countermeasures | Short-term, Medium-term |
| 1, 2 | Near 4490 Greenwood Drive (Northbound, see photo 40), Near 4670 Greenwood Drive (Northbound, see photo 41) | Roadway Design Improvements – Widen Shoulders | ★★★★ | 6659 | Medium/high | FHWA Proven Safety Countermeasures | Medium-term |
| 1, 2 | Near 4490 Greenwood Drive (Northbound, see photo 40), Near 4670 Greenwood Drive (Northbound, see photo 41) | Roadway Design Improvements - SafetyEdge[SM] | ★★★★★ | 8661 | Medium/High | FHWA Proven Safety Countermeasures | Long-term |
| 3 | Greenwood Drive, between Cecil Gray Rd and Mill Springs Rd (Northbound, see photo 42) | Roadway Design Improvements: Replace and extend metal-beam guardrail with appropriate end treatment and add to other side of the road. | ★★★ | 10306 | Low/Medium | FHWA Proven Safety Countermeasures | Short-term |

| Site | Site-Specific Location (Geographic Coordinates) | Countermeasure | CMF Rating/ CTW Rating | CMF ID | Cost (Low/ Medium/ High) | Source (e.g., Proven Safety Countermeasure) | Timeline |
|---|---|---|---|---|---|---|---|
| 4 | Greenwood Drive, between Rock Church Rd and Greenwood Drive (Southbound, see photo 43) | Roadway Design Improvements: install additional chevrons | ★★ | 9726 | Low/Medium | FHWA Proven Safety Countermeasures | Short-term; |
| 5 | Intersection of Greenwood Drive and Mill Springs Road (See photo 44) | Roundabout – Access Management; Signage to indicate roads at intersection | ★★ | 10422 | Low/High | FHWA Proven Safety Countermeasures | Long-term; Short-term |
| 5 | Intersection of Greenwood Drive and Mill Springs Road (See photo 44) | Signage to indicate roads at intersection | -- | -- | Low | - | Short-term |

## Summary

Old Gray Station Road, Gray Station Road, and Greenwood Drive are priority corridors within the county, Tennessee that connect residents to their homes, places of worship, schools, businesses, and commercial centers. Several locations throughout these corridors have seen recent safety investments, with new signage warning of nearby roadway hazards and speed limit changes, paint to demarcate lanes, and high visibility elements enhancing signposts and guardrails. There are, however, still many sites that need remediation. The recommendations provided in this report can be used by the county to help determine ways to improve the safety, mobility, and comfort of all road users in these corridors.


*Figure 46: New signage on Greenwood Drive near Brethren Church Drive*

**FHWA, Office of Safety**

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