REPORT

ROAD SAFETY AUDIT: NH-111 AND ERMER ROAD INTERSECTION

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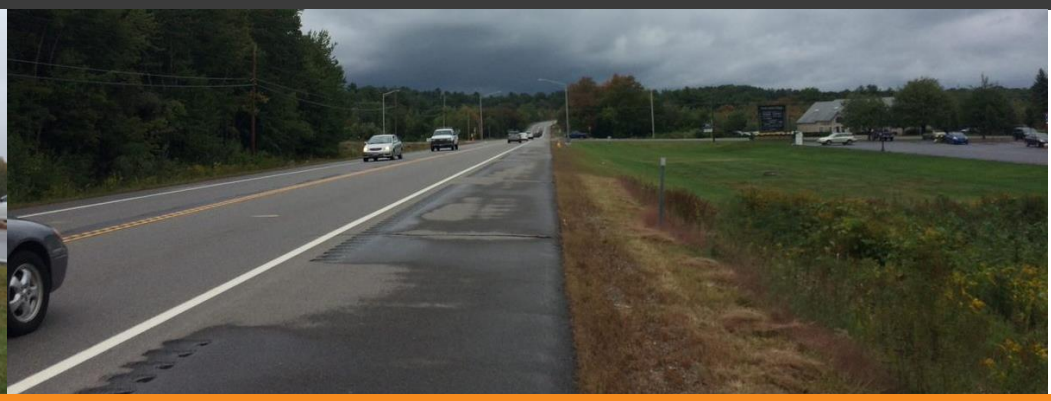
9.20.2017



PREPARED FOR:
NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION

SUBMITTED BY:
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STATUTORY NOTICE

23 U.S. Code § 409 - Discovery and admission as evidence of certain reports and surveys:

Notwithstanding any other provision of law, reports, surveys, schedules, lists, or data compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential accident sites, hazardous roadway conditions, or railway-highway crossings, pursuant to sections 130, 144, and 148 of this title or for the purpose of developing any highway safety construction improvement project which may be implemented utilizing Federal-aid highway funds shall not be subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data.

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1.0 INTRODUCTION

In December 2016, the Town of Salem, New Hampshire, submitted a request to the New Hampshire Department of Transportation (NHDOT) to conduct a Road Safety Audit at the intersection of New Hampshire Route 111 and Ermer Road in Salem. NH-111 has high traffic volumes, and the roadway design at this intersection encourages high speeds. The intersection was the site of a recent fatal crash, and crashes at this location have a higher likelihood of serious injuries compared to other intersections in Salem.

NHDOT approved the request and retained RSG as a third-party consultant to perform a Road Safety Audit (RSA) with planners and engineers from NHDOT, the Rockingham Planning Commission, and Town planners and engineers, as well as Town emergency first responders. An RSA was conducted in September 2017. This report summarizes the existing conditions of the project area, observations made in the field during the RSA, and short-, medium-, and long-term recommendations.

According to the Federal Highway Administration (FHWA), a **Road Safety Audit (RSA)** is a formal safety performance examination of an existing or future road or intersection by an independent, multidisciplinary team. It qualitatively estimates and reports on potential road safety issues and identifies opportunities for improvements in safety for all road users.

FIGURE 1-1: SUMMARY OF WHAT RSA'S ARE AND ARE NOT

RSAs *are*:	RSAs *are not*:
✓ **Focused on road safety.**	× A means to evaluate the design of a facility.
✓ **A formal examination.**	× A check of compliance with standards.
✓ **Proactive in nature.**	× A means of ranking or justifying one project over another.
✓ **Conducted by a multidisciplinary team.**	× A means of rating one design option over another.
✓ **Conducted by a team that is independent of the operations, design, or ownership of the facility.**	× A redesign of a project.
✓ **Conducted by a qualified team.**	× A crash investigation (although the crash history of an existing facility is reviewed by an RSA team).
✓ **Broad enough to consider the safety of all road users of the facility.**	
✓ **Qualitative in nature.**	

2.0 PROJECT BACKGROUND

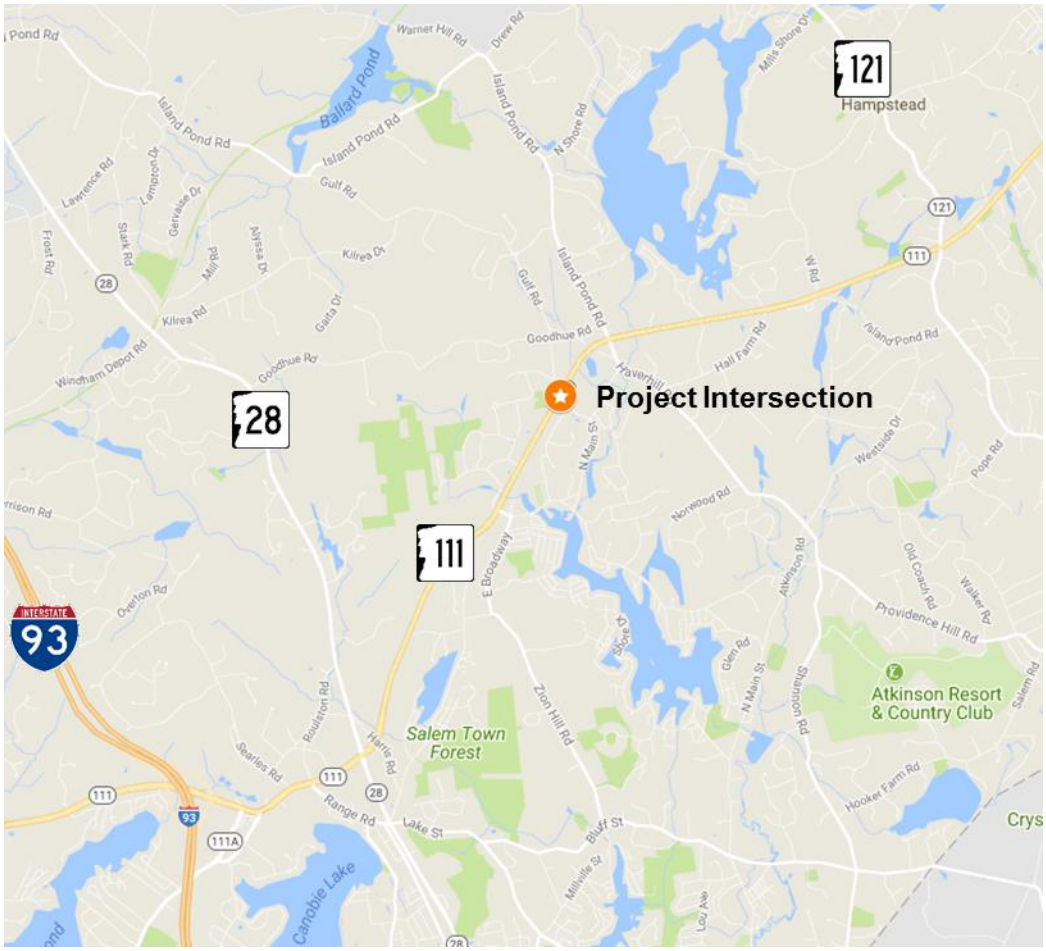
2.1 | PROJECT LOCATION

The project intersection of NH-111 and Ermer Road is in Salem, New Hampshire, about halfway between NH-28 and NH-121 (Figure 2-1). It is an unsignalized intersection. Approximately four miles to the west of the intersection is the interchange of NH-111 with Interstate 93.

NH-111 is a federal aid eligible Tier 2 state highway under NHDOT District 5 jurisdiction.

At the study intersection, NH-111 runs northeast-southwest, but because NH-111 is generally an east-west corridor, this report will refer to travel along NH-111 as eastbound or westbound, and travel along Ermer Road as northbound or southbound.

FIGURE 2-1: PROJECT LOCATION



Source: Google Maps

2.2 | PROJECT TEAM

RSAs require an independent, qualified, and multidisciplinary team of experts. Team members should act independently of the project owner/design team and have the freedom, ability, and comfort to comment frankly on potentially controversial safety issues. Having a combination of skills and experience in different areas is also helpful to ensure the most critical aspects of the project are addressed.[1]

The NH-111 & Ermer Road RSA's project team included twelve members, identified in Table 1 along with the elements of the audit for which they were present. Erica Wygonik of RSG was the RSA team leader.

TABLE 1: RSA TEAM MEMBERS AND ATTENDANCE

Name	Agency	AM Peak Hour Review	Pre-Audit Meeting	Field Review	Debriefing Meeting	NHDOT Debriefing Meeting	PM Peak Hour Review
Michelle Marshall	NHDOT Highway Safety		X	X	X	X	
Mike Dugas	NHDOT Highway Design Bureau		X	X	X	X	
Bob Bollinger	NHDOT Traffic Bureau		X	X	X	X	
Bill Lambert	NHDOT Traffic Bureau		X	X	X	X	
Rich Radwanski	NHDOT District 5		X	X	X	X	
Dan Hudson	Town of Salem Engineering		X	X	X		
Dave Wholley	Town of Salem DPW		X	X	X		
Tom Kench	Town of Salem Police Department		X	X	X		
Lawrence Best	Town of Salem Fire Department		X	X	X		
Dave Walker	Rockingham Planning Commission		X	X	X	X	
Erica Wygonik (team leader)	RSG (Consultant)	X	X	X	X	X	X
Corey Mack	RSG (Consultant)	X	X	X	X	X	X
Roxanne Meuse	RSG (Consultant)	X	X	X	X	X	X

The Pre-Audit Meeting and Field Review included several interested members of the public. Their input is collected and documented in the notes for these activities and informed the development of this Road Safety Audit.

[1] FHWA Road Safety Audit Guidelines, Publication No. FHWA-SA-06-06, page 27.

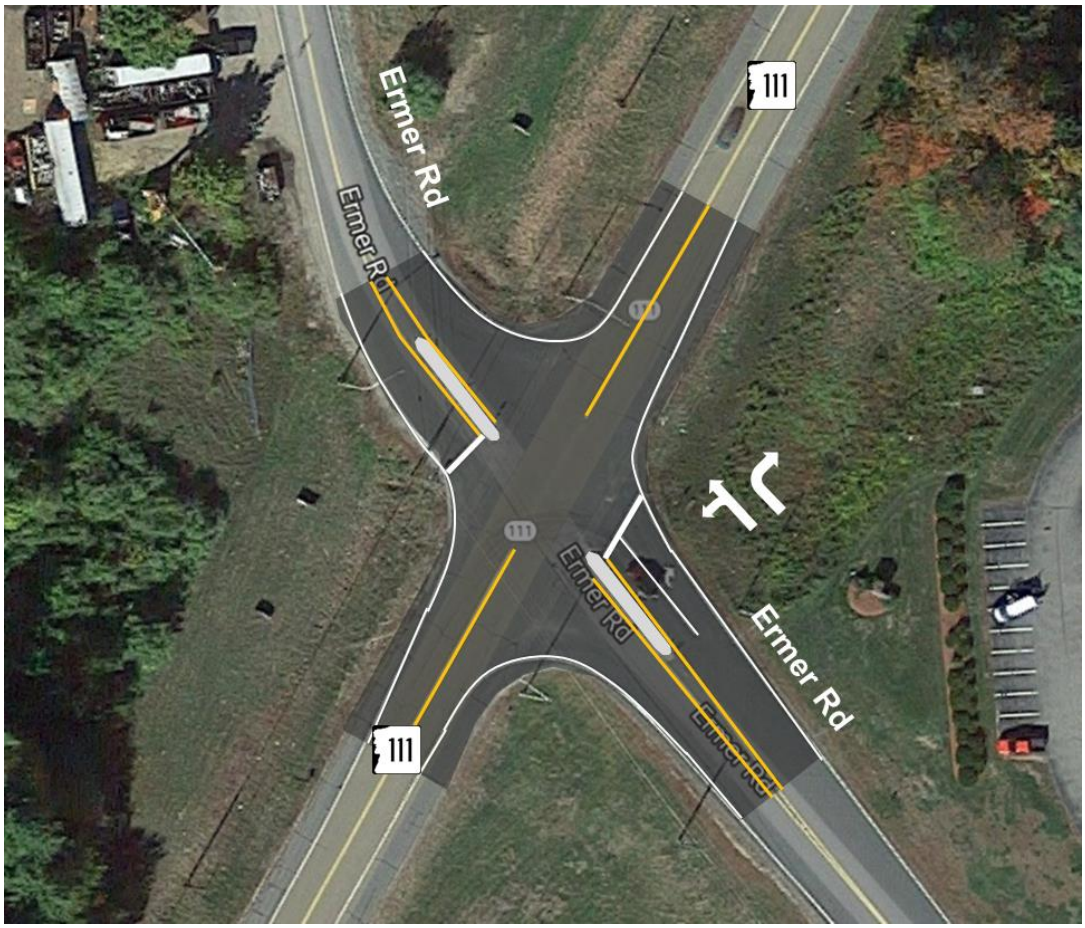
3.0 EXISTING CONDITIONS

3.1 | INTERSECTION GEOMETRY AND CONTROL

Ermer Road crosses NH-111 to form a four-legged intersection (Figure 3-1). Both roadways have one lane in each direction, but the southern Ermer Road approach has a right-turn lane and a combined through and left-turn lane; the other three approaches do not have dedicated turn lanes. Ermer Road has 50-foot long curbed medians at the northern and southern approaches and is stop-controlled. NH-111 is uncontrolled.

There are no pedestrian or bicycle facilities – such as crosswalks, sidewalks, bike lanes, or shared use paths – at or near the intersection.

FIGURE 3-1: PLAN VIEW OF INTERSECTION



Source: Google Earth Imagery with RSG overlay

3.2 | LAND USE

A plaza is located at the southwest corner of the project intersection and a single store is located on the southeast corner, both with access to Ermer Road (Figure 3-2). The store sells tactical clothing and supplies for police and has approximately 30 parking spaces. The plaza, called North Salem Village, contains a pizza place, an ice cream shop, and various

professional services and offices. Immediately south of the plaza, Chappy Lane meets Ermer Road, and a church is located just south of Chappy Lane.

FIGURE 3-2: LAND USE AT THE STUDY INTERSECTION

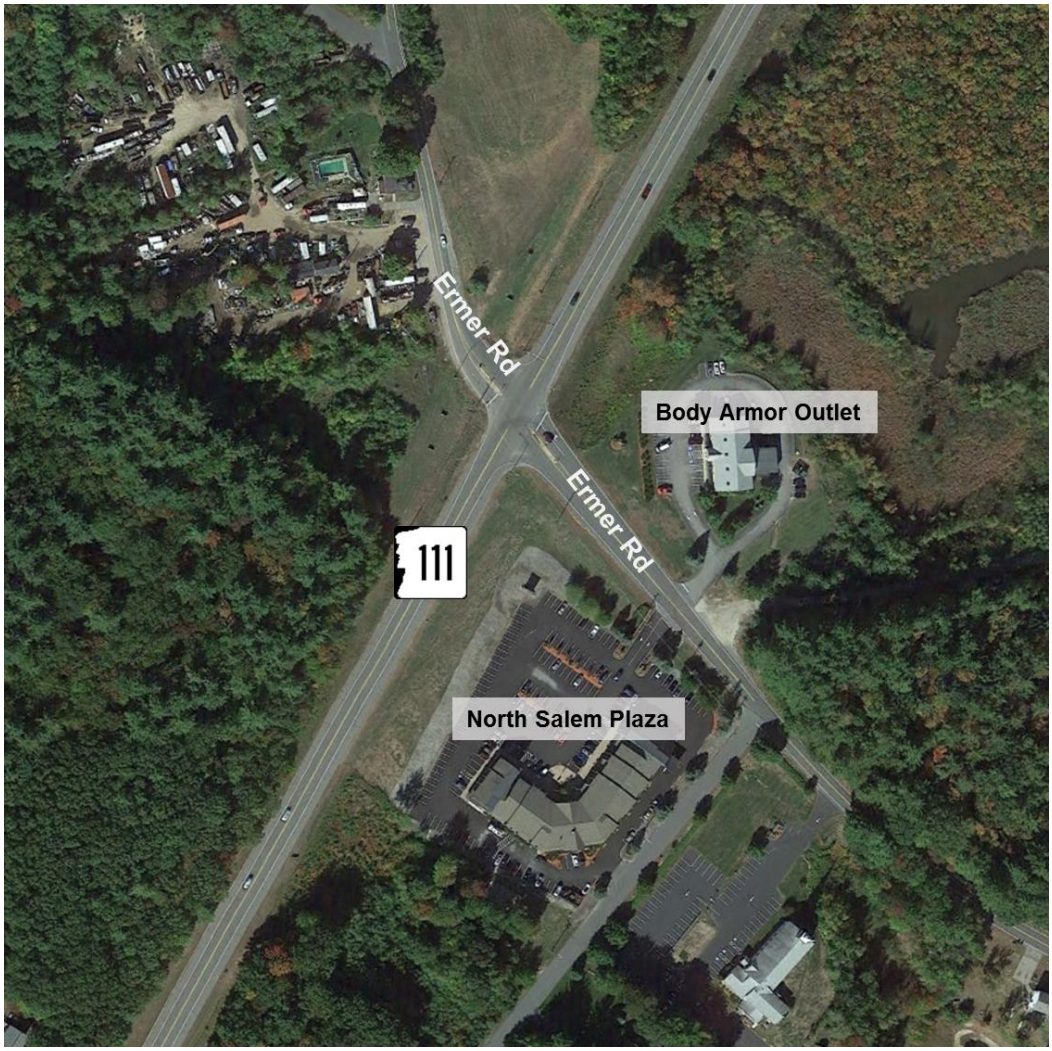


Image source: Google Earth Imagery with RSG overlay.

3.3 | ROAD NETWORK

NH-111 between NH-28 and Zachary's Crossing is a bypass segment, constructed in 2008. The speed limit along this segment and to the east through the study intersection is 50 mph, except when reduced to 40 mph in advance of traffic signals. Generally, the corridor is designed to prioritize regional mobility with minimal delay to through traffic.

South and north of the project intersection are networks of residential streets off Ermer Road, which connect back to NH-111 at Zachary's Crossing approximately 1 mile west of Ermer Road, and Haverhill Road/Island Pond Road to the approximately ½ mile east of Ermer Road (Figure 3-3). These two intersections are the closest intersections to Ermer Road along NH-111 and are both signalized.

FIGURE 3-3: ROAD NETWORK

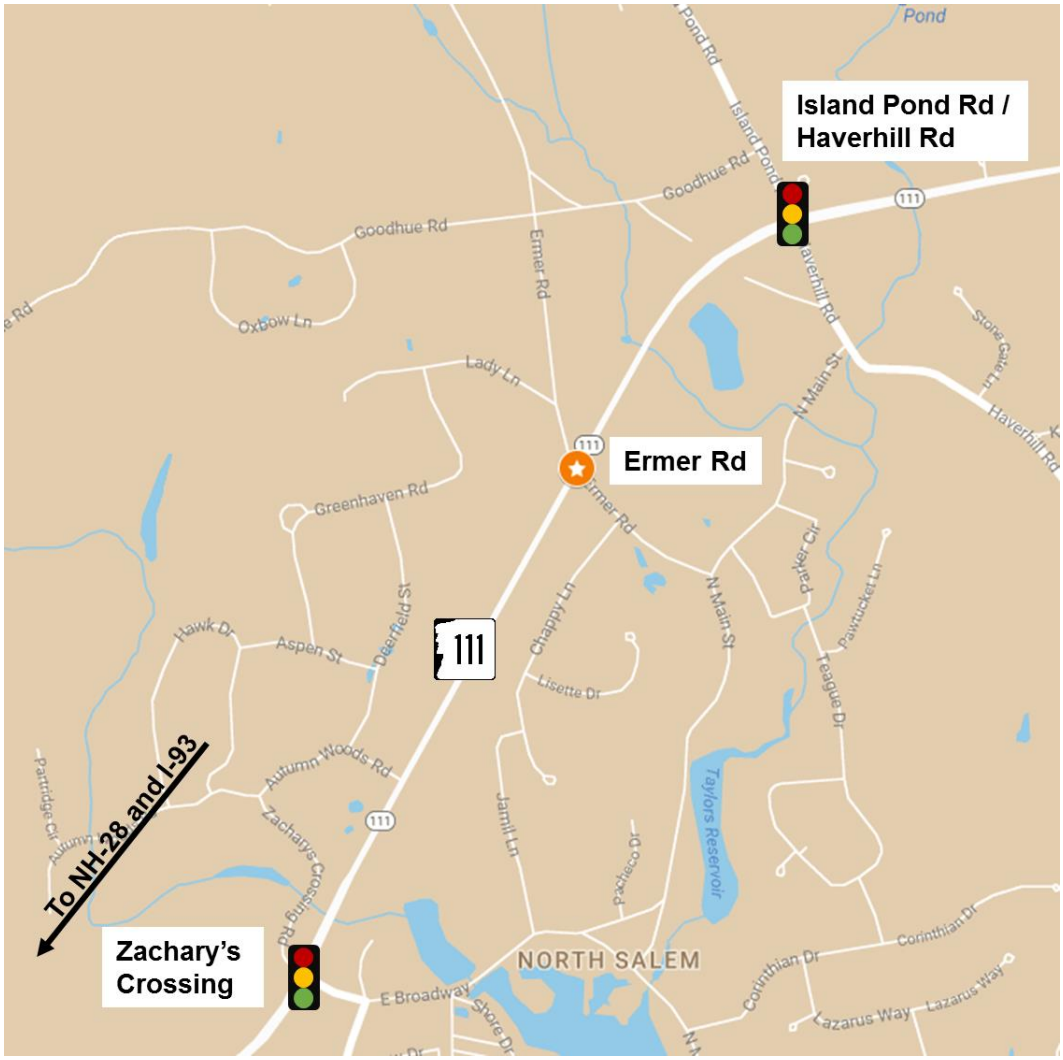


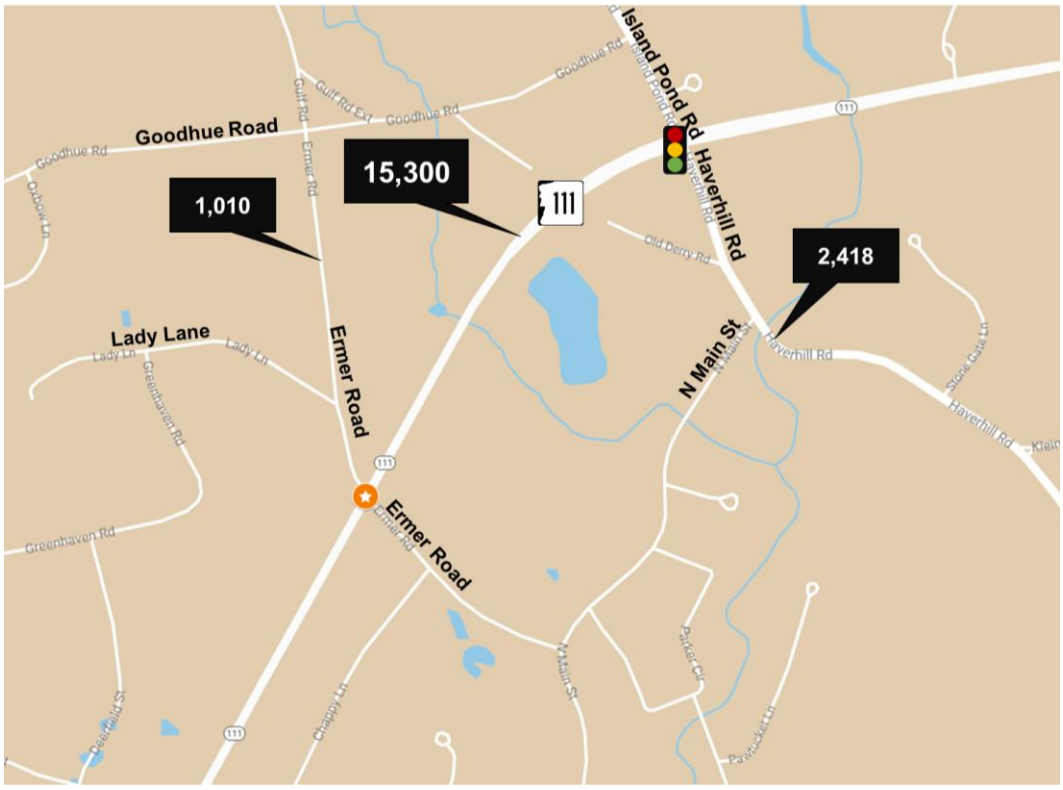
Image source: Google Maps with RSG overlay.

3.4 | TRAFFIC AND SAFETY ANALYSIS

TRAFFIC VOLUMES

Traffic volumes from automatic traffic recorder locations near the project intersection are shown in Figure 3-4. Volumes are shown as average annual daily traffic (AADT). NH-111 experiences 15,300 vehicles per day on average near the project intersection.

FIGURE 3-4: AVERAGE ANNUAL DAILY TRAFFIC



Data Source: NHDOT Transportation Data Management System.

Image source: Google Maps with RSG overlay.

PEAK HOUR TURNING MOVEMENTS

In addition to field observations conducted the day of the RSA, RSG collected turning movement count data at the project intersection between 7:00 am and 7:00 pm using traffic cameras. Most data were collected on September 19, 2017, the third Tuesday of September. Data between 7:00 am and 9:30 am were collected on October 17, 2017, the third Tuesday of October. Hourly volumes by approach throughout the day are shown in Figure 3-5 and Figure 3-6. The morning (AM) and evening (PM) peak hour counts are shown in Figure 3-7.

FIGURE 3-5: HOURLY VOLUME BY APPROACH

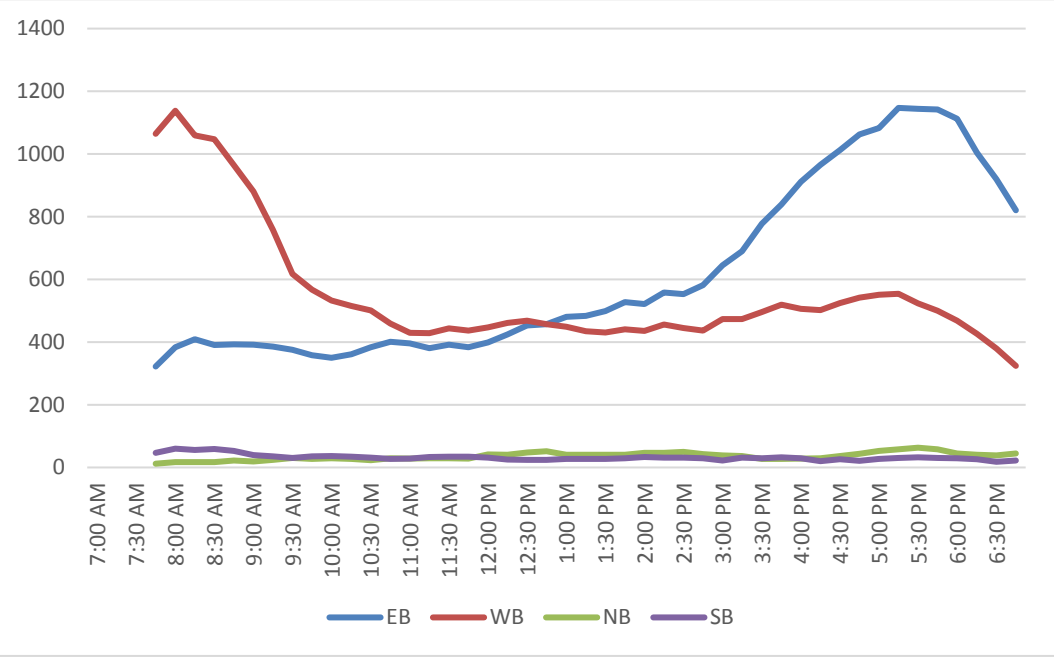


FIGURE 3-6: HOURLY VOLUME BY APPROACH, ERMER ROAD ONLY

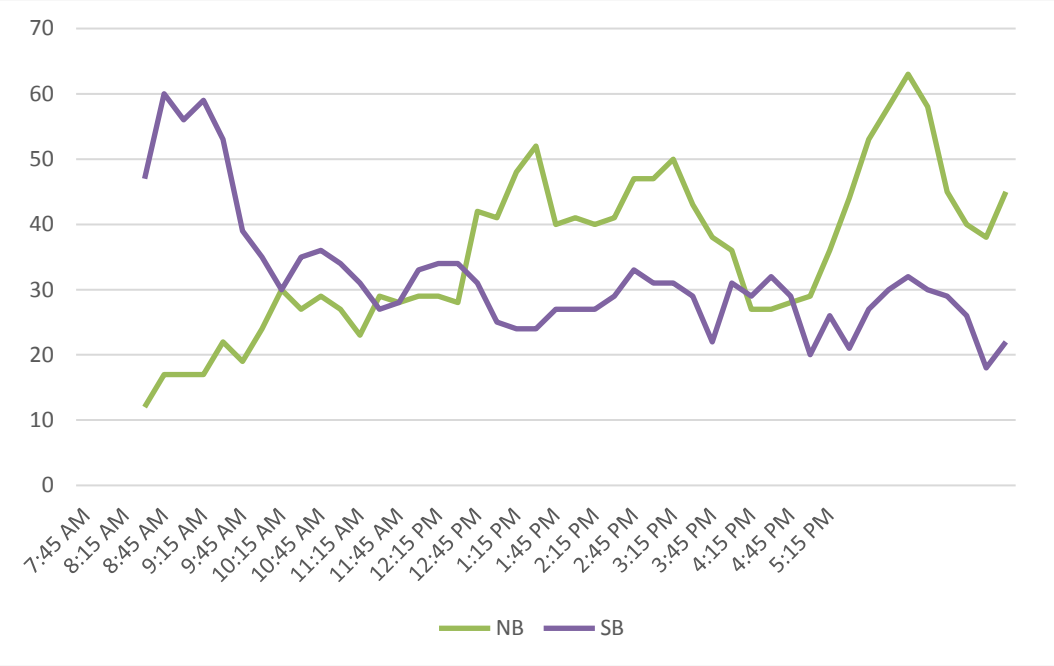
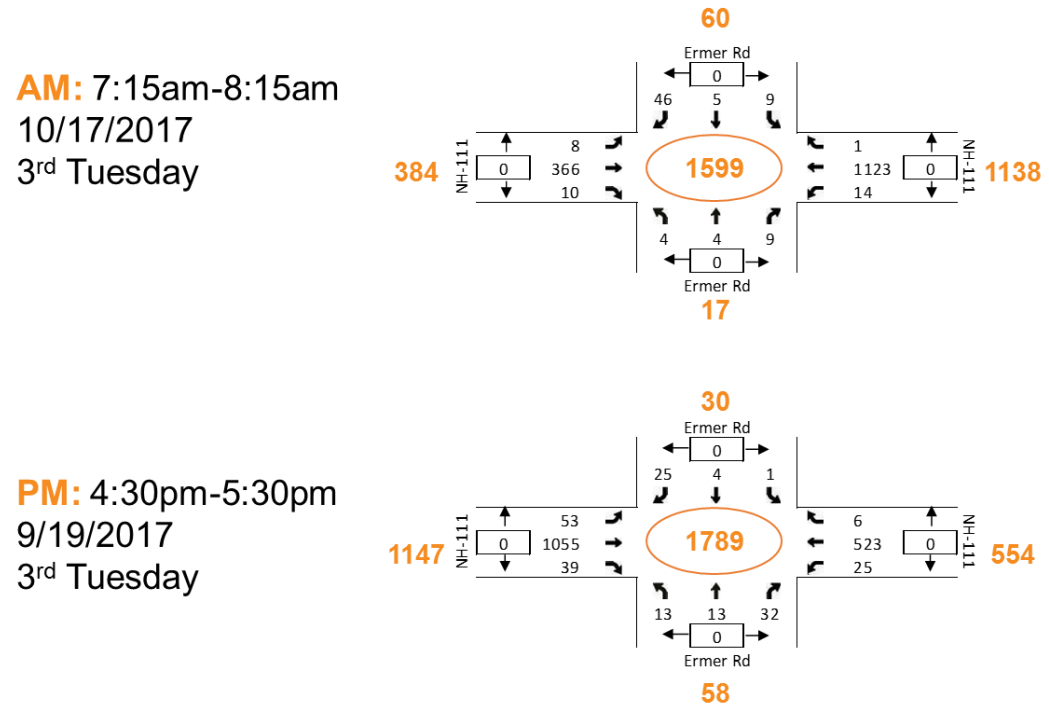


FIGURE 3-7: 2017 TURNING MOVEMENT COUNTS



Source: RSG

The counts show very few left-turn and through movements from the Ermer Road approaches, especially on the southbound approach. This may be in part due to vehicles avoiding left-turn and through movements. From RSG's in-person observations during the AM peak hour, there were at least two instances of southbound vehicles waiting 40 seconds or more to make a through or left-turn movement before changing their route and turning right.

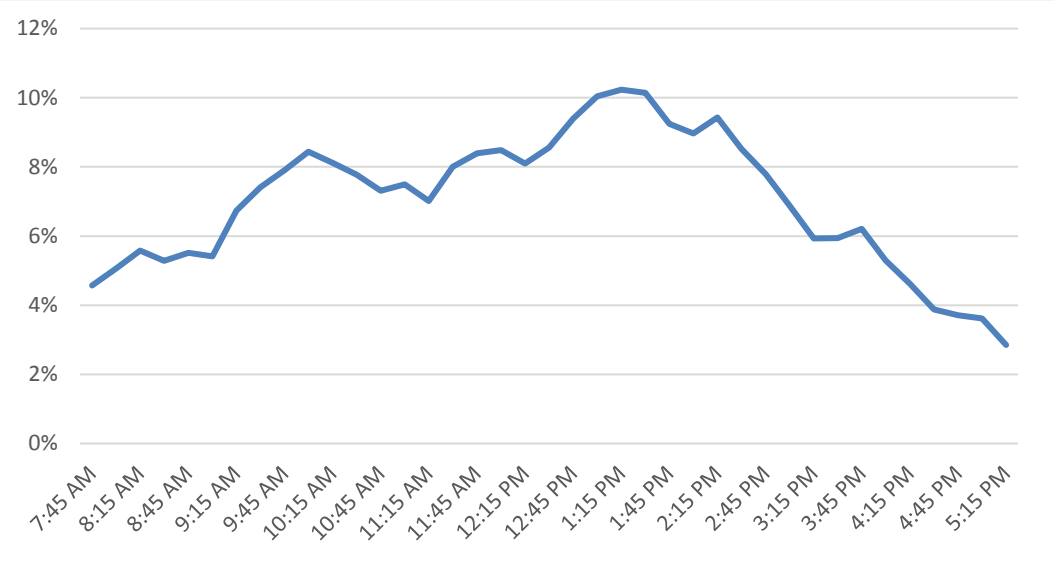
The peak hours show a significant directional distribution of traffic along NH-111. In the AM peak hour, westbound traffic exceeds 1,100 vehicles and eastbound traffic is under 400 vehicles. In the PM peak hour, this distribution is roughly reversed, with just over 1,100 eastbound vehicles and fewer than 600 westbound vehicles.

Ermer Road experiences a decrease in southbound traffic over the course of the day and an increase in northbound traffic over the course of the day.

The proportion of truck traffic to all vehicular traffic is relatively high and reaches a peak of over 10% between approximately 12:15 pm and 1:30 pm (see Figure 3-8).

One pedestrian and one person riding a bicycle were observed on the day of the RSA. One pedestrian and three people riding bicycles were observed during the 12-hour turning movement count.

FIGURE 3-8: HOURLY HEAVY VEHICLE PROPORTION OF ALL TRAFFIC



LEVEL OF SERVICE

Definition

Level-of-service (LOS) is a qualitative measure describing the operating conditions as perceived by motorists driving in a traffic stream. LOS is calculated using the procedures outlined in the 2000 and 2010 Highway Capacity Manuals. In addition to traffic volumes, key inputs include the number of lanes at each intersection, traffic control type (signalized or unsignalized), and the traffic signal timing plans.

The 2010 Highway Capacity Manual defines six qualitative grades to describe the level of service at an intersection. Level-of-Service is based on the average control delay per vehicle. Table 2 shows the various LOS grades and descriptions for signalized and unsignalized intersections.

TABLE 2: LEVEL-OF-SERVICE CRITERIA FOR SIGNALIZED AND UNSIGNALIZED INTERSECTIONS

LOS	CHARACTERISTICS	UNSIGNALIZED TOTAL DELAY (SEC)	SIGNALIZED TOTAL DELAY (SEC)
A	Little or no delay	≤10	≤10
B	Short delays	>10–15.0	>10–20
C	Average delays	>15–25	>20–35
D	Long delays	>25–35	>35–55
E	Very long delays	>35–50	>55–80
F	Extreme delays	>50	>80

Analysis at the Project Intersection

A LOS analysis was conducted at the project intersection based on the raw data from the AM and PM peak hour turning movement counts. For each major road movement and minor road lane during the AM and PM peak hours, the LOS (based on criteria for an unsignalized intersection) is shown in Table 3, and the average delay is shown in Table 4. Due to the high speeds and volumes on NH-111, vehicles entering the intersection from Ermer Road experience long delays when crossing or turning left onto NH-111. In the AM peak hour, vehicles on the northbound and southbound approaches experience LOS D and LOS E conditions, respectively. In the PM peak hours, vehicles on the northbound approach experience LOS F conditions, and those on the southbound approach experience LOS C. Vehicles on the NH-111 approaches experience LOS A in the AM and PM peak hours.

TABLE 3: PEAK HOUR LEVEL OF SERVICE

Approach	AM	PM
EB, NH-111	A	A
WB, NH-111	A	A
NB, Ermer Rd	D	F
SB, Ermer Rd	E	C

Source: RSG

TABLE 4: PEAK HOUR CONTROL DELAY (SECONDS)

Approach	AM	PM
EB, NH-111	1	2
WB, NH-111	1	1
NB, Ermer Rd	33	77
NB, Ermer Rd	44	25

Source: RSG

Queues

The longest queue that RSG observed on Ermer Road was five vehicles, on the southbound approach during the AM peak hour the day of the RSA.

On NH-111, RSG observed rolling queue conditions in the westbound traffic direction during the AM peak hour on the day of the RSA, beginning at approximately 7:30 am. The queue was observed to originate from the signal at Zachary's Crossing, 0.9 miles to the west. The queue cleared at approximately 8:15 am.

FIGURE 3-9: WESTBOUND ROLLING QUEUE DURING AM PEAK HOUR OF 9/20/17

Source: RSG

3.5 | SPEEDS

Speed data along NH-111 at the project intersection was collected through several methods, including tube data and radar gun data collected on-site by RSG and National Performance Management Research Data Set (NPMRDS) data, which is based on GPS data.[2] With the available data sources, there is no notable difference in 85th percentile speeds in the eastbound and westbound directions.

Peak Traffic Conditions

Between 6 am and 9 am and between 4 pm and 7 pm (AM and PM peak conditions when congestion is observed), 85th percentile speeds are 53 mph in the eastbound direction and 52 mph in the westbound direction, according to NPMRDS data. (No other data is available for these peak periods.)

[2] RSG collected tube data between 1:00pm and 2:45pm on the day of the RSA with an automatic traffic recorder in the eastbound direction. RSG collected westbound data between 9:30am and 10:15am on Tuesday, October 17 using a radar speed gun. National Performance Management Research Data Set (NPMRDS) data along NH-111 between Zachary's Crossing and Island Pond Road was also reviewed during peak period and free flow conditions.

Midday Free Flow Conditions

Between 1:00 pm and 2:45 pm (midday free-flow conditions), the 85th percentile speed is 61 mph in the eastbound direction according to tube data collected by RSG. According to NPMRDS, the 85th percentile speed during this period is 47 mph in the eastbound direction and 49 mph in the westbound direction.

Between 9:30 am and 10:15 am, the 85th percentile speed is 53 mph in the eastbound direction and 52 mph in the westbound direction, according to radar gun data collected by RSG. According to NPMRDS data, the 85th percentile speed during this period is 50 mph in the eastbound direction and 53 mph in the westbound direction.

Discussion

The speed limit along NH-111 at the project intersection is 50 mph. Thus, vehicles travel up to eleven mph over the speed limit in free-flow conditions. The speed limit at the nearest signals - Zachary's Crossing and Island Pond Road – reduces to 40 mph approximately ¼ mile before the intersections. Speed data was not gathered for these areas, which are outside the project scope.

3.6 | SIGHT DISTANCE

RSG measured intersection sight distance at the project intersection and stopping sight distance to the west of the project intersection where there is a crest curve. The available sight distances were compared to the design sight distances - the minimum recommended sight distances according to the 2011 edition of A Policy on Geometric Design of Highways and Streets (AASHTO).

INTERSECTION SIGHT DISTANCE

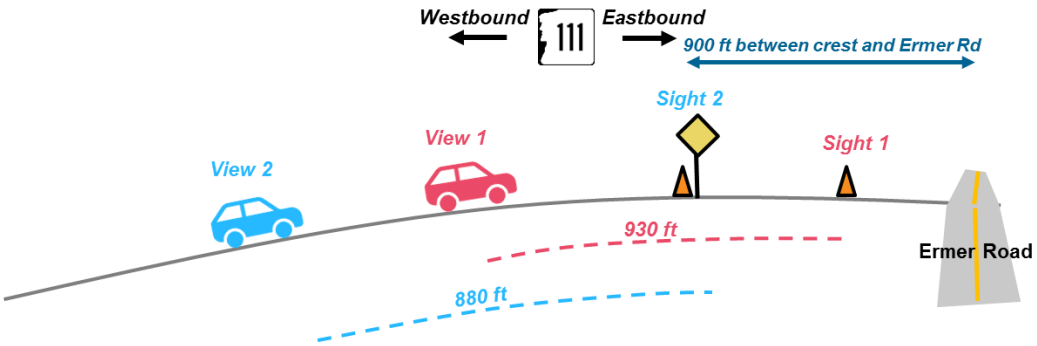
From both the northbound and southbound approaches on Ermer Road, available sight distance **exceeds design sight distance** for both the 50-mph design speed and the 60-mph 85th free flow speed, looking both right and left from each approach. The shortest sight distance is 1,048 feet looking right (west) from the southbound approach of Ermer Road. The design sight distance for this view is 480 feet for 50 mph and 575 feet for 60 mph.

STOPPING SIGHT DISTANCE

Stopping sight distance was measured for two locations along NH-111 to the west of the project intersection due to a crest curve. The peak of the crest is located roughly at an eastbound intersection warning sign, 900 feet west of the project intersection. Measurements were taken west of the intersection warning sign and west of a cone placed 300 feet from Ermer Road (see Figure 3-10). The measurements for **both locations exceeded the design sight distance** by at least 450 feet.

The design sight distance for 50 mph is 425 feet, and the design sight distance for 60 mph is 570 feet.

FIGURE 3-10: STOPPING SIGHT DISTANCE MEASUREMENTS



Drawing Not to Scale

Source: RSG

3.7 | CRASH SUMMARY

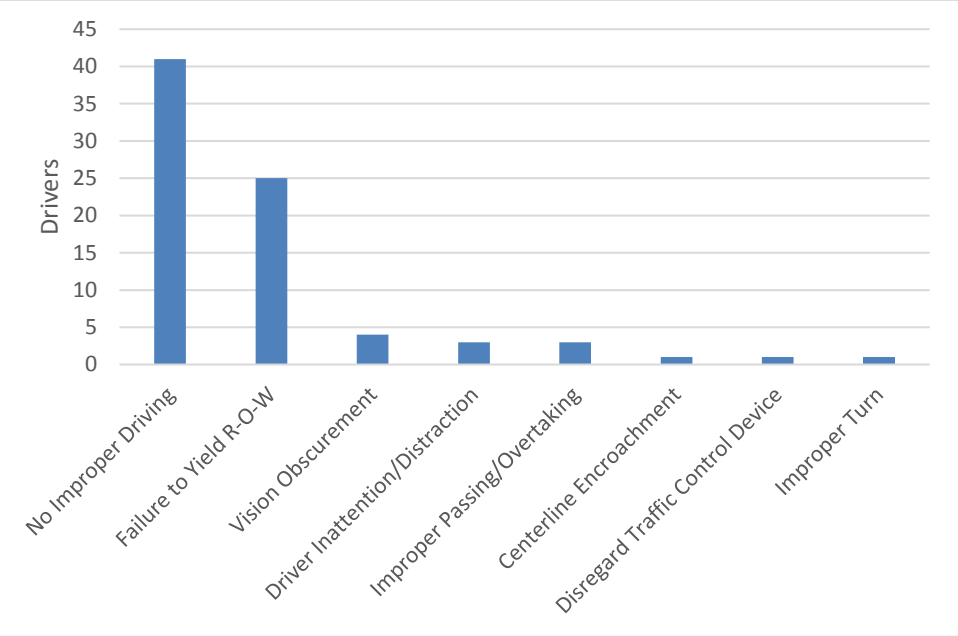
One of the requirements for an intersection to be eligible for a road safety audit is it has had a history of serious safety issues, including a fatal or serious injury crash occurring in the past ten years. Between 2006 and 2015 (the ten years prior to the RSA application submittal in 2016), the intersection of NH-111 and Ermer Road had one fatal crash - in 2016 - and three serious injury crashes, according to crash data provided by NHDOT.

The most notable crash-related aspect of the study intersection is the high proportion of serious injury crashes compared to other injury severities and non-injury crashes, according to the Salem Fire Department. When responding to crashes at the study intersection, the Fire Department automatically sends extra resources including heavy rescue, two ambulances, a battalion chief, and other additional vehicles or personnel.

A notable aspect of the intersection from NHDOT crash data is that the most common contributing factor to crashes[3] is failure to yield right of way, comprising 31% of drivers. This factor includes drivers on Ermer Road approaches entering the intersection without a sufficient gap in traffic on NH-111. Other contributing factors are significantly less common, as shown in Figure 3-11.

[3] excluding cases of no improper driving (51% of drivers).

FIGURE 3-11: CONTRIBUTING FACTORS TO CRASHES, BY NUMBER OF DRIVERS, 2006-2015



Source: NHDOT

4.0 FINDINGS AND OPTIONS

4.1 | SUMMARY OF ISSUES

The following list of issues are a compilation of the project team's observations during the RSA field review on September 20, 2017, the experience of Town officials and members of the public, and the crash history and volumes discussed in Section 3.

SAFETY ISSUES

A. 85th percentile speeds along NH-111 reach 10 miles per hour above the speed limit during free flow conditions.
B. There is a large speed differential between through-traffic on NH-111 and vehicles entering the project intersection from Ermer Road.
C. There is a large speed differential between through-traffic on NH-111 and vehicles stopped along NH-111 to turn onto Ermer Road.
D. Intersection sight distance is sufficient but can be limited due to solar glare and weather conditions.
E. Pedestrians and bicyclists do not have a safe way to cross NH-111 at Ermer Road. Although few pedestrians and bicyclists cross here, it is a desirable crossing location particularly for the pizza and ice cream shops in North Salem Village.
F. According to members of the public, there is insufficient police enforcement of speed along NH-111 proximate to the project intersection.

OTHER ISSUES AND INSIGHTS

G. Vehicles on Ermer Road waiting to cross NH-111 or turn left onto it experience long delays and a failing level of service.
H. Motorists familiar with the intersection commonly avoid it due to safety concerns, which pushes traffic to the adjacent intersections of Zachary's Crossing and Island Pond Road/Haverhill Road. Observed Ermer Road approach volumes may be lower than demand due to this issue.
I. The Island Pond Road / Haverhill Road signalized intersection does not have protected left turns.

4.2 | MEASURES FOR CONSIDERATION

The following are short-, medium-, and long-term measures that the RSA project team has identified for consideration. Some, but not all, can be combined with other measures.

SHORT-TERM MEASURES

Short-Term Measure 1: Increase speed enforcement.

Description and benefits: Increased police presence would allay concerns from the public, control speeding as it occurs, and potentially deter speeding by those familiar with the enforcement measures. The Town can also monitor the availability of grants from the National Highway Traffic Safety Administration (NHTSA) and the Office of Highway Safety in case speed enforcement grants become available. 2018 NHTSA awards are shown in Figure 4-1.

FIGURE 4-1: NHTSA GRANT CATEGORIES AWARDED IN 2018

OCCUPANT PROTECTION GRANTS	STATE TRAFFIC SAFETY INFORMATION SYSTEM IMPROVEMENTS GRANTS	IMPAIRED DRIVING COUNTER-MEASURES GRANTS	IGNITION INTERLOCK LAW GRANTS	24-7 SOBRIETY PROGRAM GRANTS	COMPREHENSIVE DISTRACTED DRIVING GRANTS	SPECIAL DISTRACTED DRIVING GRANTS	MOTORCYCLIST SAFETY GRANTS	GRADUATED DRIVER LICENSING LAW GRANTS	NON-MOTORIZED SAFETY GRANTS

Source: NHTSA. https://www.nhtsa.gov/highway-safety-grants-program/fy-2018-grant-funding-table

Issues Addressed: A-C, F

Disadvantages/Limitations: None identified

Cost Estimate: $50,000

Short-Term Measure 2: Install radar speed feedback signs.

Description and benefits: Speeding on NH-111 near Ermer Road was shown to be an issue outside of peak hours. One countermeasure for consideration on NH-111 and inexpensive to install is the use of radar speed feedback signs, which have been shown to decrease 85th percentile speeds on rural, non-work zones roadways by 2 to 4 mph, even after two years in place.[4] Such signs should be placed below static speed limit signs and show vehicles' speeds once they drive above the speed limit. They also would be most effective if combined with consistent police enforcement.

[4] FHWA, A Desktop Reference of Potential Effectiveness in Reducing Speed, July 2014, https://safety.fhwa.dot.gov/speedmgt/ref_mats/eng_count/2014/reducing_speed.cfm

FIGURE 4-2: RADAR SPEED FEEDBACK SIGN

Source: Richard Drful, Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Radar_speed_sign_-_close-up_-_over_limit.jpg

Issues Addressed: A-C

Disadvantages/Limitations: Radar speed feedback signs are typically used and are proven effective in urban and village settings where speed limits are low or where there is a change in the speed limit, including in work zones or ahead of curves. In these areas, the roadway context and characteristics support the message of the signs. NH-111 at the study intersection does not share these factors and therefore would not be an appropriate location for radar speed feedback signs. In addition to likely not being effective here, misuse of such signs could make them less effective elsewhere.

Cost Estimate: $20,000

Short-Term Measure 3: *Install Vehicle-Activated Warning Signs.*

Description and benefits: The existing static intersection warning signs could be upgraded to include a flashing beacon or LED-enhancement that activates when a vehicle is waiting on Ermer Road to turn onto NH-111 (see Figure 4-3). NHDOT has found that yellow beacons that constantly blink are not effective, and the agency is currently studying the effectiveness of vehicle-activated beacons. Unlike a radar speed feedback sign, these would only alert drivers when there is potential for a vehicle to be crossing their lane.

FIGURE 4-3: INTELLIGENT INTERSECTION WARNING SIGNS

Source: K&K Systemes, Inc *Source: FHWA*

LED-enhanced sign (left) and yellow flashing beacon (right). Exact language to be determined.

Issues Addressed: B

Disadvantages: None identified.

Cost Estimate: $30,000

MEDIUM-TERM MEASURES

Medium-Term Measure 1: Conduct a corridor study of NH-111.

Description and benefits: The safety concerns at the project intersection are not unique to this location; they are common at the unsignalized intersections along the NH-111 corridor. Conducting a corridor study would help the Town and NHDOT understand how other intersections and the corridor operate in terms of traffic and safety, identify high-priority intersections and segments for improvement, and find opportunities to apply the in-depth understanding of the Ermer Road intersection to other intersections.

Of particular relevance to Ermer Road, a corridor study could evaluate the suitability of adding protected left turns for the side streets at the Island Pond Road/Haverhill Road intersection. Protected left turns use a green arrow to give left-turn movements the right of way at a signalized intersection. Changing the Island Pond Road intersection to have protected left turns for the side street approaches may make the intersection safer for all left-turning vehicles, including those that use this intersection to avoid the Ermer Road intersection.

Issues Addressed: A, F, G, I, and other issues not yet identified

Disadvantages: None identified

Cost Estimate: $50,000

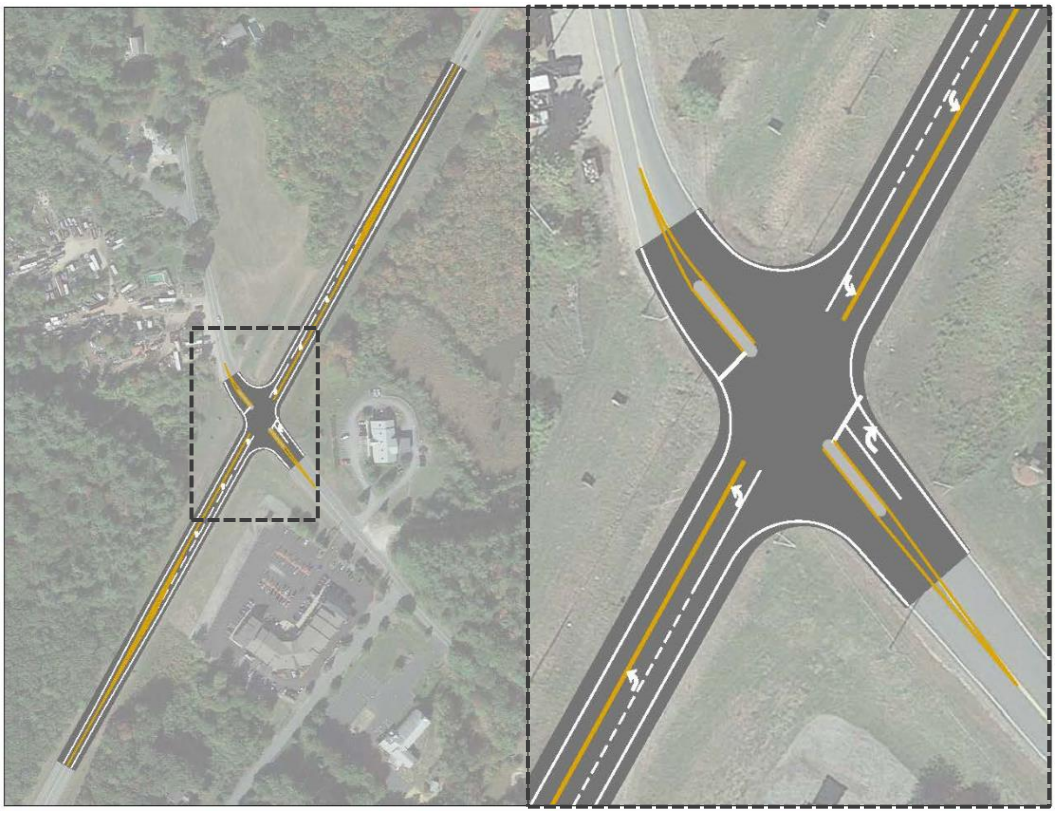
Medium-Term Measure 2: Install left-turn lanes on NH-111 in both directions.

Description and benefits: Currently, eastbound and westbound vehicles on NH-111 waiting for a gap in traffic to turn left onto Ermer Road must wait in the through-traffic stream. This may contribute to rear-end crashes when through-traffic does not expect a stopped car. Through vehicles were also observed to pass waiting left-turning vehicles on the right. Left-turn lanes would provide an area for vehicles along NH-111 to wait to turn left outside of the through-traffic stream, reducing the risk of rear-ends and reducing delay.

From conceptual calculations and drawing left-turn lanes over satellite imagery, left-turn lanes would not require widening the roadway unless existing shoulder widths need to be maintained; thus, this could be a short-term measure.

Warrant Analysis Results: A left-turn lane is warranted for both eastbound and westbound approaches in both the AM and PM peak hours.

FIGURE 4-4: CONCEPTUAL DRAWING OF LEFT TURN LANES



Source: RSG

Issues Addressed: B

Disadvantages: This measure would not address Safety Issue B (speed differential between NH-111 traffic and vehicles turning onto NH-111 from Ermer Road), one of the most significant safety issues. In addition, left-turn lanes on NH-111 could make left turns from Ermer Road more difficult.

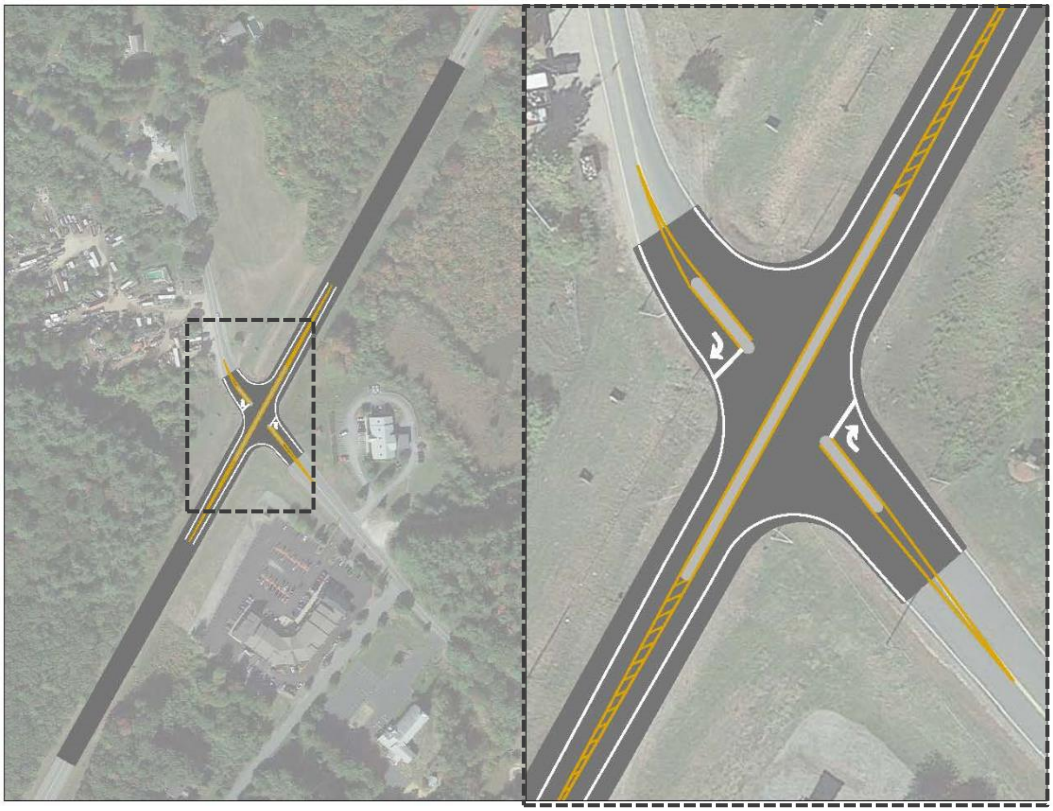
Cost Estimate: $260,000

Medium-Term Measure 3: Install a median on NH-111 to prohibit left turns onto NH-111 and left turns onto Ermer Road.

Description and benefits: Most of the safety issues at the project intersection are due to risks associated with left turns from NH-111 and Ermer Road and through movements across NH-111. A median would physically prevent these movements and therefore remove the safety issues associated with them. The intersection would be "right in, right out." Many drivers already avoid turning at this intersection.

A median would also provide an informal pedestrian refuge space if constructed wide enough.

FIGURE 4-5: CONCEPTUAL DRAWING OF A MEDIAN ON NH-111



Source: RSG

Issues Addressed: A-D

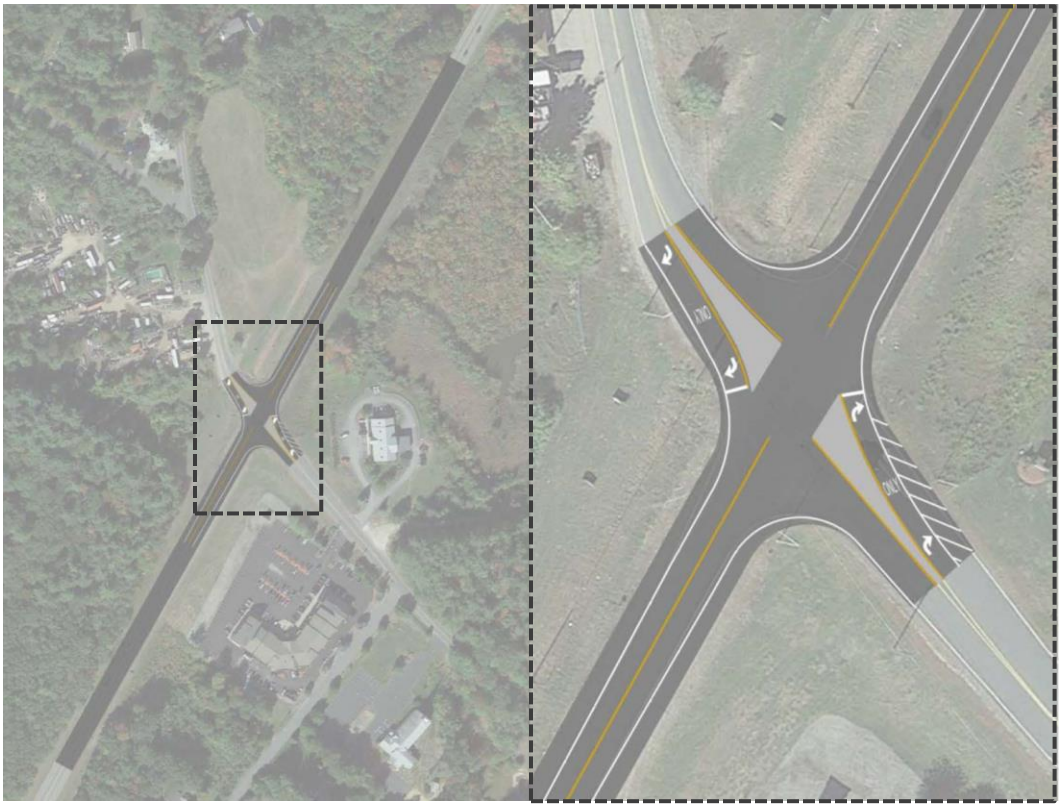
Disadvantages: This measure would limit access to Ermer Road - including emergency vehicle access and access to proximate businesses - and make future development at the intersection less likely. It may also be an obstacle for snow plowing. In addition, traffic would increase slightly along residential streets if drivers who currently turn left into or out of Ermer Road at NH-111 must access their destinations from other streets rather than from this intersection.

Cost Estimate: $270,000

Medium-Term Measure 4: Install triangular directional islands on the Ermer Road approaches to permit only right turns from Ermer Road.

Description and benefits: This measure would use directional islands on the Ermer Road approaches to permit only right turns (see Figure 4-6). Traffic on NH-111 would continue to be able to make left turns onto Ermer Road, a movement that has a lower risk than left turns from Ermer Road onto NH-111. This measure could be combined with left turn lanes on NH-111 to further increase safety and assist traffic flow. This design would retain emergency access across the intersection.

FIGURE 4-6: DIRECTIONAL ISLANDS ON ERMER ROAD



Issues Addressed: A, B

Disadvantages: This measure would limit access to NH-111 from Ermer Road, which is a safety benefit but an inconvenience to drivers. As a result, traffic would increase slightly along residential streets if drivers who currently cross NH-111 or turn left out from Ermer Road at NH-111 must access their destinations from other streets rather than from this intersection.

Conversely, the medians may not prevent all drivers from making left turns or through movements from Ermer Road. The medians will guide drivers to only turn right and supporting signage would prohibit left turns and through movements, but drivers will physically be able to drive around the medians and may make those movements, albeit illegally.

Cost Estimate: $120,000

LONG-TERM MEASURES

Long-Term Measure 1: *Install a traffic signal.*

Description and benefits: A traffic signal would reduce delay for the Ermer Road approaches by giving vehicles on Ermer Road dedicated time to cross or turn onto NH-111. If a traffic signal is installed, left turn lanes on NH-111 and pedestrian crossing facilities could also be included. Delay to the NH-111 approaches may be reduced by coordinating signals for the directional traffic; if timed appropriately, the signals may also encourage lower vehicle speeds along NH-111.

A signal may require an advanced warning sign and beacon to prevent rear-end crashes.

Warrant Analysis Results: The study intersection does not meet the volume-based warrants under current traffic conditions. The distance to the nearby signals limits the suitability of Warrant 6. No school is near the intersection, and no at-grade rail crossing is present. As such, a traffic signal is not currently warranted. If traffic patterns change or traffic volumes increase, and short- or medium-term measures fail to adequately address the safety issues, the traffic signal alternative could be reconsidered.

Issues Addressed: A, B, D, F

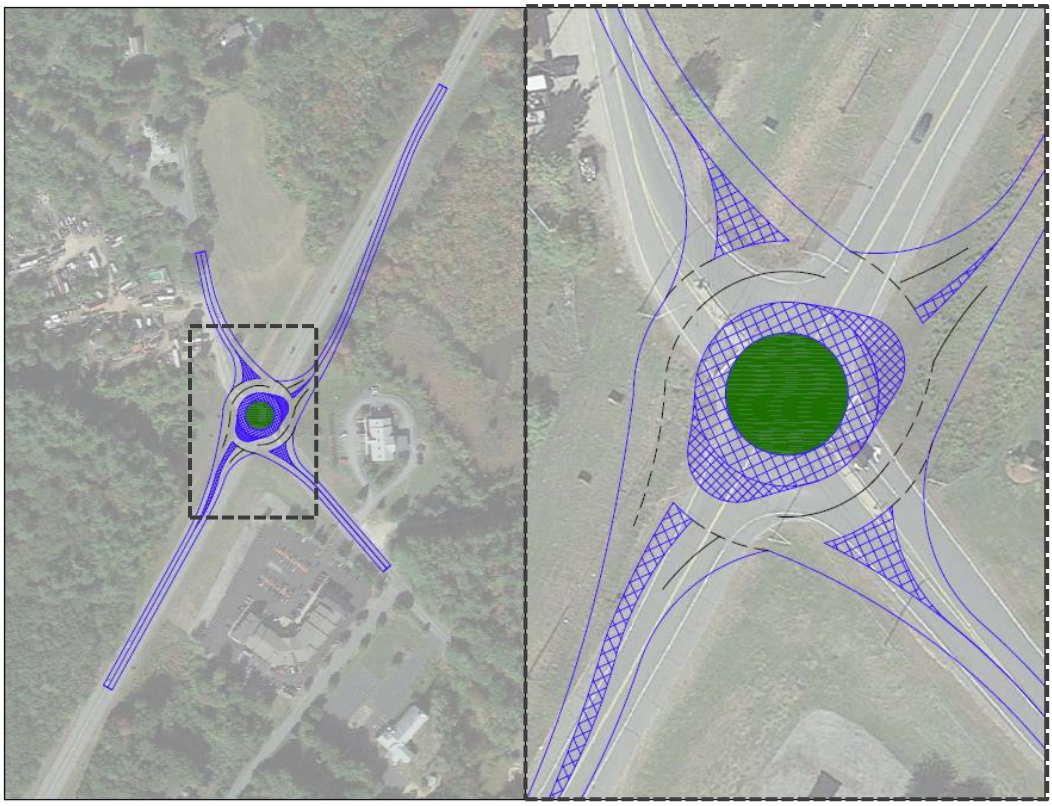
Disadvantages: A traffic signal would increase delay for through-traffic on NH-111. It would also increase the risk of rear-end crashes due to queuing at the signal.

Cost Estimate: $670,000

Long-Term Measure 2: ***Install a roundabout.***

Description and benefits: Roundabouts slow down traffic without stopping traffic, reduce the number of conflict points, and are proven to reduce the severity of crashes. A hybrid roundabout at this location, such as the example shown in Figure 4-7, would provide a high level of service to all movements. With splitter islands and crosswalks, a roundabout would also provide a safer crossing for pedestrians.

FIGURE 4-7: CONCEPTUAL DRAWING OF A HYBRID ROUNDABOUT AT THE STUDY INTERSECTION



Source: RSG

Issues Addressed: A-D, F

Disadvantages: A roundabout would be an expensive option for construction alone. An additional and potentially more significant cost would involve right of way acquisition to construct the appropriate deflection and radii for all approaches, due to the acute angle of westbound NH-111 and southbound Ermer Road.

Cost Estimate: $2,150,000

4.3 | BENEFIT-COST ANALYSIS

To determine how the above measures may reduce crashes, the Highway Safety Manual approach was used; crash modification factors (CMFs) from the CMF Clearinghouse were applied to each measure when there was an equivalent countermeasure in the Clearinghouse. Not all measures have an equivalent countermeasure in the CMF Clearinghouse for various reasons. The lower the CMF, the greater reduction in crashes a countermeasure is expected to produce.

The following table shows the improvements with their equivalent countermeasure (in language from the CMF Clearinghouse), CMF, and benefit-cost ratio. A benefit-cost ratio above 1 means the benefit of a countermeasure is greater than the cost of that countermeasure. All of the suggestions have benefit-cost ratios above 1.

TABLE 5: BENEFIT-COST ANALYSIS

	Measure	Countermeasure	CMF	Benefit-Cost Ratio (BCR)
SHORT TERM				
1	Increase speed enforcement.	*No corresponding countermeasure*		*CMF would need to be 0.99 for a BCR of 2*
2	Install radar speed feedback signs.	**#6885** Install dynamic speed feedback sign	0.95	17
3	Install vehicle-activated warning signs.	**#2808** Install dynamic advance intersection warning system	0.3	156
MEDIUM TERM				
1	Conduct a corridor study of NH-111.	*This is not a direct improvement; it is not applicable for a CMF.*		*n/a*
2	Install left-turn lanes on NH-111 in both directions.	**#268** Provide a left-turn lane on both major-road approaches	0.52	13
3	Install a median to prohibit left turns onto NH-111 and left turns onto Ermer Road.	*No corresponding countermeasure*		*CMF would need to be 0.92 for a BCR of 2*
4	Install triangular directional islands on the Ermer Road approaches to only permit right turns from Ermer Road.	*No corresponding countermeasure*		*CMF would need to be 0.96 for a BCR of 2*
LONG TERM				
1	Install a traffic signal.	**#325** Install a traffic signal	0.56	4
2	Install a roundabout.	**#229** Convert intersection with minor-road stop control to modern roundabout	0.29	2.2

RECOMMENDATIONS

The following is a summary of recommendations based on known operations, safety, and geometry at the study intersection and the preliminary evaluation of the measures described in Section 4.

TABLE 6: RECOMMENDATIONS

	Measure	Recommended?	Details
SHORT TERM			
1	Increase speed enforcement.	Yes	Begin as soon as possible.
2	Install radar speed feedback signs.	No	While the risk of speeding in the study area must be addressed, radar speed feedback signs are not appropriate for the context.
3	Install vehicle-activated warning signs.	Yes	Install as soon as possible.
MEDIUM TERM			
1	Conduct a corridor study of NH-111.	Yes	Conduct as soon as possible.
2	Install left-turn lanes on NH-111 in both directions.	Yes	Left-turn lanes are a relatively inexpensive measure that will increase safety in the medium-term and may be later incorporated into directional islands (M-4) or a traffic signal (L-1).
3	Install a median to prohibit left turns onto NH-111 and left turns onto Ermer Road.	Not at this time	To consider if other measures are insufficient.
4	Install triangular directional islands on the Ermer Road approaches to only permit right turns from Ermer Road.	Yes, but conditional on further study	Base decision on the corridor study (M-1) and/or further evaluation of the intersection.
LONG TERM			
1	Install a traffic signal.	Not at this time	To consider if traffic volumes change and other measures are insufficient.
2	Install a roundabout.	Yes, but conditional on further study	Base decision on the corridor study (M-1) and/or further evaluation of the intersection.

Directional islands on Ermer Road, a traffic signal, and a roundabout are all viable options but conflict with each other; we recommend pursuing one of them based on further evaluation of the intersection and the corridor.

5.0 APPENDIX

This appendix includes:

1. Presentation from pre-audit meeting
2. Pre-Audit and Field Review Meeting Notes
3. Additional crash history charts
4. Left-turn lane warrant analysis (NCHRP tool)
    a. Eastbound and westbound approaches, AM and PM
5. Signal warrant Analysis (PC-Warrants software)
6. LOS Analysis (Synchro software)
    a. Existing conditions AM and PM
    b. Traffic signal AM and PM
    c. Single-lane roundabout AM and PM
    d. Two-lane roundabout AM and PM

RSG
the science of insight

New Hampshire DOT
Department of Transportation

Road Safety Audit

NH Route 111 and Ermer Road
Salem, NH

Field Review

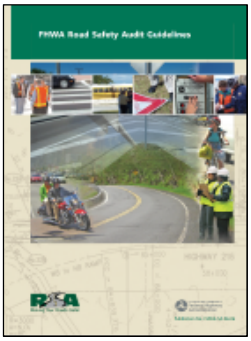
September 20, 2017

RSA Overview

A **Road Safety Audit (RSA)** is a formal safety performance examination of an existing or future road or intersection by an independent audit team.

Guidance:

FHWA Road Safety Audit Guidelines



RSA Overview

What is the purpose of an RSA on existing roads?

- Evaluate all roadway and roadside features, design elements and local conditions (glare, night visibility, adjacent land uses, etc.) that would increase the likelihood and severity of a crash.
- Review firsthand the interaction of the various design elements with each other and the surrounding road network.
- Observe how road users are interacting with the road facility.
- Determine if the needs of all road users have been adequately and safely met.
- Explore emerging operational trends or safety issues at that location.

RSA Overview

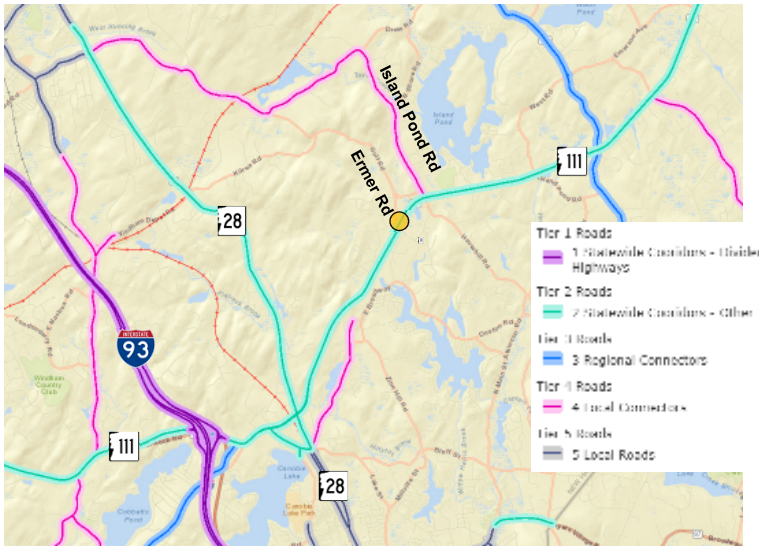
RSAs *are*:	RSAs *are not*:
✓ **Focused on road safety.**	× A means to evaluate the design of a facility.
✓ **A formal examination.**	× A check of compliance with standards.
✓ **Proactive in nature.**	× A means of ranking or justifying one project over another.
✓ **Conducted by a multidisciplinary team.**	× A means of rating one design option over another.
✓ **Conducted by a team that is independent of the operations, design, or ownership of the facility.**	× A redesign of a project.
✓ **Conducted by a qualified team.**	× A crash investigation (although the crash history of an existing facility is reviewed by an RSA team).
✓ **Broad enough to consider the safety of all road users of the facility.**	
✓ **Qualitative in nature.**	

RSA Process

1. Identify project ✓
2. Select RSA team ✓
3. Conduct pre-audit meeting
4. Perform field review
5. Conduct analysis and prepare report
6. Present findings to NHDOT & City
7. NHDOT & City prepares formal response
8. Incorporate findings into the project when appropriate

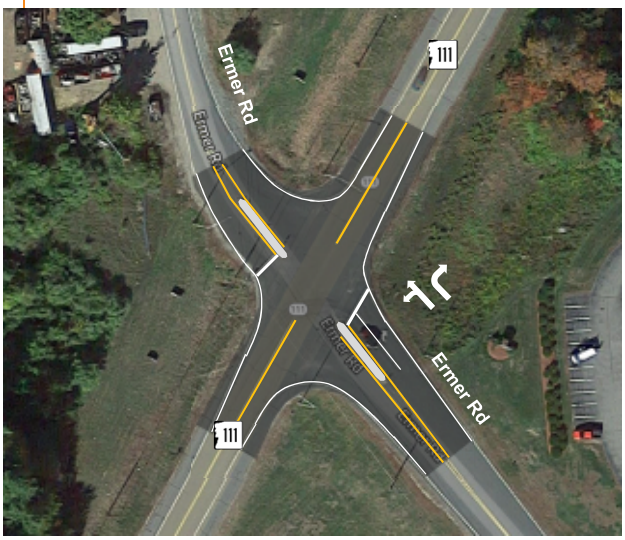
TODAY

Project Location



Intersection Approaches

Intersection Detail



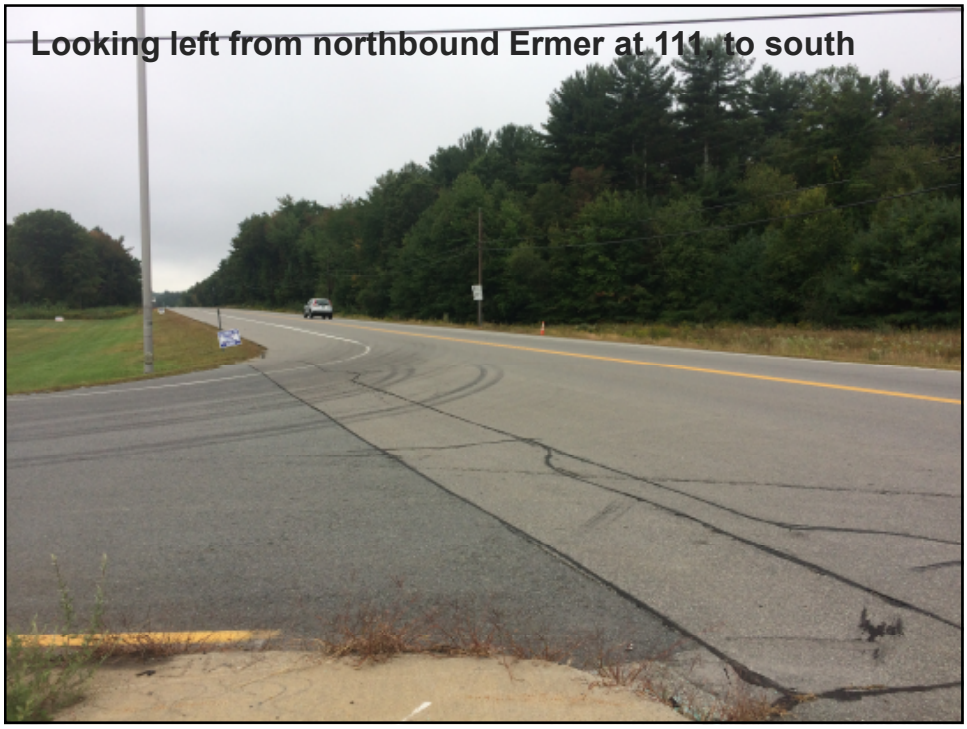
Known Issues

- High speeds
- Crash history, including recent fatal crash
- Speeds exceed 55 mph
- Intersection Angle = 75°

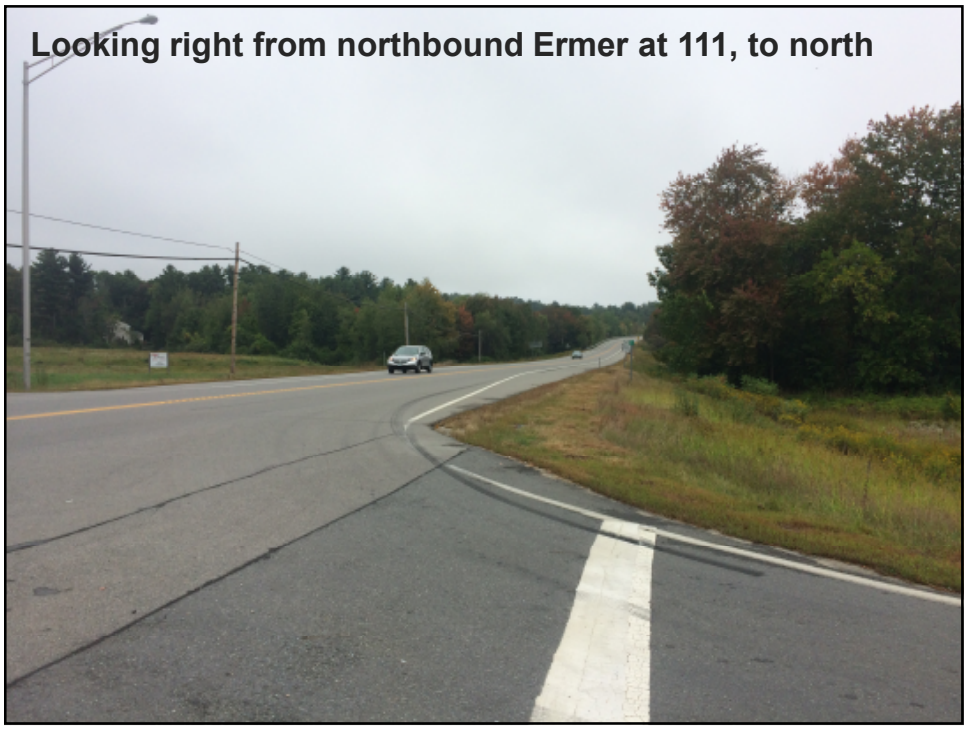
Previous findings:

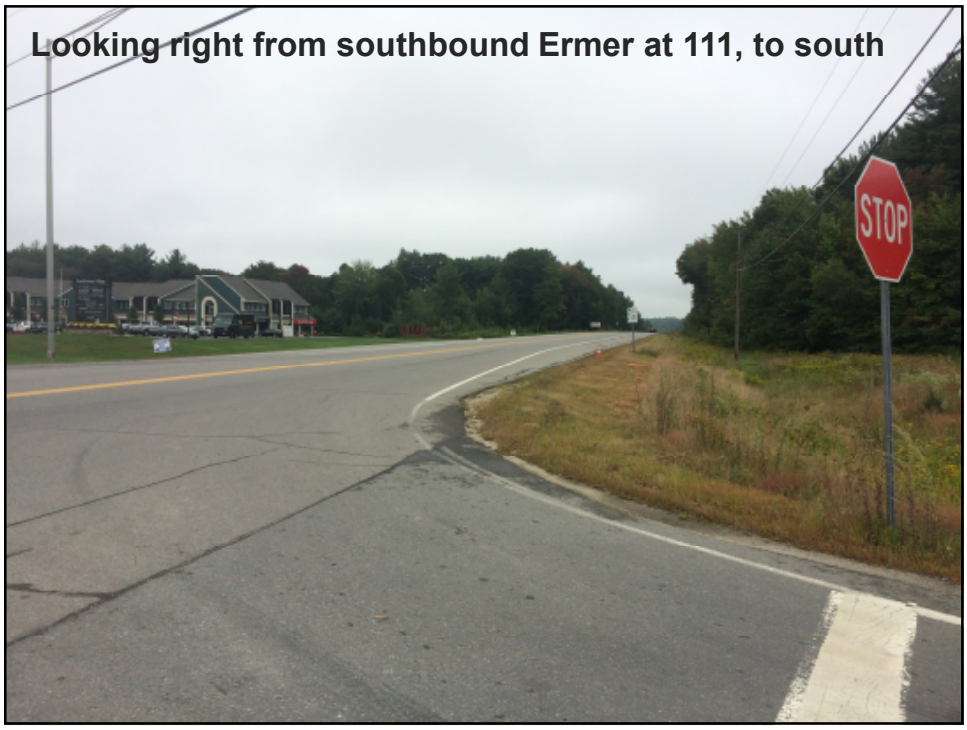
- 1997; meets MUTCD signal warrant #6

Looking left from northbound Ermer at 111, to south



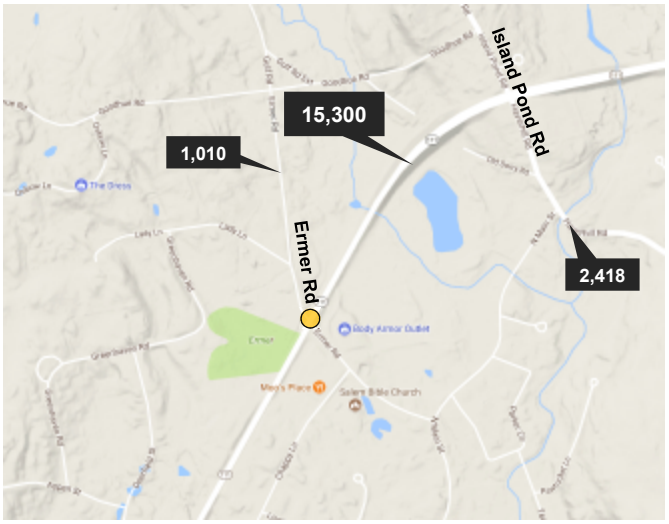
Looking right from northbound Ermer at 111, to north




Looking right from southbound Ermer at 111, to south
STOP

Intersection Data

Volumes



Posted Speed Limits

15

Field Review

Field Review

- **Goals:**
  - Observe existing conditions
  - Identify/verify safety concerns
- **To consider: E.R.O.D.E.**
  - **E**valuate all roadway and roadside features
  - **R**eview the interaction of the design elements with each other and the surrounding road network
  - **O**bserve road users and their needs
  - **D**etermine if the needs of road users have been met
  - **E**xplore emerging operational trends or safety issues

Field Review: Focus Items

- Traffic patterns and driver behavior
- Turning, accelerating, decelerating
- Lane changes, merges, weaving
- Sign locations, type, condition
- Visibility, sight distance
- Geometry of all approaches (skews, lane widths, etc)
- Right of way considerations
- Access points and conflict points
- Lighting needs
- Maintenance issues
- Vulnerable road users (pedestrians, bicycles, motorcycles)

Field Review

- **To Do's**
  - Discuss your observations with others from the RSA team
  - Take photos, videos, and notes as appropriate
- **Safety First**
  - Wear safety vest
  - Be careful of traffic, curbs, culverts, manholes, vegetation, rocks kicked up by trucks, etc
  - Do not block sight lines

Post-Field Discussion

RSA Process

1. Identify project ✓
2. Select RSA team ✓
3. Conduct pre-audit meeting ✓
4. Perform field review ✓
5. Conduct analysis and prepare report
6. Present findings to NHDOT & Town
7. NHDOT & Town prepares formal response
8. Incorporate findings into the project when appropriate

NEXT (RSG)

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MEETING NOTES

MEETING:	Pre-Audit Meeting and Field-Review
PROJECT:	Road Safety Audit: Intersection of NH-111 and Ermer Road in Salem, NH (Complex Intersection B)
DATE:	September 20, 2017
ATTENDEES - PROJECT TEAM:	**Town of Salem:** Dan Hudson (Engineering), Dave Wholley (DPW), Tom Kench (Police Dept and accident reconstruction team), Lawrence Best (Fire Dept) **NHDOT:** Michelle Marshall (Highway Safety), Bob Bollinger and Bill Lambert (Traffic), Mike Dugas (Highway Design), Rich Radwanski (District 5) **Rockingham Planning Commission:** Dave Walker **RSG:** Erica Wygonik, Corey Mack, Roxanne Meuse
ATTENDEES - PUBLIC:	**Salem Life Magazine:** Kim Whiting **Neighbors:** Michelle Federico (Autumn Woods), Deborah Adams (Pawtucket Lane), Kalley Cutler

RSG facilitated a road safety audit (RSA) for the intersection of NH Route 111 and Ermer Road with a technical team of staff from the Town of Salem, the New Hampshire Department of Transportation (NHDOT), and the Rockingham Planning Commission (RPC). Several members of the public were also present and contributed to the discussion and observations. The group gathered for a pre-audit meeting at Salem Town Hall at 10am, then held a field review, where we stood at the southwest corner of the intersection to observe traffic operations and discuss the needs of the intersection. At the end of the field review, we debriefed in the field and made a list of short-, medium-, and long-term recommendations. Following this, RSG met with Michelle Marshall (NHDOT) to confirm the list and plan the deliverables. RSG also observed the intersection during the AM and PM peak hours for a holistic understanding of the intersection.

PRE-AUDIT MEETING NOTES

Project Team

- Dave Wholley (Public Works)
    - Solar glare is an issue
    - For plowing, the Town avoids plowing the corners of the Ermer Road intersection when they plow the roads due to safety issues associated with maneuvering the plow around the corners. They'll only clear snowbanks between 10pm and 2am when there is very little traffic
- Tom Kench (Salem PD)
    - Speed limit is a factor in crashes
    - For cars stopped along NH-111 to turn left, the speed differential is dangerous for the stopper to get up to speed to take the turn, and for thru traffic not expecting a stopped car
    - Sun glare is an issue as the road runs east-west
    - It's hard to tell if crashes here are more locals or non-locals
    - A lot of crashes have to do with impairment - at this intersection and at other locations
    - As a resident living in North Salem, he typically avoids turning at this intersection
- Corey Mack (RSG)
    - We're focusing on the Ermer Road crossing but our findings here may be able to be applied to other intersections along the NH-111 corridor
- Lawrence Best (Salem Fire Dept)
    - Crossing traffic and turning traffic causes the worst crashes here
    - For 911 calls regarding this intersection, the Fire Dept sends heavy rescue - extra resources than they would normally send to an intersection. Normally they just send an engine and ambulance, but here they send two ambulances, a battalion chief, etc.
- Michelle Marshall (NHDOT)
    - Rumble strips were put in because this area was prioritized to have safety improvements
    - They wanted to have a rumble stripe on the shoulder line, but the contractors put a rumble strip in the shoulder
- Rich Radwinski (NHDOT District 5)
    - Plowing the roadway is no particular issue here
    - Asked about sight distance calculations - if we only consider sight lines on a nice, clear, dry day, what about when it's foggy or if there are snowbanks?
- Dan Hudson (Town Engineer)
    - Schoolbuses go straight across NH-111 on Ermer, and they are more slow-moving
    - He has seen bicyclists and pedestrians crossing NH-111 at Ermer as well
    - There's no transit along NH-111
    - He has received emails from the public that he will forward to the RSA team

Public

- Michelle Frederico (resident)
    - There is speeding on all of NH-111. Signals would keep speeds down
    - There is no police presence along NH-111 in Salem
    - East of Zachary's Crossing has the most issues
    - There are lots of neighborhoods around, with kids playing in the streets
    - Since the bypass (NH-111) was constructed, people have had a highway mentality, and there have been worse speeds in the past 5-7 years
    - Around 2:30pm the traffic starts picking up with school getting let out
    - Rumble strips don't make a difference
    - There is a school bus stop between Autumn Woods and Ermer Road
- Deb Adams (resident)
    - Never uses Ermer to get on NH-111 - it's too dangerous
    - There are many changes in speed limits along NH-111
    - There should be a light at Ermer so people can safely access NH-111
    - There's no police presence in Salem on NH-111
    - People ignore radar speed signs
- Kim Whiting (Salem Life Magazine)
    - She has interviewed Salem residents and people who work at the plaza at the intersection. Everyone told her they avoid the NH-111-Ermer Rd intersection.
    - It seems like with the speed limit, there's not enough sight distance looking west from Ermer onto NH-111, especially with the incline from northbound Ermer
    - She will send her article to Dan Hudson, to send to RSG

FIELD REVIEW NOTES

Weather: warm, alternating light rain and overcast

Observations between 7:30 am and 8:45 am by RSG:

- From driving eastbound and westbound on NH-111 going at the same speed as traffic, Roxanne barely reached 55 mph
- Heavy westbound queuing a few times, but mostly moving steady
- Slower westbound traffic due to Zachary Crossing signal
- Westbound traffic heavier than eastbound. Northbound and southbound traffic very light. Slightly more southbound than northbound traffic.
- More trucks in eastbound direction
- At one point, a queue of 4-5 cars on southbound Ermer approach: car in front was trying to turn thru or left and waiting over a minute, then turned right (gave up on thru or left turn)
- There was at least one other instance of a southbound car trying to head thru or left, but gave up (waited about 40 seconds before turning right)
- Noticeably less traffic and queuing and more even directional distribution by 8:15 am

Observations between 11:30 am and 12:00 pm by entire Project Team and members of the public:

- Vehicles are traveling faster than in AM peak
- Like in the AM peak (though not as extreme), there is heavier westbound traffic than eastbound traffic
- There are more trucks going eastbound than westbound
- Eastbound-right vehicles drive into the shoulder a bit
- It's clear when the light has gone green at Zachary Crossing and Island Pond Road, as vehicles tend to platoon

Comments during the field review from the building owner of North Salem Plaza:

- There are a lot of near misses
- 3 to 6:30 peak traffic is hard to leave Ermer Road
- Bicyclist but few if any pedestrians
- Stop sign during peak condition is used as a yield sign not a stop just to get into the gap
- If we change to a signal then he could add new businesses to his plaza. Currently folks do not feel safe using the intersection
- He would also like the cross removed from his front lawn

Debrief at 12:00 pm with entire Project Team and members of the public:

- Background info from Michelle (resident): people do walk across NH-111 to reach the ice cream and pizza places
- Background info: U-turns are allowed at Zachary Crossing and Island Pond Road intersections
- Background info: There is a petition for a signal to be installed at this intersection
- No pedestrians or bicyclists observed
- Lighting is good at the intersection, but not further
- Ermer approaches are treated as a yield (not stop) if drivers can see a gap in traffic early enough

Observations between 4:30 pm and 5:15 pm by RSG:

- There is less traffic than in the AM peak
- Eastbound traffic heavier than westbound traffic (opposite of AM peak)
- There is a higher northbound Ermer volume than seen at other times of the day
- Seems much less busy than around 3:30 pm when RSG was installing road tubes

ALTERNATIVES TO CONSIDER

Recommendations were discussed during the debrief after the field observations, with the entire project team and members of the public.

Short-Term Measures

- Apply for a NHTSA speed enforcement grant if available
- Continue to ensure sight lines are provided in winter
- Install radar speed feedback signs
- Change Island Pond signal to have protected left turns

Medium-Term Measures

- Install left-turn lanes on NH-111 (if the roadway is already wide enough, this may be a short-term measure)
- Install a two-way left turn lane
- Install a median to prohibit left turns onto NH-111 and left turns onto Ermer Road
- Install a traffic signal

Long-Term Measures

- Install a roundabout

Recommendations not specific to the project intersection

- Conduct a corridor study of NH-111

NEXT STEPS

1. RSG to review crash data compiled by Lt. Kench and compare crash history to other signalized intersections along NH-111 if available
2. RSG to review sight distances and speed data collected on the day of the field audit
3. Dan Hudson to forward emails from the public to the project team
4. Kim Whiting to send Dan Hudson and/or RSG her article about this intersection in Salem Life Magazine
5. RSG to write a draft report of findings and recommendations
6. NHDOT to review draft report

MEDIA LINKS ABOUT THE PROJECT INTERSECTION

Salem Life article (May 2017): http://www.salemlifemagazine.com/z-cms/index_9_1358111540.pdf

Eagle Tribune article (November 23, 2016): http://www.eagletribune.com/news/salem-fatal-crash-spurs-traffic-light-request/article_4ea9566a-9a9a-5eac-85e0-01286e5e8223.html

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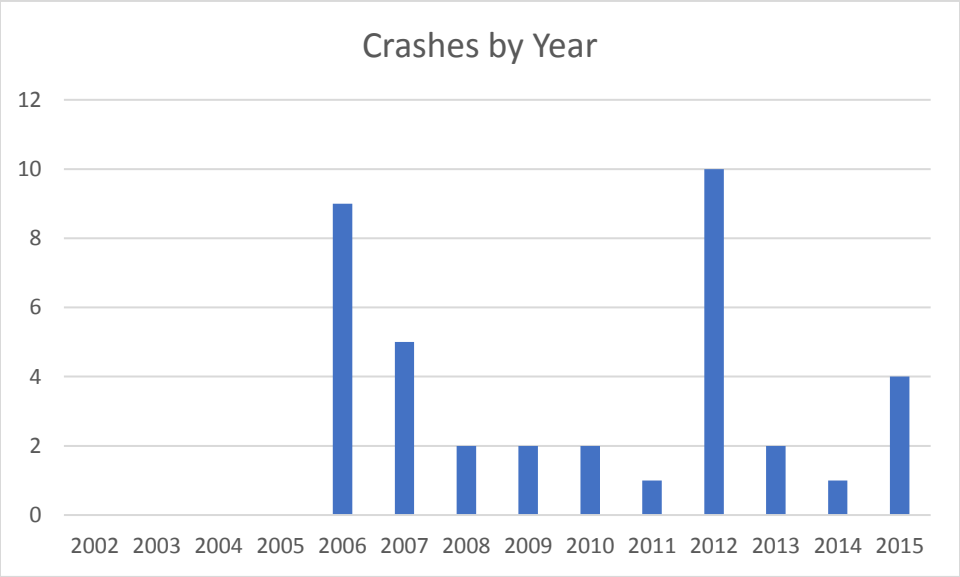
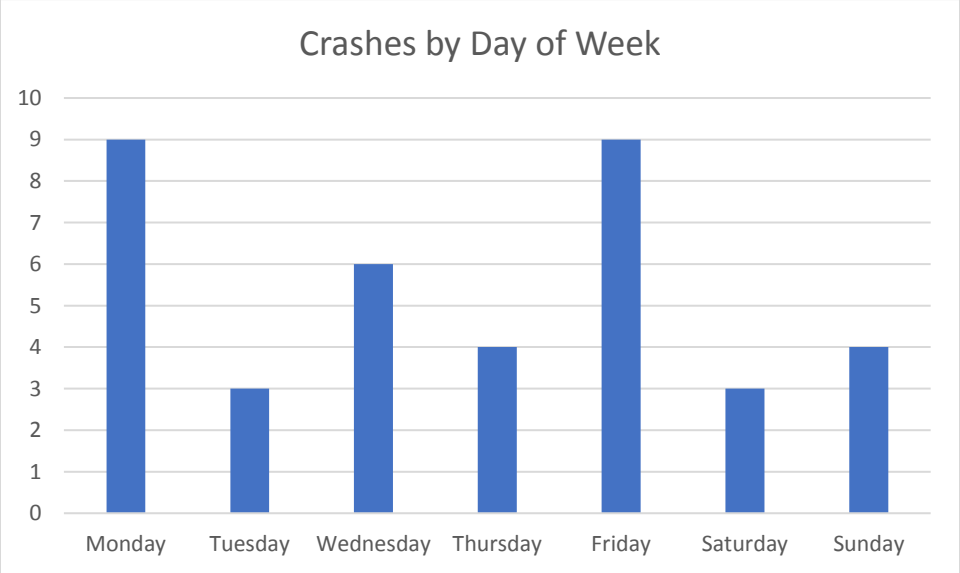
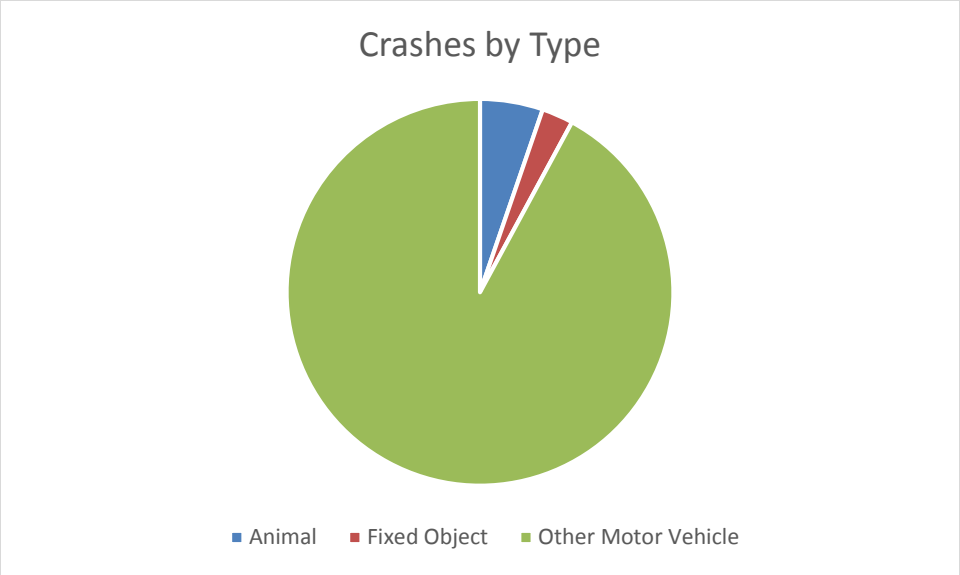
Notes compiled by Roxanne Meuse (RSG), 9/22/2017

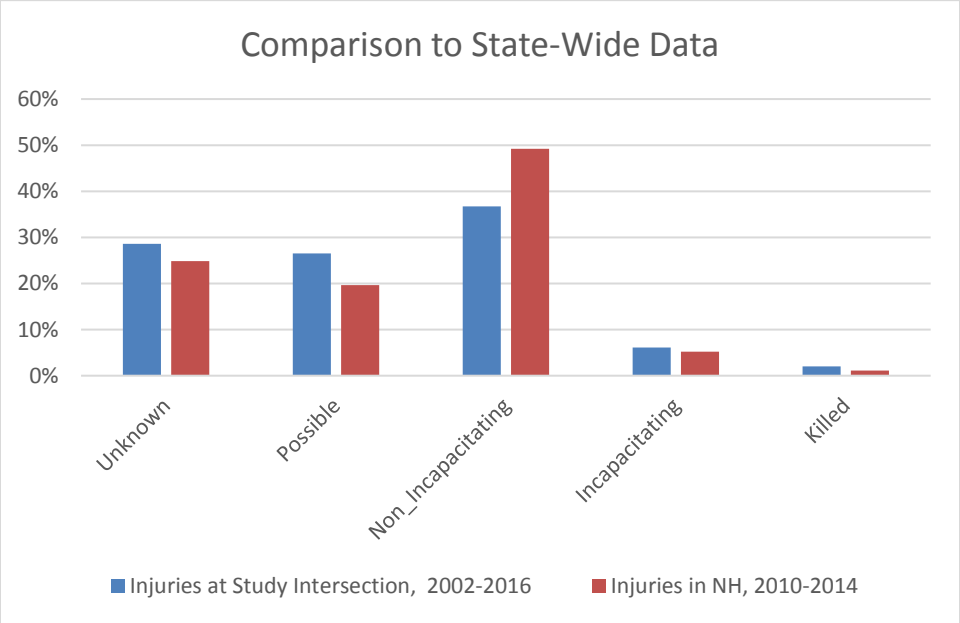
Crash History, 2006-2015

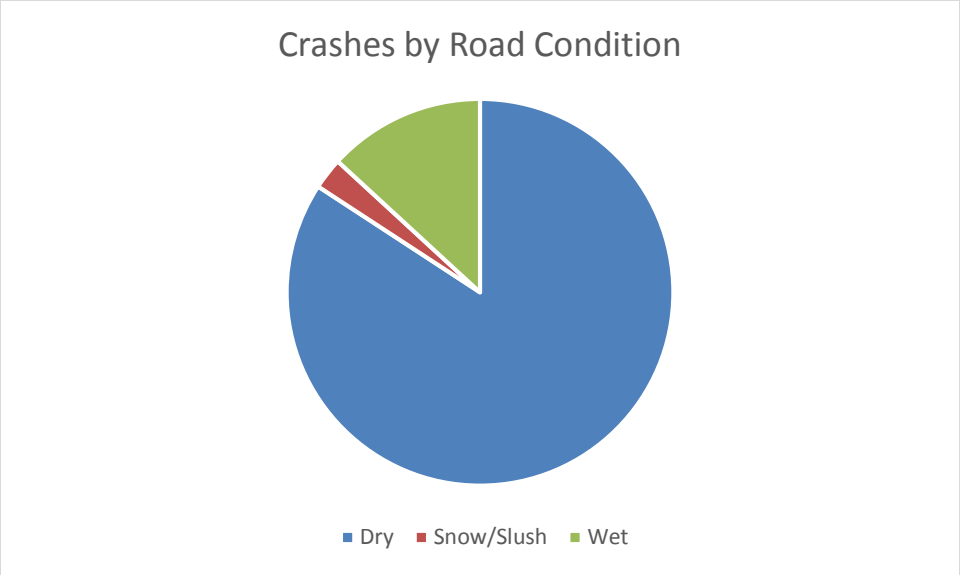
Source: NHDOT

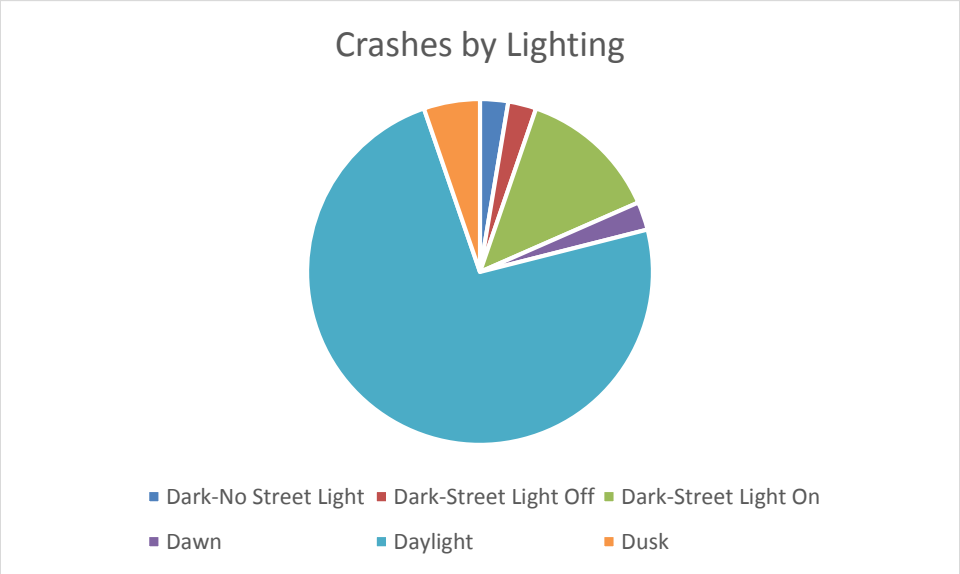


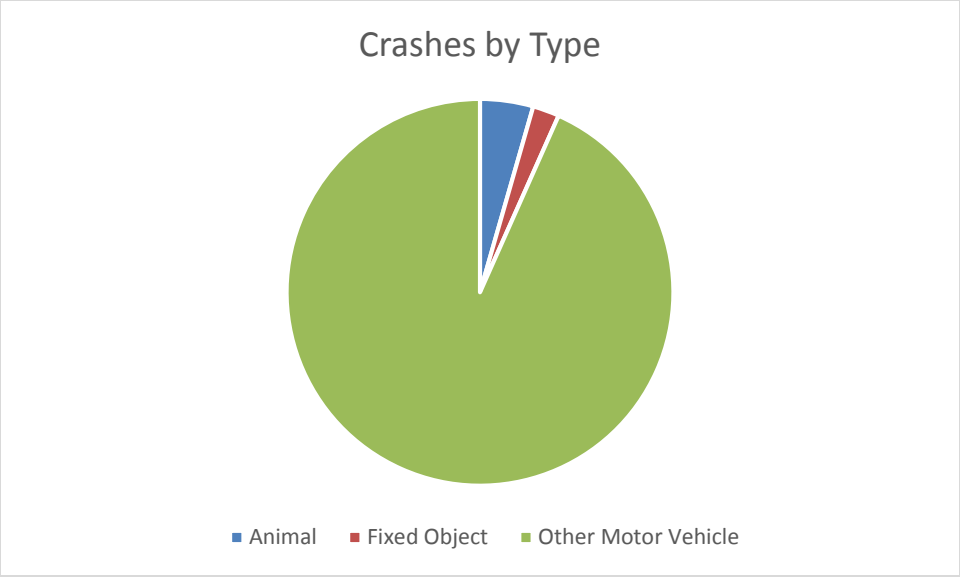



Crashes by Type
Animal
Fixed Object
Other Motor Vehicle


Comparison to State-Wide Data
60%
50%
40%
30%
20%
10%
0%
Unknown
Possible
Non_Incapacitating
Incapacitating
Killed
Injuries at Study Intersection, 2002-2016
Injuries in NH, 2010-2014


Crashes by Road Condition
Dry
Snow/Slush
Wet


Crashes by Lighting
Dark-No Street Light
Dark-Street Light Off
Dark-Street Light On
Dawn
Daylight
Dusk


Crashes by Type
Animal
Fixed Object
Other Motor Vehicle

NH Left Turn Lane NCHRP1 - Eastbound AM

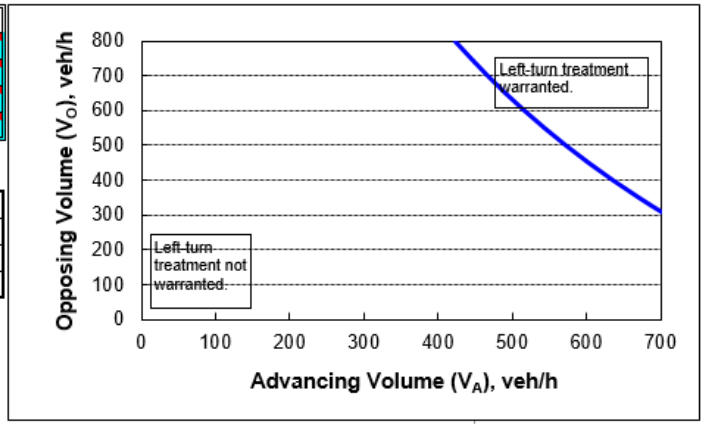
2-lane roadway (English)

INPUT

Variable	Value
85th percentile speed, mph:	53
Percent of left-turns in advancing volume (V_A), %:	2%
Advancing volume (V_A), veh/h:	384
Opposing volume (V_O), veh/h:	1124

OUTPUT

Variable	Value
Limiting advancing volume (V_A), veh/h:	309
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

NH Left Turn Lane NCHRP1 - Eastbound PM

Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

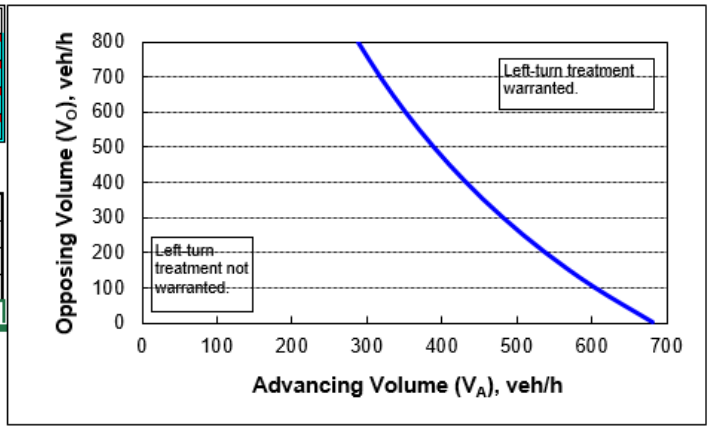
2-lane roadway (English)

INPUT

Variable	Value
85th percentile speed, mph:	53
Percent of left-turns in advancing volume (V_A), %:	5%
Advancing volume (V_A), veh/h:	1147
Opposing volume (V_O), veh/h:	529

OUTPUT

Variable	Value
Limiting advancing volume (V_A), veh/h:	378
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

NH Left Turn Lane NCHRP1 - Westbound AM

Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

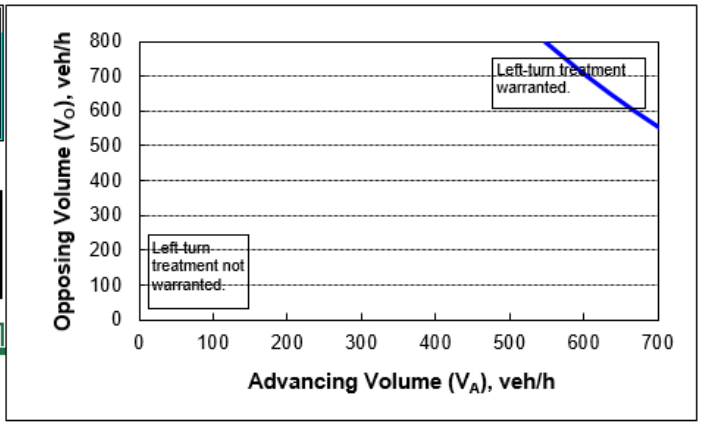
2-lane roadway (English)

INPUT

Variable	Value
85th percentile speed, mph:	53
Percent of left-turns in advancing volume (V_A), %:	1%
Advancing volume (V_A), veh/h:	1138
Opposing volume (V_O), veh/h:	376

OUTPUT

Variable	Value
Limiting advancing volume (V_A), veh/h:	844
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

NH Left Turn Lane NCHRP1 - Westbound PM

Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

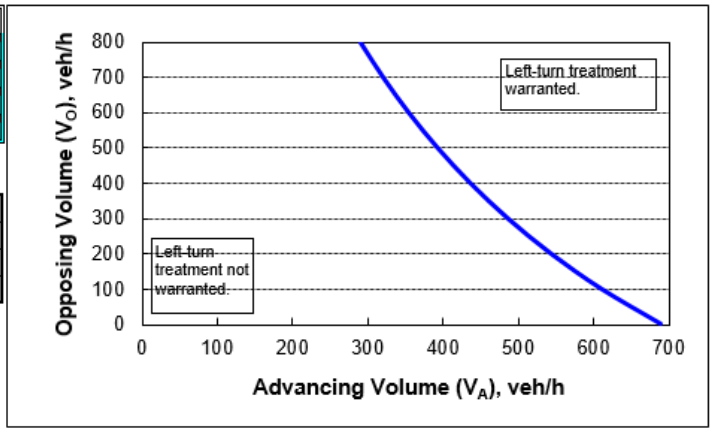
2-lane roadway (English)

INPUT

Variable	Value
85th percentile speed, mph:	53
Percent of left-turns in advancing volume (V_A), %:	5%
Advancing volume (V_A), veh/h:	554
Opposing volume (V_O), veh/h:	1094

OUTPUT

Variable	Value
Limiting advancing volume (V_A), veh/h:	219
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

NH-111 and Ermer Road

Salem, New Hampshire

Study Name: **NH111-ErmerRd**
Study Date : **10/17/17**

Signal Warrants - Summary

Major Street Approaches

Eastbound: **NH-111**
Number of Lanes: **1**
85% Speed > 40 MPH.
Total Approach Volume: **5,920**

Westbound: **NH-111**
Number of Lanes: **1**
85% Speed > 40 MPH.
Total Approach Volume: **6,148**

Minor Street Approaches

Northbound: **Ermer Road**
Number of Lanes: **1**
Total Approach Volume: **356**

Southbound: **Ermer Road**
Number of Lanes: **1**
Total Approach Volume: **347**

Warrant Summary **(Rural values apply.)**

Warrant 1 - Eight Hour Vehicular Volumes ..... **Not Satisfied**

Warrant 1A - Minimum Vehicular Volume ..... **Not Satisfied**
Required volumes reached for 0 hours, 8 are needed

Warrant 1B - Interruption of Continuous Traffic ..... **Not Satisfied**
Required volumes reached for 2 hours, 8 are needed

Warrant 1 A&B - Combination of Warrants ..... **Not Satisfied**
Required volumes reached for 0 hours, 8 are needed

Warrant 2 - Four Hour Volumes ..... **Not Satisfied**
Number of hours (1) volumes exceed minimum < minimum required (4).

Warrant 3 - Peak Hour ..... **Not Satisfied**

Warrant 3A - Peak Hour Delay .....**Not Satisfied**
Total approach volumes and delays on minor street do not exceed minimums for any hour.

Warrant 3B - Peak Hour Volumes ..... **Not Satisfied**
Volumes do not exceed minimums for any hour.

Warrant 4 - Pedestrian Volumes ..... **Not Evaluated**

Warrant 5 - School Crossing ..... **Not Evaluated**

Warrant 6 - Coordinated Signal System ..... **Satisfied**
Nearest coordinated signal (2,500) is more than 1,000 feet away.

Warrant 7 - Crash Experience ..... **Not Evaluated**

Warrant 8 - Roadway Network ..... **Not Evaluated**

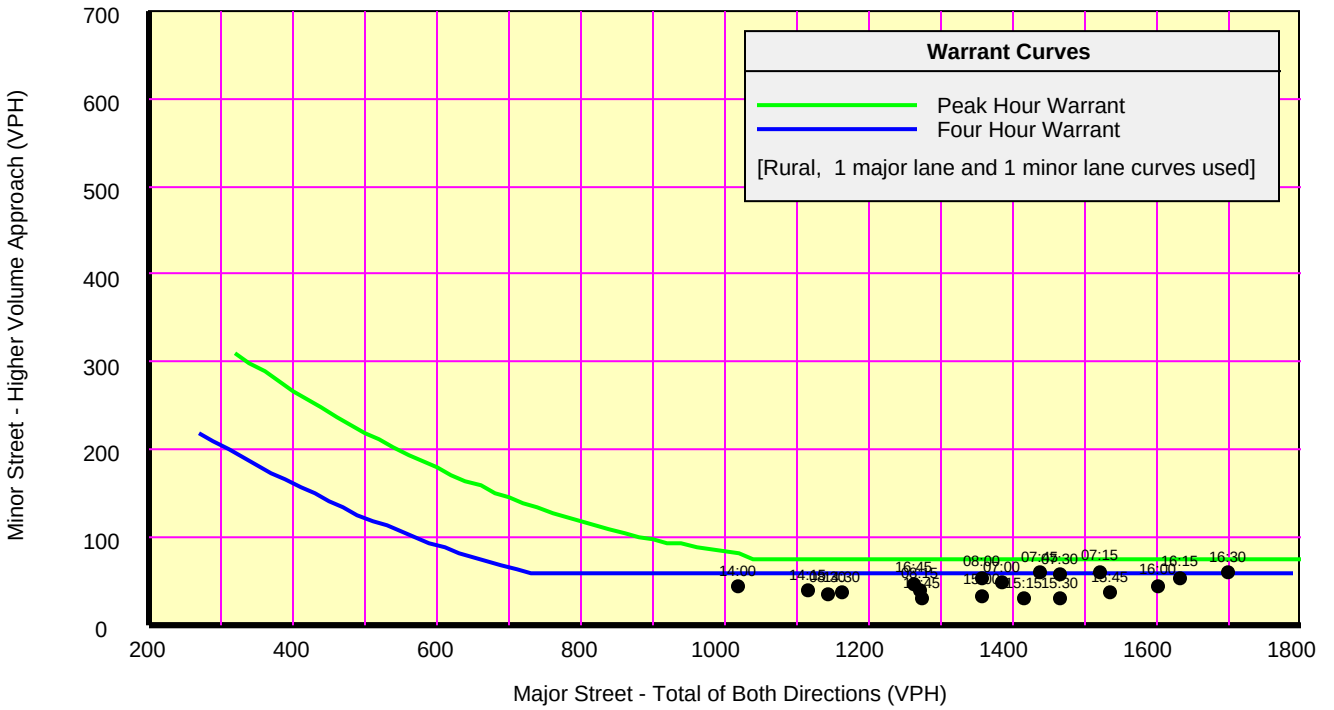
Warrant 9 - Intersection Near a Grade Crossing ..... **Not Evaluated**

NH-111 and Ermer Road

Salem, New Hampshire

Study Name: **NH111-ErmerRd**
Study Date : **10/17/17**

Signal Warrants - Summary



Analysis of 8-Hour Volume Warrants:

War 1A-Minimum Volume

Hour Begin	Major Total	Minor Vol	Minor Dir	Maj 350	Min 105
16:30	1,701	58	NB	Yes	No
16:15	1,634	53	NB	Yes	No
16:00	1,604	44	NB	Yes	No
15:45	1,536	36	NB	Yes	No
07:15	1,522	60	SB	Yes	No
07:30	1,468	56	SB	Yes	No
15:30	1,467	29	NB	Yes	No
07:45	1,438	59	SB	Yes	No
15:15	1,417	29	SB	Yes	No
07:00	1,386	47	SB	Yes	No
15:00	1,358	32	SB	Yes	No
08:00	1,357	53	SB	Yes	No
14:45	1,274	29	SB	Yes	No
08:15	1,273	39	SB	Yes	No
16:45	1,264	46	NB	Yes	No
14:30	1,163	36	NB	Yes	No
08:30	1,144	35	SB	Yes	No
14:15	1,118	38	NB	Yes	No
14:00	1,019	43	NB	Yes	No
13:30	1,014	47	NB	Yes	No
13:45	998	50	NB	Yes	No
06:45	995	35	SB	Yes	No
08:45	992	30	SB	Yes	No

War 1B-Interruption of Traffic

Hour Begin	Major Total	Minor Vol	Minor Dir	Maj 525	Min 53
16:15	1,634	53	NB	Yes	Yes
07:15	1,522	60	SB	Yes	Yes
16:00	1,604	44	NB	Yes	No
15:45	1,536	36	NB	Yes	No
15:30	1,467	29	NB	Yes	No
15:15	1,417	29	SB	Yes	No
07:00	1,386	47	SB	Yes	No
15:00	1,358	32	SB	Yes	No
14:45	1,274	29	SB	Yes	No
08:15	1,273	39	SB	Yes	No
14:30	1,163	36	NB	Yes	No
14:00	1,019	43	NB	Yes	No
13:30	1,014	47	NB	Yes	No
13:45	998	50	NB	Yes	No
06:45	995	35	SB	Yes	No
08:45	992	30	SB	Yes	No
16:45	1,264	46	NB	Yes	No
08:30	1,144	35	SB	Yes	No
14:15	1,118	38	NB	Yes	No
13:15	957	47	NB	Yes	No
12:45	929	40	NB	Yes	No
12:15	929	40	NB	Yes	No
09:00	925	35	SB	Yes	No

War 1C-Combination of Warrants

Hour Begin	Major Total	Minor Vol	Minor Dir	Maj 420	Min 84
16:30	1,701	58	NB	Yes	No
16:15	1,634	53	NB	Yes	No
16:00	1,604	44	NB	Yes	No
15:45	1,536	36	NB	Yes	No
07:15	1,522	60	SB	Yes	No
07:30	1,468	56	SB	Yes	No
15:30	1,467	29	NB	Yes	No
07:45	1,438	59	SB	Yes	No
15:15	1,417	29	SB	Yes	No
07:00	1,386	47	SB	Yes	No
15:00	1,358	32	SB	Yes	No
08:00	1,357	53	SB	Yes	No
14:45	1,274	29	SB	Yes	No
08:15	1,273	39	SB	Yes	No
16:45	1,264	46	NB	Yes	No
14:30	1,163	36	NB	Yes	No
08:30	1,144	35	SB	Yes	No
14:15	1,118	38	NB	Yes	No
14:00	1,019	43	NB	Yes	No
13:30	1,014	47	NB	Yes	No
13:45	998	50	NB	Yes	No
06:45	995	35	SB	Yes	No
08:45	992	30	SB	Yes	No

13:00	968	41	NB	Yes	No	11:45	921	48	NB	Yes	No	13:00	968	41	NB	Yes	No

Intersection	
Int Delay, s/veh	2.2

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↰	↱		↕	
Traffic Vol, veh/h	8	366	10	14	1123	1	4	4	9	9	5	46
Future Vol, veh/h	8	366	10	14	1123	1	4	4	9	9	5	46
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	200	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	12	10	0	0	4	0	0	0	22	0	0	0
Mvmt Flow	9	398	11	15	1221	1	4	4	10	10	5	50

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	1222	0	0	409	0	0	1700	1673	403	1675	1678	1221
Stage 1	-	-	-	-	-	-	421	421	-	1252	1252	-
Stage 2	-	-	-	-	-	-	1279	1252	-	423	426	-
Critical Hdwy	4.22	-	-	4.1	-	-	7.1	6.5	6.42	7.1	6.5	6.2
Critical Hdwy Stg 1	-	-	-	-	-	-	6.1	5.5	-	6.1	5.5	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.1	5.5	-	6.1	5.5	-
Follow-up Hdwy	2.308	-	-	2.2	-	-	3.5	4	3.498	3.5	4	3.3
Pot Cap-1 Maneuver	537	-	-	1161	-	-	74	97	606	77	96	221
Stage 1	-	-	-	-	-	-	614	592	-	213	246	-
Stage 2	-	-	-	-	-	-	206	246	-	613	589	-
Platoon blocked, %		-	-		-	-						
Mov Cap-1 Maneuver	537	-	-	1161	-	-	52	91	606	70	90	221
Mov Cap-2 Maneuver	-	-	-	-	-	-	52	91	-	70	90	-
Stage 1	-	-	-	-	-	-	600	579	-	208	236	-
Stage 2	-	-	-	-	-	-	149	236	-	585	576	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0.2	0.1	37.7	45
HCM LOS			E	E

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	66	606	537	-	-	1161	-	-	153
HCM Lane V/C Ratio	0.132	0.016	0.016	-	-	0.013	-	-	0.426
HCM Control Delay (s)	67.7	11	11.8	0	-	8.1	0	-	45
HCM Lane LOS	F	B	B	A	-	A	A	-	E
HCM 95th %tile Q(veh)	0.4	0	0	-	-	0	-	-	1.9

Intersection	
Int Delay, s/veh	4

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↰	↱		↕	
Traffic Vol, veh/h	53	1055	39	25	523	6	13	13	32	1	4	25
Future Vol, veh/h	53	1055	39	25	523	6	13	13	32	1	4	25
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	200	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	2	3	3	4	3	0	0	8	0	0	0	4
Mvmt Flow	58	1147	42	27	568	7	14	14	35	1	4	27

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	575	0	0	1189	0	0	1925	1912	1168	1916	1930	572
Stage 1	-	-	-	-	-	-	1283	1283	-	626	626	-
Stage 2	-	-	-	-	-	-	642	629	-	1290	1304	-
Critical Hdwy	4.12	-	-	4.14	-	-	7.1	6.58	6.2	7.1	6.5	6.24
Critical Hdwy Stg 1	-	-	-	-	-	-	6.1	5.58	-	6.1	5.5	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.1	5.58	-	6.1	5.5	-
Follow-up Hdwy	2.218	-	-	2.236	-	-	3.5	4.072	3.3	3.5	4	3.336
Pot Cap-1 Maneuver	998	-	-	580	-	-	51	66	238	52	67	516
Stage 1	-	-	-	-	-	-	205	229	-	475	480	-
Stage 2	-	-	-	-	-	-	466	466	-	203	232	-
Platoon blocked, %		-	-		-	-						
Mov Cap-1 Maneuver	998	-	-	580	-	-	37	51	238	29	52	516
Mov Cap-2 Maneuver	-	-	-	-	-	-	37	51	-	29	52	-
Stage 1	-	-	-	-	-	-	169	189	-	392	447	-
Stage 2	-	-	-	-	-	-	407	434	-	132	192	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0.4	0.5	96.3	28.1
HCM LOS			F	D

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	43	238	998	-	-	580	-	-	188
HCM Lane V/C Ratio	0.657	0.146	0.058	-	-	0.047	-	-	0.173
HCM Control Delay (s)	186.8	22.7	8.8	0	-	11.5	0	-	28.1
HCM Lane LOS	F	C	A	A	-	B	A	-	D
HCM 95th %tile Q(veh)	2.5	0.5	0.2	-	-	0.1	-	-	0.6

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	8	366	10	14	1123	1	4	4	9	9	5	46
Future Volume (veh/h)	8	366	10	14	1123	1	4	4	9	9	5	46
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1696	1732	1900	1900	1827	1900	1900	1900	1557	1900	1900	1900
Adj Flow Rate, veh/h	9	398	11	15	1221	1	4	4	10	10	5	50
Adj No. of Lanes	1	1	0	1	1	0	0	1	1	0	1	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	12	10	10	0	4	4	0	0	22	0	0	0
Cap, veh/h	107	1158	32	669	1260	1	210	193	277	74	51	263
Arrive On Green	0.69	0.69	0.69	0.69	0.69	0.69	0.21	0.21	0.21	0.21	0.21	0.21
Sat Flow, veh/h	414	1677	46	992	1825	1	718	919	1324	132	245	1257
Grp Volume(v), veh/h	9	0	409	15	0	1222	8	0	10	65	0	0
Grp Sat Flow(s),veh/h/ln	414	0	1723	992	0	1827	1637	0	1324	1634	0	0
Q Serve(g_s), s	1.9	0.0	8.7	0.6	0.0	56.3	0.0	0.0	0.5	0.0	0.0	0.0
Cycle Q Clear(g_c), s	58.2	0.0	8.7	9.2	0.0	56.3	0.3	0.0	0.5	2.9	0.0	0.0
Prop In Lane	1.00		0.03	1.00		0.00	0.50		1.00	0.15		0.77
Lane Grp Cap(c), veh/h	107	0	1190	669	0	1261	403	0	277	388	0	0
V/C Ratio(X)	0.08	0.00	0.34	0.02	0.00	0.97	0.02	0.00	0.04	0.17	0.00	0.00
Avail Cap(c_a), veh/h	109	0	1197	673	0	1269	403	0	277	388	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	40.2	0.0	5.7	7.5	0.0	13.0	28.2	0.0	28.3	29.3	0.0	0.0
Incr Delay (d2), s/veh	0.3	0.0	0.2	0.0	0.0	18.2	0.1	0.0	0.2	0.9	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.2	0.0	4.1	0.2	0.0	34.2	0.2	0.0	0.2	1.4	0.0	0.0
LnGrp Delay(d),s/veh	40.5	0.0	5.8	7.5	0.0	31.2	28.3	0.0	28.6	30.2	0.0	0.0
LnGrp LOS	D		A	A		C	C		C	C		
Approach Vol, veh/h		418			1237			18			65	
Approach Delay, s/veh		6.6			30.9			28.5			30.2	
Approach LOS		A			C			C			C	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6		8
Phs Duration (G+Y+Rc), s		23.4		66.6		23.4		66.6
Change Period (Y+Rc), s		4.5		4.5		4.5		4.5
Max Green Setting (Gmax), s		18.5		62.5		18.5		62.5
Max Q Clear Time (g_c+I1), s		2.5		60.2		4.9		58.3
Green Ext Time (p_c), s		0.3		2.0		0.3		3.4

Intersection Summary	
HCM 2010 Ctrl Delay	25.0
HCM 2010 LOS	C

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	53	1055	39	25	523	6	13	13	32	1	4	25
Future Volume (veh/h)	53	1055	39	25	523	6	13	13	32	1	4	25
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1863	1845	1900	1827	1845	1900	1900	1827	1900	1900	1838	1900
Adj Flow Rate, veh/h	58	1147	42	27	568	7	14	14	35	1	4	27
Adj No. of Lanes	1	1	0	1	1	0	0	1	1	0	1	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	3	3	4	3	3	8	8	0	0	0	0
Cap, veh/h	528	1205	44	123	1240	15	212	193	353	43	53	294
Arrive On Green	0.68	0.68	0.68	0.68	0.68	0.68	0.22	0.22	0.22	0.22	0.22	0.22
Sat Flow, veh/h	835	1768	65	460	1819	22	696	882	1615	9	240	1347
Grp Volume(v), veh/h	58	0	1189	27	0	575	28	0	35	32	0	0
Grp Sat Flow(s),veh/h/ln	835	0	1833	460	0	1841	1578	0	1615	1597	0	0
Q Serve(g_s), s	3.1	0.0	52.9	5.1	0.0	13.0	0.0	0.0	1.6	0.0	0.0	0.0
Cycle Q Clear(g_c), s	16.1	0.0	52.9	58.0	0.0	13.0	1.1	0.0	1.6	1.4	0.0	0.0
Prop In Lane	1.00		0.04	1.00		0.01	0.50		1.00	0.03		0.84
Lane Grp Cap(c), veh/h	528	0	1249	123	0	1255	405	0	353	390	0	0
V/C Ratio(X)	0.11	0.00	0.95	0.22	0.00	0.46	0.07	0.00	0.10	0.08	0.00	0.00
Avail Cap(c_a), veh/h	530	0	1253	124	0	1258	405	0	353	390	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	10.4	0.0	13.0	39.3	0.0	6.6	27.9	0.0	28.1	28.0	0.0	0.0
Incr Delay (d2), s/veh	0.1	0.0	15.3	0.9	0.0	0.3	0.3	0.0	0.6	0.4	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.7	0.0	31.4	0.7	0.0	6.6	0.6	0.0	0.7	0.7	0.0	0.0
LnGrp Delay(d),s/veh	10.5	0.0	28.3	40.2	0.0	6.9	28.2	0.0	28.7	28.5	0.0	0.0
LnGrp LOS	B		C	D		A	C		C	C		
Approach Vol, veh/h		1247			602			63			32	
Approach Delay, s/veh		27.5			8.4			28.5			28.5	
Approach LOS		C			A			C			C	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6		8
Phs Duration (G+Y+Rc), s		24.2		65.8		24.2		65.8
Change Period (Y+Rc), s		4.5		4.5		4.5		4.5
Max Green Setting (Gmax), s		19.5		61.5		19.5		61.5
Max Q Clear Time (g_c+I1), s		3.6		54.9		3.4		60.0
Green Ext Time (p_c), s		0.3		5.4		0.3		1.3

Intersection Summary	
HCM 2010 Ctrl Delay	21.6
HCM 2010 LOS	C

Intersection	
Intersection Delay, s/veh	73.2
Intersection LOS	F

Approach	EB	WB	NB	SB
Entry Lanes	1	1	1	1
Conflicting Circle Lanes	1	1	1	1
Adj Approach Flow, veh/h	418	1237	18	65
Demand Flow Rate, veh/h	459	1286	20	65
Vehicles Circulating, veh/h	30	18	458	1289
Vehicles Exiting, veh/h	1324	460	31	15
Follow-Up Headway, s	3.186	3.186	3.186	3.186
Ped Vol Crossing Leg, #/h	0	0	0	0
Ped Cap Adj	1.000	1.000	1.000	1.000
Approach Delay, s/veh	8.3	99.2	5.9	15.6
Approach LOS	A	F	A	C

Lane	Left	Left	Left	Left
Designated Moves	LTR	LTR	LTR	LTR
Assumed Moves	LTR	LTR	LTR	LTR
RT Channelized				
Lane Util	1.000	1.000	1.000	1.000
Critical Headway, s	5.193	5.193	5.193	5.193
Entry Flow, veh/h	459	1286	20	65
Cap Entry Lane, veh/h	1097	1110	715	311
Entry HV Adj Factor	0.911	0.962	0.900	1.000
Flow Entry, veh/h	418	1237	18	65
Cap Entry, veh/h	999	1068	643	311
V/C Ratio	0.419	1.159	0.028	0.209
Control Delay, s/veh	8.3	99.2	5.9	15.6
LOS	A	F	A	C
95th %tile Queue, veh	2	35	0	1

Intersection	
Intersection Delay, s/veh	71.6
Intersection LOS	F

Approach	EB	WB	NB	SB
Entry Lanes	1	1	1	1
Conflicting Circle Lanes	1	1	1	1
Adj Approach Flow, veh/h	1247	602	63	32
Demand Flow Rate, veh/h	1283	620	64	33
Vehicles Circulating, veh/h	33	88	1241	627
Vehicles Exiting, veh/h	627	1217	75	81
Follow-Up Headway, s	3.186	3.186	3.186	3.186
Ped Vol Crossing Leg, #/h	0	0	0	0
Ped Cap Adj	1.000	1.000	1.000	1.000
Approach Delay, s/veh	105.0	11.8	14.9	6.8
Approach LOS	F	B	B	A

Lane	Left	Left	Left	Left
Designated Moves	LTR	LTR	LTR	LTR
Assumed Moves	LTR	LTR	LTR	LTR
RT Channelized				
Lane Util	1.000	1.000	1.000	1.000
Critical Headway, s	5.193	5.193	5.193	5.193
Entry Flow, veh/h	1283	620	64	33
Cap Entry Lane, veh/h	1093	1035	327	604
Entry HV Adj Factor	0.972	0.971	0.983	0.970
Flow Entry, veh/h	1247	602	63	32
Cap Entry, veh/h	1062	1005	321	585
V/C Ratio	1.174	0.599	0.196	0.055
Control Delay, s/veh	105.0	11.8	14.9	6.8
LOS	F	B	B	A
95th %tile Queue, veh	36	4	1	0

Intersection	
Intersection Delay, s/veh	9.4
Intersection LOS	A

Approach	EB	WB	NB	SB
Entry Lanes	2	2	1	1
Conflicting Circle Lanes	2	2	2	2
Adj Approach Flow, veh/h	418	1237	18	65
Demand Flow Rate, veh/h	459	1286	20	65
Vehicles Circulating, veh/h	30	18	458	1289
Vehicles Exiting, veh/h	1324	460	31	15
Follow-Up Headway, s	3.186	3.186	3.186	3.186
Ped Vol Crossing Leg, #/h	0	0	0	0
Ped Cap Adj	1.000	1.000	1.000	1.000
Approach Delay, s/veh	5.6	10.8	5.1	9.9
Approach LOS	A	B	A	A

Lane	Left	Right	Left	Right	Left	Left
Designated Moves	LT	TR	LT	TR	LTR	LTR
Assumed Moves	LT	TR	LT	TR	LTR	LTR
RT Channelized						
Lane Util	0.471	0.529	0.470	0.530	1.000	1.000
Critical Headway, s	4.293	4.113	4.293	4.113	4.113	4.113
Entry Flow, veh/h	216	243	604	682	20	65
Cap Entry Lane, veh/h	1105	1106	1115	1116	820	458
Entry HV Adj Factor	0.910	0.912	0.963	0.961	0.900	1.000
Flow Entry, veh/h	197	222	581	656	18	65
Cap Entry, veh/h	1005	1009	1073	1073	738	458
V/C Ratio	0.196	0.220	0.542	0.611	0.024	0.142
Control Delay, s/veh	5.4	5.7	10.0	11.5	5.1	9.9
LOS	A	A	A	B	A	A
95th %tile Queue, veh	1	1	3	4	0	0

Intersection	
Intersection Delay, s/veh	9.4
Intersection LOS	A

Approach	EB	WB	NB	SB
Entry Lanes	2	2	1	1
Conflicting Circle Lanes	2	2	2	2
Adj Approach Flow, veh/h	1247	602	63	32
Demand Flow Rate, veh/h	1283	620	64	33
Vehicles Circulating, veh/h	33	88	1241	627
Vehicles Exiting, veh/h	627	1217	75	81
Follow-Up Headway, s	3.186	3.186	3.186	3.186
Ped Vol Crossing Leg, #/h	0	0	0	0
Ped Cap Adj	1.000	1.000	1.000	1.000
Approach Delay, s/veh	10.9	6.4	9.6	5.6
Approach LOS	B	A	A	A

Lane	Left	Right	Left	Right	Left	Left
Designated Moves	LT	TR	LT	TR	LTR	LTR
Assumed Moves	LT	TR	LT	TR	LTR	LTR
RT Channelized						
Lane Util	0.470	0.530	0.469	0.531	1.000	1.000
Critical Headway, s	4.293	4.113	4.293	4.113	4.113	4.113
Entry Flow, veh/h	603	680	291	329	64	33
Cap Entry Lane, veh/h	1102	1104	1058	1062	474	729
Entry HV Adj Factor	0.972	0.972	0.972	0.970	0.983	0.970
Flow Entry, veh/h	586	661	283	319	63	32
Cap Entry, veh/h	1071	1073	1028	1030	466	706
V/C Ratio	0.547	0.616	0.275	0.310	0.135	0.045
Control Delay, s/veh	10.1	11.7	6.2	6.6	9.6	5.6
LOS	B	B	A	A	A	A
95th %tile Queue, veh	3	4	1	1	0	0