Road Safety Assessment

Diamond Hill Road | Woonsocket, RI

SEPTEMBER 2020

RIdot Driven to get you there

HSIP Highway Safety Improvement Prog Data Driven Decisions

U.S. Department of Transportation Federal Highway Administration

Strategic Highway Safety Plan RHODE2SAFETY Ocean State

Leads Toward Zero Deaths

Table of Contents

List of Tables

List of Figures

List of Appendices

1

Introduction

The Highway Safety Improvement Program (HSIP) was created under Section 1401 of SAFETEA-LU with the purpose of reducing traffic fatalities and serious injuries on public roadways. The Moving Ahead for Progress in the 21st Century Act (MAP-21) then the Fixing America's Surface Transportation (FAST) Act provided continuations of the HSIP, which is authorized under United States Code Title 23 Section 148 (23 U.S.C. 148). As part of the Rhode Island Department of Transportation (RIDOT) HSIP, RIDOT has created several programs that target specific safety improvements such as Roadway Departure, Intersection Safety, Safety Corridor, Interchange Improvements, RI*STARS, Vulnerable Road User, Local Safety, and Safety Data Collection programs.

In order for the state to reach its goals set forth in their Strategic Highway Safety Plan (SHSP) to halve fatalities and serious injuries by 2030, the RIDOT developed the Safety Corridor – Road Diet and Vulnerable Road User Programs to mitigate crash issues on state- and locally-maintained roadways as well as provide funding (when available) to implement crash measures.

The goal of the programs has been to target roadway segments with high frequencies of crashes for roadway safety assessments. The intersection of Diamond Hill Road and Walnut Hill Road was identified for a Road Safety Assessment (RSA) due to a State Traffic Commission (STC) request. The intersection in question has a high occurrence of angle and rear-end crashes, and vulnerable user crashes, which tend to have a higher severity than crashes involving two or more passenger vehicles.

For all locations investigated as part of the HSIP, RIDOT conducts a Road Safety Assessment (RSA) where RIDOT and an interdisciplinary team evaluate existing conditions and identify possible factors contributing to crash history and severity at these locations. The findings are then prioritized in order of perceived importance and associated with potential opportunities for targeted improvement/corrective mitigation. The potential improvements to be considered are either spot or systemic and are categorized as immediate-, near-, or long-term, representing the timeframe in which they should or could be implemented.

1.1 Study Area

Woonsocket, Rhode Island is a city located in Providence County, south of the Massachusetts state line. The study area is focused on the intersection of Diamond Hill Road and Walnut Hill Road. Diamond Hill Road has a speed limit of 35 miles per hour and Walnut Hill Road has a speed limit of 20 miles per hour.

Figure 1-1 depicts the location of the study area.

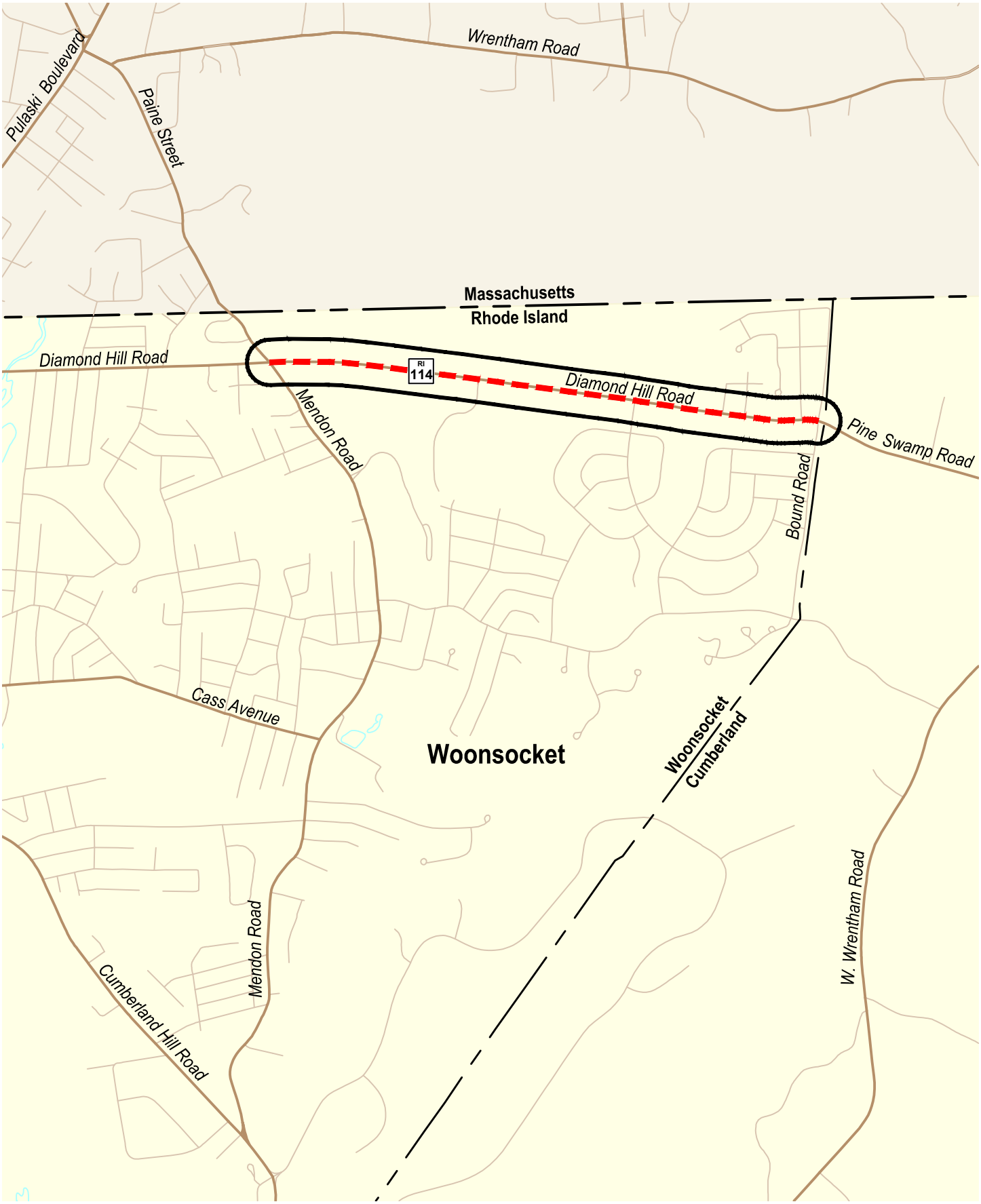
- **Diamond Hill Road**

  Within the studied intersection area, Diamond Hill Road is a five-lane (two lanes in each direction plus a center turn lane) arterial road with an east-west orientation connecting northern Cumberland to the City of Woonsocket. East of Walnut Hill Road it is a four-lane road (two lanes in each direction), then the road drops from a four-lane road to a two-lane road at the intersection with Bound Road. There are four major shopping plazas just west of the intersection with Walnut Hill Road as well as some small apartment complexes and small businesses nearby. The road has two RIPTA bus stops (one for each direction) just west of the intersection. There is no on-street parking on either side of the road at the intersection.

- **Walnut Hill Road**

  Walnut Hill Road is a two lane (one lane each direction) local road with a north-south orientation. Walnut Hill Road connects a housing neighborhood to Diamond Hill Road. There is no parking between the driveway to the apartment complex to the intersection on the northbound side.

\\vhb\gbl\proj\Providence\73000.10\Graphics\FIGURES\Diamond Hilll Rd\FIG1 - Study Area (Diamond Hilll Rd).dwg



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Project Area
Diamond Hill Road (Route 114)
Woonsocket, Rhode Island

Figure 1

0 1500 Feet

2

Roadway Safety Assessment

2.1 Objective of Road Safety Assessments

The FHWA defines a Roadway Safety Assessment (RSA) as a "formal safety performance evaluation of an existing or future road or intersection by an independent, multidisciplinary team". RSAs are a valuable tool for transportation agencies to evaluate road safety issues contributing to injuries and deaths and to identify opportunities for improvement. The success of RSAs has led to the FHWA including the RSA process as one of its prior nine "proven safety countermeasures".

Some element of safety is considered in every project; however, sometimes conditions merit a more detailed safety review. RSAs examine these conditions in detail by pulling together an interdisciplinary team that looks at the issues from different perspectives – perspectives that are often not a part of a traditional safety review. RSAs also consider safety from a human factor point of view, which aims to answer the following questions:

- How and why are people reacting to the roadway conditions?
- What do people sense and how do they react to those senses?
- What are the associated risks with those elements?

2.2 Road Safety Assessment Interdisciplinary Team

An interdisciplinary team approach is a key factor in the success of Roadway Safety Assessment. Interactions between all road users (e.g., pedestrians and motor

vehicles, commuter traffic and recreational vehicle traffic, bicycles and motor vehicles, etc.) are investigated to determine potential risks and to identify programs and measures to help reduce those risks and create safer environments for all road users. By working with an interdisciplinary team of stakeholders the views of each of the unique users can be captured and integrated into solutions and countermeasures.

The Interdisciplinary RSA Team for the assessment consisted of engineers and stakeholders from the Rhode Island Department of Transportation (RIDOT), the Rhode Island Department of Transportation Office on Highway Safety (RIDOT OHS), and the Woonsocket Police Department. Representatives from VHB facilitated the RSA, which was conducted on July 8th, 2020. The members of the RSA team are as follows:

- Chief Thomas F. Oates III – Woonsocket Police Department
- John Picard – Woonsocket Police Department
- Gregory Klocek – Woonsocket Police Department
- Sean Raymond – RIDOT, Managing Engineer, Office of Safety
- Kelsey Lynch – RIDOT OHS
- Jason Farias – RIDOT OHS
- Skye Levin – VHB
- Benjamin Scott – VHB

2.3 Crash Analysis

Crash data for the assessment area was provided by the Rhode Island Department of Transportation (RIDOT) for the five-year period between January 1, 2015 and December 31st, 2019. Additionally, one fatal was reviewed from 2020 that has been included in this data set. The crashes were reviewed by severity and crash type. Severity is measured using the KABCO method, which assigns a severity type to each crash. K-type crashes result in a fatality, A-type crashes result in an incapacitating injury, B-type crashes result in an evident injury, C-type crashes result in complaints of pain, and O-type crashes result in property damage only.

Throughout the study area, there were a total of nineteen crashes in the five-year period spanning from 2015 to 2019 after filtering out accidents that occurred in parking lots or accidents that occurred over a half a mile away from the intersection. Additionally, one fatal crash was reviewed from 2020 and included in this data set, for a total of twenty crashes. Out of those crashes, one (5%) was a fatal K-type crash, one of the crashes (5%) was a B-type crash, six of the crashes (30%) were C-type crashes, while the remaining twelve crashes (60%) resulted in property damage only.

Of the twenty total crashes in the area, eleven of them occurred in the intersection, including one K-type crash, one B-type crash, three C-type crashes, and six O-type crashes.

The majority of the crashes during this period were either angle crashes (25%) or rear end crashes (30%). Emphasis areas for the crashes during this period highlighted intersection related crashes, roadway departure crashes, crashes involving elderly drivers, and crashes involving vulnerable users. The category of vulnerable road users is comprised of pedestrians, cyclists and motorcycle operators. Of the two crashes involving vulnerable users, one of them involved a motorcycle and was a K-type crash, and the other one involved a go-kart and was a C-type crash. **Appendix A** provides a detailed summary of the crash data.

Figures 2-1 presents the crash diagram for the study area.

Figures 2-2 and **Figure 2-3** provide a summary of the crash severities and crash types for the Diamond Hill Road and Walnut Hill Road.

\\vhb\gbl\proj\Providence\73000.02\Graphics\FIGURES\Diamond Hill Rd at Walnut Hill Rd\Collision Diagram (Diamond Hill at Walnut Hill.dwg

Source:
2020 Aerial Photograph provided by RIGIS
Crash data provided by RIDOT Traffic Research Unit.
The dates of the crash data presented are 2015 through 2020.

Collision Summary
Diamond Hill Road at Walnut Hill Road
Woonsocket, Rhode Island

Figure 2-1

Figure 2-2 Crash Severity Summary for Diamond Hill at Walnut Hill Roads

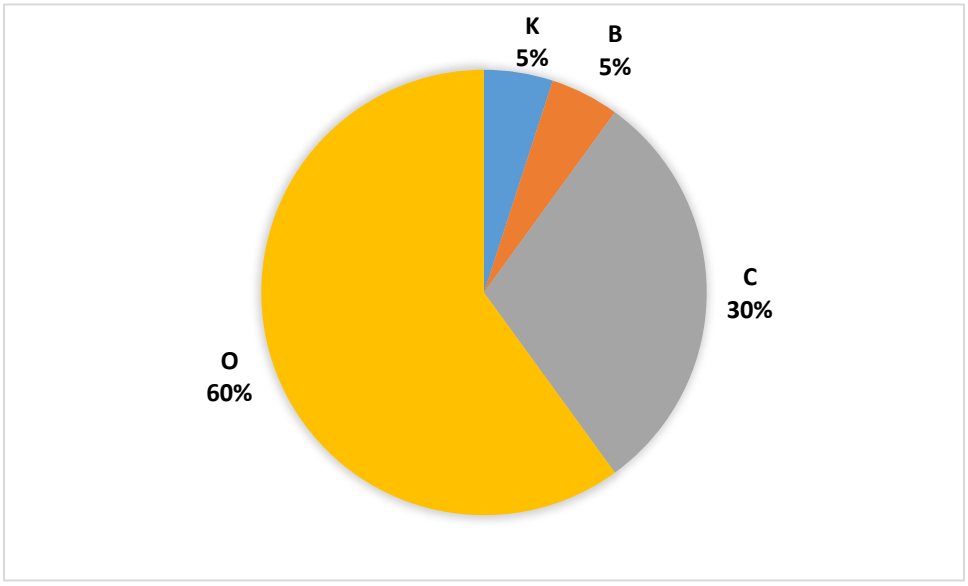
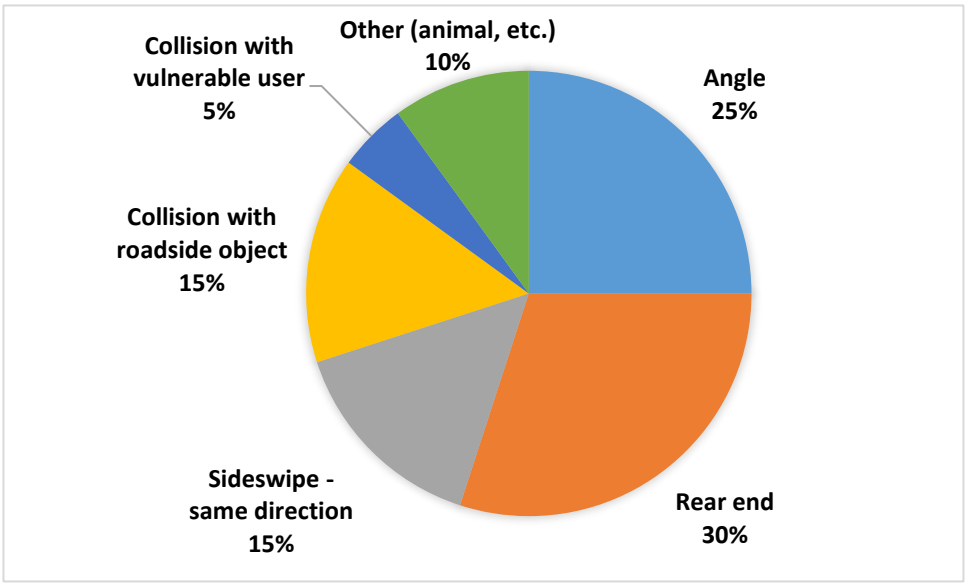


Figure 2-3 Crash Type Summary for Diamond Hill at Walnut Hill Roads



2.4 RSA Findings and Suggestions for Improvement

Based on a review of the provided crash data and of the existing field conditions, the RSA participants identified several key safety-related findings within the assessment area. These findings were prioritized in order of perceived importance and associated with potential opportunities for targeted improvement/corrective mitigation.

Table 2-1 summarizes the findings and suggestions for the Diamond Hill Road and Walnut Hill Road area.

Table 2-1 Summary of RSA Findings and Suggestions for Diamond Hill at Walnut Hill Roads

OBSERVATION	IMMEDIATE TERM IMPROVEMENTS Under 6 months	NEAR TERM IMPROVEMENTS Under 2 years	LONGER TERM IMPROVEMENTS Over 2 years	COMMENTS
Poor Visibility Intersection – Turning on to Diamond Hill Road from Walnut Hill Road is difficult due to multiple sight line obstacles blocking the view of oncoming traffic while stopped at the stop line and the general speed that cars are travelling along this roadway. 	**ENGINEERING:** **1.1** Consider installing an intersection warning sign on the Eastbound side of Diamond Hill Road an appropriate distance away from the intersection.	**ENGINEERING:** **1.2** Coordinate with the owners of Walnut Hill Apartments about removing the brick wall on the southwest and southeast corner of the intersection and trimming the tree on the southwest corner in order to improve visibility for the intersection. **1.3** Consider implementing a Road Diet on Diamond Hill Road, reducing the number of lanes from five to three, one lane for each direction and a center turn lane, creating an 8' shoulder on the sides.	**ENGINEERING:** **1.4** Consider implementing a traffic signal control at the intersection of Diamond Hill Road and Walnut Hill Road.	**The City of Woonsocket should work in conjunction with Walnut Hill Apartments in order to improve sight visibility by removing the brick wall and trees that are impacting the sight lines.** **An engineering study must be conducted in order to understand the feasibility of a road diet on Diamond Hill Road.** **Further research must go in to see if the intersection itself warrants a traffic signal based on traffic counts and other variables**

OBSERVATION	IMMEDIATE TERM IMPROVEMENTS Under 6 months	NEAR TERM IMPROVEMENTS Under 2 years	LONGER TERM IMPROVEMENTS Over 2 years	COMMENTS
Speeding Vehicles – Vehicles are travelling at a high rate of speed throughout the Diamond Hill Road corridor. Higher speeds can result in crashes of higher severity and inadequate gaps for vehicles entering the mainline of traffic.  	**ENFORCEMENT:** **1.5** Consider a speeding enforcement campaign on Diamond Hill Road to discouraged speeding. **ENGINEERING:** **1.6** Install dynamic speed feedback sign to discourage speeding along the corridor. **1.7** Install new speed limit signs spaced more appropriately and remove existing signs, as needed.		**ENGINEERING:** **1.8** If the Road Diet is considered as described in Item 1.3 and adequate time to evaluate has passed, consider reducing the roadway speed limit.	**A speed study was conducted at the intersection**
Inadequate Vulnerable Road User Facilities and Accommodations – A lack of available crosswalks on Diamond Hill Road forces pedestrians to cross the road outside of crosswalks. Given the width of the road and the speed at which vehicles travel on this road it is a hazard to the safety of pedestrians that need to cross the street. 	**EDUCATION:** **1.9** Consider a "Yield to Pedestrians" educational campaign to instruct drivers to yield to pedestrians in crosswalks. **ENGINEERING:** **1.10** Review pedestrian signal equipment to identify and resolve any issues. **1.11** Install continental style pavement markings at all marked crosswalks.	**ENGINEERING:** **1.12** Reconstruct all non-compliant sidewalks and wheelchair ramps with an ADA compliant design at the intersection of Diamond Hill Road and Walnut Hill Road. Ensure no pinch points less than 36" and appropriate sidewalk slopes at the intersection. Incorporate these improvements into existing and future redevelopment projects.	**ENGINEERING:** **1.13** Install rectangular rapid flashing beacons (RRFB) at uncontrolled crosswalks to enhance pedestrian visibility in key locations along the corridor.	**1.12 Pending study conducted in 1.21**

OBSERVATION	IMMEDIATE TERM IMPROVEMENTS Under 6 months	NEAR TERM IMPROVEMENTS Under 2 years	LONGER TERM IMPROVEMENTS Over 2 years	COMMENTS
Bicycle Accommodations – There are no marked bicycle lanes throughout this corridor of Diamond Hill Road. 	**EDUCATION:** **1.14** Consider an educational campaign to instruct drivers to watch for and share the road with cyclists. **ENGINEERING:** **1.15** If a Road Diet is conducted, consider bicycle lane pavement markings and signage as described in Chapter 9 of the MUTCD in the newly formed shoulders. **1.16** If bicycle lanes are implemented, provide enhanced pavement markings at signalized intersection to guide bicyclists through the intersection and driveways.	**ENGINEERING:** **1.17** Revise City of Woonsocket Comprehensive Plan to include bicycle accommodations.	**ENGINEERING:** **1.18** Consider developing a City bicycle plan.	**All bicycle related actions are contingent on implementing a road diet along Diamond Hill Road and approval from the City of Woonsocket**
Inadequate signage – Traffic sign clutter along the corridor has the potential for increased driver workload and may be confusing for drivers. Existing signage in the area was found to be damaged, obstructed or missing. 	**ENGINEERING:** **1.19** Conduct a comprehensive traffic sign audit to verify sign size/height, retro-reflectivity, current sign standards, consistency, redundancy, and unnecessary signs. Revise signs accordingly. **1.20** Exposed traffic sign breakaway posts should be removed or repaired, as necessary. **1.21** Inventory existing sidewalk and wheelchair ramp condition.			**Since the completion of the Road Safety Assessment, corridor videos were acquired.**

3

Countermeasure Implementation

All recommendations from this RSA have been reviewed and vetted by the assessment team. This chapter provides a high-level evaluation of the proposed mitigation measures for implementation feasibility and appropriateness.

3.1 Implementation Plan

Table 3-1 presents the implementation plan for the RSA recommendations, including the timeframe in which each recommendation could reasonably be implemented. In addition, the table lists the "Safety Benefit - Costs" (where applicable) and the status of the recommendation.

The "Safety Benefit-Cost" column is a preliminary determination of the actual safety benefit expected as well as the cost to implement each recommendation made by the RSA team. Safety benefit estimates are subjective and may be based on the relative percent of crashes that may be reduced by the enhancement based on site specific crash data, statewide systemic crash trends, and known and documented crash reduction factors. Implementation costs are order-of-magnitude estimates based on recent contracts and other sources. The following exhibit illustrates the general guidance uses when making this determination.

Safety Benefit	Implementation Costs
High – Enhancement greatly reduces (>20%) crash types and severities experienced and/or addresses high risk facility types.	High – > $100K
Medium – Enhancement reduces (<20%) crash types and severities experienced or addresses high risk facility types.	Medium – $10K - $100K
Low – Enhancement offers general safety benefits but not directly related to crash types and severities experienced or high-risk facility types.	Low – <$10K

3.2 Funding

The implementation of recommendations is contingent on available funding. Per the Fixing America's Transportation (FAST) Act legislation, the RIDOT is responsible for the reduction of fatalities and serious injuries on all public roadways, regardless of ownership. Therefore, the RIDOT has the potential to provide partial or full funding for several of the improvements identified in this report as part of the Safety Corridor Road Diet Program and the Vulnerable Road User Program.

Any funding requested to implement the recommendations listed in the RSA should go through the HSIP Eligibility request process, which requires justification of the projected safety benefits for recommended improvements. RIDOT will then determine if it is eligible for HSIP funds and distribute the funds needed (dependent on availability), so that the design and/or construction of the improvements can be administered.

Table 3-1 Implementation Matrix

Mitigation Measures	Timeframe	Benefit Safety Cost	Status	Team Lead	Next Steps
Poor Visibility Intersection					
1.1 Consider installing an intersection warning sign on the Eastbound side of Diamond Hill Road an appropriate distance away from the intersection	Immediate Term	Low	Work Order	RIDOT Traffic	
1.2 Coordinate with the owners of Walnut Hill Apartments about removing the brick wall on the southwest and southeast corner of the intersection and trimming the tree on the southwest corner in order to improve visibility for the intersection.	Near Term	Medium	Pending action from the City of Woonsocket	City of Woonsocket	
1.3 Consider implementing a Road Diet on Diamond Hill Road, reducing the number of lanes from five to three, one lane for each direction and a center turn lane, creating an 8' shoulder on the sides.	Near Term	Medium	Pending action from the City of Woonsocket	RIDOT Traffic	The analysis is currently being completed.
1.4 Consider implementing a traffic signal control at the intersection of Diamond Hill Road and Walnut Hill Road.	Long Term	High	Consider 12 months after the road diet has been implemented if issues still exist at the intersection	RIDOT Traffic	A traffic signal is not warranted, as it doesn't meet MUTCD and FHWA guidelines.
Speeding Vehicles					
1.5 Consider a speeding enforcement campaign on Diamond Hill Road to discouraged speeding.	Immediate Term Immediate Term	Low	Ongoing Enforcement Work Order	Woonsocket PD	

1.6 Install dynamic speed feedback sign to discourage speeding along the corridor.	Immediate Term Immediate Term	Low	Ongoing Enforcement Work Order	Woonsocket PD RIDOT Traffic	
1.7 Install new speed limit signs spaced more appropriately and remove existing signs, as needed.	Immediate Term	Low	Work Order	RIDOT Traffic	
1.8 If the Road Diet is considered as described in Item 1.3 and adequate time to evaluate has passed, consider reducing the roadway speed limit.	Long Term	Low	Town to request RIDOT Traffic to perform study and subsequent work order	RIDOT Traffic	
Inadequate Vulnerable Road User Facilities and Accommodations					
1.9 Consider a "Yield to Pedestrians" educational campaign to instruct drivers to yield to pedestrians in crosswalks.	Immediate Term	Low	Pending materials from OHS	OHS	
1.10 Review pedestrian signal equipment to identify and resolve any issues.	Immediate Term	Low	Pending review from RIDOT Traffic	RIDOT Traffic	
1.11 Install continental style pavement markings at all marked crosswalks.	Immediate Term	Low	Work Order	RIDOT Traffic	
1.12 Reconstruct all non-compliant sidewalks and wheelchair ramps with an ADA compliant design at the intersection of Diamond Hill Road and Walnut Hill Road. Ensure no pinch points less than 36" and appropriate sidewalk slopes at the intersection. Incorporate these improvements into existing and future redevelopment projects.	Near Term	High	Pending decision from the City of Woonsocket	City of Woonsocket	

1.13 Install rectangular rapid flashing beacons (RRFB) at uncontrolled crosswalks to enhance pedestrian visibility in key locations along the corridor.	Long Term	Medium	Pending action from the City of Woonsocket	RIDOT Traffic	
Bicycle Accommodations					
1.14 Consider an educational campaign to instruct drivers to watch for and share the road with cyclists.	Immediate Term	Low	Pending materials from OHS	OHS	
1.15 If a Road Diet is conducted, consider bicycle lane pavement markings and signage as described in Chapter 9 of the MUTCD in the newly formed shoulders.	Immediate Term	Low	Work Order	RIDOT Traffic	
1.16 If bicycle lanes are implemented, provide enhanced pavement markings at signalized intersection to guide bicyclists through the intersection and driveways.	Immediate Term	Low	Work Order	RIDOT Traffic	
1.17 Revise City of Woonsocket Comprehensive Plan to include bicycle accommodations.	Near Term	Low	Pending action from the City of Woonsocket	City of Woonsocket	
1.18 Consider developing a City bicycle plan.	Long Term	Low	Pending action from the City of Woonsocket	City of Woonsocket	
General Maintenance					
1.19 Conduct a comprehensive traffic sign audit to verify sign size/height, retro-reflectivity, current sign standards, consistency, redundancy, and unnecessary signs. Revise signs accordingly.	Immediate Term	Low	Work Order after RIDOT Traffic review	RIDOT Traffic	

1.20 Exposed traffic sign breakaway posts should be removed or repaired, as necessary.	Immediate Term	Low	City of Woonsocket should contact RIDOT Maintenance when necessary	City of Woonsocket	
1.21 Inventory existing sidewalk and wheelchair ramp condition.	Immediate Term	Low	Pending review from RIDOT Traffic	RIDOT Traffic	

3.3 Supporting Data

3.3.1 Speed Study

In order to implement design recommendations at the intersection of Diamond Hill Road and Walnut Hill Road, a speed study was conducted to determine eligibility for each consideration.

The posted speed limit along Diamond Hill Road is 35 mph, and the posted speed limit on Walnut Hill Road is 20 mph. Speed measurements were collected by VHB on Wednesday, July 8, 2020 at the intersection of Diamond Hill Road and Walnut Hill Road.

The speed measurements were collected during off peak periods using a radar gun. The 85th percentile speeds were determined from this study. The 85th percentile speed is a speed at or below which 85 percent of the observed traffic on the roadway travel and is used as a typical measure of free flow speed in the traffic engineering profession. **Table 3-2** shows the results of the speed study.

Table 3-2 Speed Data Summary

	Posted Speed Limit (mph)	85th Percentile Speed (mph)	Average Speed (mph)
Diamond Hill Road at Walnut Hill Road			
Eastbound	35	47	42
Westbound	35	49	45

As shown in **Table 3-2**, the 85th percentile speed on Diamond Hill Road is 12 mph higher than the posted speed limit in the eastbound direction and 14 mph higher than the posted speed limit in the westbound direction. The full results from the speed study can be found in **Appendix B**.

3.4 Findings

The following considerations should be reviewed in determining the feasibility and appropriateness of implementing the proposed mitigation measures.

3.4.1 Countermeasure Effectiveness

3.4.1.1 Road Diet

A road diet would modify the number of through travel lanes on Diamond Hill Road from five lanes (two in each direction with a center turn lane) to three lanes (one in each direction with center turn lane). This would provide a wider shoulder along Diamond Hill Road for additional facilities such as buffered bike lanes or RIPTA bus berths.

The Crash Modification Factor (CMF) Clearinghouse provides a crash modification factor for narrowing a cross section, which suggests that reducing lane width using this approach would reduce the number of total crashes on a corridor by 37 percent across all crash types and severities[1].

Likely outcomes of implementing a road diet that could lead to a reduction in crashes are reduced vehicle travel speeds due to the reduction in lanes, reduced driver workload due to fewer lanes and driving maneuvers, increased room to pull forward in order to see oncoming traffic better from side streets, and more easily identifiable gaps because vehicles have fewer lanes to consider while making a turn.

A road diet is suggested along Diamond Hill Road from Mendon Road to Bound Street. A capacity analysis shall be performed to determine the feasibility of the road diet.

3.4.1.2 Buffered Bicycle Lanes

Currently on Diamond Hill Road, there are no accommodations for bike users on the roadway. The shoulder is very narrow and does not have bicycle accommodations along the roadway. If a road diet is implemented, there could be an open shoulder created on Diamond Hill Road. In conjunction with the City of Woonsocket's effort to encourage bicycle use, buffered bicycle lanes are recommended as a potential use for the newly opened shoulder in order to protect these vulnerable users. A buffered bicycle lane is separated from the adjacent general-purpose travel lane or parking lane by a pattern of standard longitudinal markings. The buffer area may include chevron or diagonal markings and may be placed on the one of both sides of the bicycle lane.

The National Association of City Transportation Officials (NACTO) Urban Street Design Guide studied the installation of buffered bike lanes.

[1] "Narrow cross section (4 to 3 lanes with two way left-turn lane)" Crash Modification Factor Clearinghouse. US Department of Transportation, Federal Highway Administration. http://www.cmfclearinghouse.org/detail.cfm?facid=874. Accessed: October 10, 2016.

The guide determined that separated bike lanes:

- Encourage bicycling by contributing to the perception of comfort and safety.
- Provide a space for bicycles to ride that is outside of the automobile door zone and provides a vertical element to separate the bicycle and travel lanes.

The CMF Clearinghouse does not provide an appropriate CMF for a buffered bicycle lane; therefore, a bicycle lane CMF was reviewed. The CMF Clearinghouse provides information concerning the impact on crashes that the installation of bicycle lane has within urban areas. The Clearinghouse provides a CMF for "Install cycle tracks, bike lanes, or on-street cycling"[2]. Although bicycle lanes are not the same as the recommended countermeasure of buffered bicycle lanes due to the fact that a buffer is not present, a buffered bicycle lane would likely enhance safety further.

The CMF Clearinghouse concluded that:

- The installation of a unidirectional bicycle lane has the potential to reduce vehicle-bicycle related injury crashes up to 59 percent.
- By providing a separate facility rather than a shared facility for bicycles, it allows the roadway to be delineated for each mode of transportation.

The buffered bicycle lane would reduce the opportunity for vehicle-bicycle related crashes. If a road diet is deemed feasible from a capacity analysis, buffered bicycle lanes could be considered along Diamond Hill Road.

3.4.1.3 Dynamic Speed Display (Feedback) Signs

Research shows mixed outcomes concerning the use of dynamic speed display signs. These signs are electronic and are used to supplement a posted speed limit sign. The electronic face of the sign displays a driver's speed to the driver and may flash to alert drivers that are exceeding the speed limit.

The Crash Modification Factor Clearinghouse provides a CMF for 'Installing a Changeable Speed Warning Sign'[3] of 0.54, meaning that 46 percent of crashes could be eliminated through the installation of a dynamic speed feedback sign. Beyond this data, little information is available on the direct benefits in terms of crash reductions yielded by a dynamic speed feedback sign.

As a surrogate for reduction in crashes, many studies have reviewed the direct benefits to speed reduction that a dynamic speed feedback sign can provide. Reductions in speed should translate into reductions in crash severity and ultimately a reduction in total crashes.

One application for speed feedback signs that has been studied is use in a rural transition area where rural highways slow down and transition into town centers.

2 "Install cycle tracks, bike lanes, or on-street cycling" Crash Modification Factor Clearinghouse. US Department of Transportation, Federal Highway Administration. http://www.cmfclearinghouse.org/detail.cfm?facid=4102. Accessed: November 29, 2016.

3" *Install changeable Speed Warning Sign"* Crash Modification Factor Clearinghouse. US Department of Transportation, Federal Highway Administration. http://www.cmfclearinghouse.org/detail.cfm?facid=78. Accessed: August 25, 2016.

These zones typically require speed limit changes from 45-55 mph to 25-30 mph. These facilities could be two lane or greater than two lane roadways.

A 2012 TRB study by Veneziano et. al.[4] summarizes the results of studies from Iowa (Hallmark, 2013) and Minnesota (Sandberg, 2008) which showed that long term speed reductions due to permanent dynamic speed feedback installations can range from 2 mph-9 mph one year following installation. A wide range of impacts such as this suggests that the impacts of dynamic speed feedback signs is inconclusive.

Although the posted speed limit for Diamond Hill Road is 35 miles per hour, the documented operating speeds were well above the threshold. Therefore, it is recommended to consider the implementation of a portable dynamic speed display sign along this corridor.

[4] Veneziano, et. al. "*Guidance for Radar Speed Sign Deployments*", Transportation Research Board, Washington D.C., 2012.