Road Safety Audit
for the Intersection of
Cedar Road and Brainard Road
and
I-271 Interchange with Brainard Road and Cedar Road

Cities of
Lyndhurst, Pepper Pike, Mayfield Heights, and Beachwood
Ohio

February 2013

Authors
Maher Holozadah, Senior Transportation Engineer
Sahar Tawfiq, Transportation Engineer

Contributors
The Road Safety Audit Team

Prepared by
Northeast Ohio Areawide Coordinating Agency
1299 Superior Avenue
Cleveland Ohio 44114
<table>
<thead>
<tr>
<th>1) Title &amp; Subtitle</th>
<th>2) NOACA Report No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Safety Audit for the Intersection of Cedar Road and Brainard Road at the I-271 Interchange in the Cities of Lyndhurst and Pepper Pike</td>
<td>TR-13-02</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3) Author(s)</th>
<th>4) Report Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maher Holozadah, Senior Transportation Engineer; and Sahar Tawfiq, Transportation Engineer</td>
<td>February 2013</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5) Performing Organization Name &amp; Address</th>
<th>6) Project Task No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast Ohio Areawide Coordinating Agency 1299 Superior Avenue, Cleveland, OH 44114-3204 Phone: (216) 241-2414 FAX: (216) 621-3024 Website: <a href="http://www.noaca.org">www.noaca.org</a></td>
<td>6251-02</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7) NOACA Contract/Grant No.</th>
<th>8) Sponsoring Agency Name &amp; Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>ODOT/FHWA</td>
<td>Ohio Department of Transportation 1980 W. Broad St., Box 899 Columbus, OH 43216-0899</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9) Type of Report &amp; Period Covered</th>
<th>10) Sponsoring Agency Code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11) Supplementary Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal funding for this project was provided by the Federal Highway Administration and administered by the Ohio Department of Transportation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>12) Abstracts</th>
</tr>
</thead>
<tbody>
<tr>
<td>This study report is for a Road Safety Audit conducted for the intersection of Cedar Road and Brainard Road and the I-271 Interchange in the City of Lyndhurst. The purpose of the audit is to examine the existing conditions at this and adjacent freeway ramp intersections, and suggest short-term, low-cost and longer-term, higher-cost safety improvement solutions.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>13) Key Words &amp; Document Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Descriptors</strong></td>
</tr>
<tr>
<td>Road Safety Audit, Cedar Road, Brainard Road, I-271 Interchange, City of Lyndhurst, City of Pepper Pike, City of Mayfield Heights, and City or Beachwood</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Identifiers/Open Ended Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSA, Safety Study</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>14) Availability Statement</th>
<th>15) No. Pages: 62</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. On the NOACA website</td>
<td></td>
</tr>
<tr>
<td>2. In hard copy and electronic print</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>16) Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Reproduction</td>
</tr>
</tbody>
</table>
# Table of Contents

Executive Summary ................................................................. 1

Background and Location of the Intersection .......................... 11

Nearby Intersections ............................................................. 12

Team Members ................................................................. 13

Pre-Audit & Post-Audit Meetings ............................................ 13

Crash History ........................................................................ 14

The Audit ............................................................................. 36

Findings of Issues and Recommended/Suggested Remedial Measures 37

*Location 1: Cedar Road/Brainard Road*
*Location 2: Brainard Road/I-271 Northbound Exit Ramp*
*Location 3: Cedar Road/I-271 Southbound Entrance Ramp*
*Location 4: Brainard Road/I-271 Southbound Exit Ramp*

Global Recommendations ...................................................... 54

Conclusion ........................................................................... 56

**Appendices:**

Appendix A: Glossary ........................................................... 58

Appendix B: High-Crash Locations Ranking Methodology ........ 59

Appendix C: ODOT Cost-Range Categories ............................ 60

Appendix D: ODOT's Review and General Comments .......... 61

(Enclosed upon ODOT District-12’s request)
Executive Summary

The Road Safety Audit (RSA) for the intersection of Cedar Road and Brainard Road in the Cities of Lyndhurst and Pepper Pike (Figure 1) is one of several audits conducted by the Northeast Ohio Areawide Coordinating Agency (NOACA) as part of NOACA’s safety studies program for State Fiscal Years 2012 and 2013 (FY2012 and FY2013). The intersection was identified as a high-crash location based on NOACA’s 2009 Crash Report titled Accident Characteristics & Intersection Accident Analysis, and ranks number 38 on the list. It ranks number 108th on ODOT's Urban Freeway Safety Analyst List. This intersection has a particularly unusual geographic environment. It is located within the expanse of a vast, spread-out interchange with ramps straddling Cedar Road and Brainard Road (Figure 2). In addition to serving local traffic, the intersection is also used as a pass-through by regional traffic entering and exiting the I-271 Freeway in the area. Furthermore, the pattern of traffic movements is greatly influenced by many local traffic generators and a peculiar set of freeway ramp connections serving the area.

Figure 1

Location Map: Road Safety Audit (RSA) for the Intersection of Cedar Road/Brainard Road
The purpose of this RSA is to have an independent road safety audit team (RSA team) examine the particulars of this intersection and other nearby roadway intersections with the I-271 Interchange ramps to enable the RSA team to make suggestions for short-term, low-cost safety improvements, as well as possible long-term, higher-cost improvements. The various intersections were referenced as Location 1, Location 2, Location 3, and Location 4, shown in Figure 2.

Figure 2: Intersection Identification Labels

The RSA team, therefore, recommends the following low-cost, short-term; low-cost, medium-term; medium-cost, longer term, and higher-cost, long-term improvements to increase the overall level of safety at this intersection. Stakeholders and municipalities affected by the prevailing traffic conditions are encouraged to evaluate the various high-cost, long-term, major, capital improvement scenarios presented in this study report that are outside the scope of ordinary safety improvements in order to identify a preferred alternative and to establish a more comprehensive solution.

Suggested high-cost, long-term improvements presented in this study that are outside the scope of ordinary safety improvements (greater than $5,000,000 in total cost), and are not fundable with safety funds, are conceptual in nature and require further analysis and evaluation. Stakeholders and municipalities affected by the prevailing traffic conditions are encouraged to evaluate these high-cost, long-term conceptual alternatives and identify a preferred alternative that provides a comprehensive solution to improve access in addition to improving safety. Stakeholders and municipalities may wish to consider establishing a special improvement district to fund studies to evaluate improvement alternatives, and ultimately, perhaps, fund or contribute toward funding the design and construction of a preferred alternative.
The main recommendations, described separately for each location, are:

**Location 1: Cedar Road/Brainard Road**

- Conduct a traffic signal progression study to coordinate the timing and phasing of the traffic control signals along Brainard Road to facilitate better traffic flow and reduce delay
- Perform capacity analysis to:
  - Provide a shorter cycle length
  - Examine introducing a phasing sequence that includes a phase for an exclusive, protected left-turn movement from the Brainard Road northbound approach to eliminate potential conflicts of traffic movements
  - Examine introducing a leading and lagging protected left-turn phase on the Brainard Road southbound approach to provide for serving this heavy left-turn traffic movement twice during the phase in the A.M peak period
  - Examine and consider converting the exclusive through-lane on the Brainard Road southbound approach to a through- and right-turn lane (Diagram 1-1)
- Provide more pronounced dashed lane-extension lines through the intersection to help traffic avoid encroaching upon adjacent turn lanes, and to help drivers stay more closely in their travel paths
- Examine the width of the Cedar Road receiving lanes on the east side of Brainard Road and widen, if necessary, to ensure availability of adequate curvature for the installation of lane-extension lines (Diagram 1-1) to enable a smoother transition for the left-turn traffic movements, and to encourage the use of the outermost left-turn lane on the southbound approach of Brainard Road which currently appears to be underutilized
• Examine whether the present heavier use of the innermost left-turn lane of the Brainard Road southbound approach at Cedar Road compared with the lighter use of the outermost left-turn lane is due to a real or perceived narrowness of the roadway, the narrowing of Cedar Road to one lane after a short distance from the end of the initial two receiving lanes, or due to a need to stay in the innermost left-turn lane in order to turn left again into driveways of businesses or establishments located on the northern side of Cedar Road
• Improve the pavement sub-grade and surface conditions on all approaches of the intersection as well as within it to improve friction and to provide a better surface conducive to receiving lane-marking paint for a longer lasting, more durable lane demarcation
• Improve pavement markings where needed
• Set back the stop bar for the exclusive left-turn lane on the Cedar Road westbound approach.
• Delete the present pedestrian crosswalk across Cedar Road located on the west side of the intersection (west of Brainard Road) and emphasize the one on the east side of the intersection (east of Brainard Road). The heavy right-turn traffic movements inhibit pedestrians from attempting to cross the road at this location, even during the recall pedestrian crossing phase. Ensure there will be pedestrian crossings on the remaining 3 of the 4 approaches. Provide a pedestrian crosswalk across Brainard Road, on the south side of Cedar Road. Provide needed sidewalks and pedestrian ramps
• Consider combining elements from the I-271–Cedar/Brainard Access-Point Modification Study with recommendations and suggested safety improvements presented in this RSA report to develop a more comprehensive and common approach toward addressing the issues identified in the two study reports
• Consider adding an exit ramp from the I-271 northbound mainline connected directly to Cedar Road eastbound to: (a) Prevent backups presently reoccurring on the freeway mainline near the gore area of the Cedar Road/Brainard Road exit ramp; and (b) Alleviate the impact of the present pattern of heavy traffic volumes, particularly during the morning peak period, on the capacities and safe operation of the intersections of Brainard Road with the I-271 northbound exit and entrance ramps, and Brainard Road with Cedar Road
**Location 2: Brainard Road and I-271 northbound Exit Ramp-northbound Entrance Ramp**

- Remove all obstructions to the line of site, especially a part of the fence protecting against vandalism on the Brainard Road Bridge parapet over I-271, and nearby shrubberies that block the line of vision of vehicle drivers stopped at the traffic control signal for the I-271 northbound exit ramp and looking to their left to check for oncoming southbound traffic on Brainard Road.
- Set back the stop bar for the exclusive left-turn bay on Brainard Road southbound approach.
- Improve pavement conditions, especially any crumbling or rutted pavements, to provide for better traction, smoother ride, and a pavement condition conducive to proper and longer lasting marking.
- Consider providing dual right-turn bays on the I-271 northbound exit ramp at Brainard Road to increase the storage capacity and increase the volume of traffic flow through the intersection during the green interval, to lessen traffic backups that often reach the freeway mainline.
- Consider building a marginal road from Brainard Road to Lander Road commencing at the opposite side of the I-271 northbound exit ramp, aligned with the exit ramp through-lane and relatively alongside the I-271 northbound entrance ramp, to help take traffic directly to Landerbrook Drive and Lander Haven Drive. This marginal Road will carry or service traffic bound for Landerbrook Drive and Lander Haven Drive and will alleviate the traffic demand on the Cedar Road/Brainard Road intersection caused by the zigzag traffic movement pattern created by traffic exiting I-271 at the northbound exit ramp to Brainard Road, which then turns right to proceed to Cedar Road to turn left to reach Lander Road and Landerbrook Drive and Lander Haven Drive (Diagrams 2-2 and 2-3).
- Consider adding a northbound I-271 exit ramp connected directly to eastbound Cedar Road to prevent backups presently reoccurring on the I-271 freeway mainline near the mouth of the northbound Brainard Road/Cedar Road exit ramp, and to alleviate the impact of heavy traffic volumes, particularly during the morning peak period, on the intersections of the Brainard Road/I-271 northbound exit ramp, and Brainard Road/Cedar Road.
- Restripe the stop line for the southbound approach and make it perpendicular to the curb of the roadway instead of the present slanted stop line.
- Add overhead lane use signs on the Brainard Road Bridge over I-271. The present sign is erected on the bridge parapet and cannot be seen by traffic coming from the I-271 southbound exit ramp.
- Remove the pedestrian crosswalk across Brainard Road. It is very unlikely pedestrians will cross to or from the southern side of the Brainard Road Bridge. That side of the Bridge is not connected with or serviced by any sidewalks. Maintain the pedestrian crosswalk across the I-271 northbound entrance ramp, as pedestrians will more likely use it because the sidewalk on the northern side of the bridge is connected to sidewalks along Brainard Road.
- Reexamine the presently closed outer through-lane on northbound Brainard Road. This through-lane may be reinstated if a tapered northbound receiving lane is built on Brainard Road north of the I-271 southbound exit ramp. The tapered through lane may also serve traffic that exits at the I-271 southbound exit ramp and turns right to go north from an exclusive right-turn bay recommended for the exit ramp (see recommendations for Location 4).
- Make the southbound left-turn movement a ‘lag’ not ‘lead’ movement.
Location 3: Cedar Road/I-271 Southbound Entrance Ramp

- Improve the curb and curvature near the Bridge. Move the curb back and increase its curvature to permit vehicles in the inner left-turn bay on the Cedar Road westbound approach to transition more easily to the I-271 southbound entrance ramps without encroaching on the adjacent left-turn lane extension line in order to minimize the potential for sideswipe passing crashes
- Emphasize or highlight the island and extension line markings
- Revisit ‘Alternative 10’ that was presented in the ‘I-271 Access Point Modification Study’ prepared for ODOT and completed in 2002, and shown here as Exhibit A, which provides for, retains, or reinstates a free-flow entrance ramp to I-271 southbound at the Cedar Road eastbound approach
- Consider combining or integrating elements from the various alternatives presented in the I-271--Cedar/Brainard Access-Point Modification Study, particularly Alternative 10 (Exhibit A), with the overall suggested safety improvements and recommendations presented in this RSA report to provide long term solutions for the issues identified in the two study reports
- Install additional overhead lane assignment signs on the Cedar Road Bridge over I-271 similar to but in advance of those that exist near the westbound approach at the I-271 southbound entrance ramp
- Consider adding an entrance ramp from Brainard Road to I-271 southbound (Diagram E-1) if the minimum required spacing between consecutive ramps can be achieved, and provided that there will not be any or a significant increase in traffic flow to the freeway that might degrade its operation
Exhibit-A: Alternative #10 presented in the 'I-271--Cedar/Brainard Access Point Modification Study' prepared by Burgess & Niple in 2002 for ODOT District-12 under PID #21029.
Diagram E-1: Suggested entrance ramp to I-271 southbound from Brainard Road
Location 4: Brainard Road/I-271 Southbound Exit Ramp

- Place overhead lane assignment signs on the bridge as the sign erected on the bridge parapet is not visible to traffic exiting at the I-271 southbound exit ramp and turning left to go south on Brainard.
- Re-examine the need for the “no-turn-on-red” sign posted opposite the exit ramp, and based on the results of the examination consider removing the ‘no-turn-on-red’ signage.
- Consider adding an exclusive right-turn bay on the exit ramp and convert the present through- and left-turn lane to an exclusive left-turn lane to make it a second left-turn lane for a dual left-turn configuration.
- Build a long taper, through-lane on Brainard Road in the northbound direction to receive traffic from the outer through lane on the bridge after opening it to traffic as it is currently closed by hatching.
- Place destination signs on the exit ramp to help drivers occupy the respective lane for the respective destination.
- Consider adding an entrance ramp to I-271 southbound commencing at the Brainard Road/I-271 southbound exit ramp, as shown in Appended Exhibit-A and Diagram E-1.
- Reexamine the viability and feasibility of adding a marginal road, running parallel to I-271, between the intersection of Brainard Road/I-271 southbound exit ramp and the intersection of Cedar Road/I-271 southbound entrance ramp, with a ‘slip’ entrance ramp from it to I-271 southbound. Perform capacity analysis for the resulting four-approach intersection of the marginal road with Cedar Road and I-271 southbound entrance ramp as part of the reexamination to determine whether such marginal road would be viable and feasible. Appended Exhibit-A shows the subject marginal road tentatively crossed-out to signify the need to address the presence of physical impediments, and the cost of any potential acquisition of right-of-way. The marginal road suggested may provide access to I-271 southbound via a slip entrance ramp from it to I-271 southbound and a direct access to Cedar Road westbound at or near its intersection with the I-271 southbound entrance ramp as shown in schematic Diagram 3-1.
Appended Exhibit-A: Alternative #10 presented in the 'I-271--Cedar/Brainard Access Point Modification Study' prepared by Burgess & Niple in 2002 for ODOT District-12 under PID #21029

Suggested 'on-ramp' from Brainard Road to I-271 southbound (Diagram E-1)
Background and Location of the Intersection

The intersection of Cedar Road and Brainard Road is located within the political boundaries of the City of Lyndhurst and the City of Pepper Pike, Figure 1. The I-271 Interchange, however, is located within the corporation lines of the cities of Lyndhurst and Beachwood and is in the proximity of the City of Pepper pike. Based on NOACA’s 2009 Crash Report, the intersection ranked 38th among the top 100 high crash locations in the NOACA region. The ranking is based on a composite index derived from crash data obtained from the Ohio Department of Public Safety through ODOT’s GIS Crash Analysis Tool (GCAT). The methodology NOACA uses to rank high crash intersections is described in Appendix B.

Figure 1
Nearby Intersections

Since the operation and function of the intersection of Brainard Road and Cedar Road, the primary intersection that is the subject of this RSA, is inevitably affected by the presence and operation of the I-271 Interchange with Brainard Road and Cedar Road, it became incumbent upon the RSA team to include in the RSA analysis all nearby intersections that have a major influence on the intersection of Brainard Road and Cedar Road. The nearby intersections are those roadways that intersect with the entrance and exit ramps of the I-271 Interchange. They are identified and labeled as shown in Figure 2 below.

Figure 2: Intersection Identification Labels
Team Members

The team members for this audit include personnel from NOACA, the Ohio Department of Transportation (ODOT) District-12 office, the Cities of Lyndhurst, Pepper Pike, Mayfield Heights, and Beachwood. The members, their titles, and their affiliations are shown in the table below.

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeff Filarski, P.E.</td>
<td>City Engineer</td>
<td>City of Lyndhurst</td>
</tr>
<tr>
<td>Rick Glady</td>
<td>Service Director</td>
<td>City of Lyndhurst</td>
</tr>
<tr>
<td>David Stasshofer</td>
<td>Traffic Commissioner</td>
<td>City of Lyndhurst</td>
</tr>
<tr>
<td>Joe Cicero</td>
<td>Mayor</td>
<td>City of Lyndhurst</td>
</tr>
<tr>
<td>Don Sheehy, P.E.</td>
<td>City Engineer</td>
<td>City of Pepper Pike</td>
</tr>
<tr>
<td>Dave McCallous, P.E.</td>
<td>City Engineer</td>
<td>City of Mayfield Heights</td>
</tr>
<tr>
<td>Rob Brininger</td>
<td>Traffic Officer</td>
<td>City of Beachwood</td>
</tr>
<tr>
<td>Brian Blayney, P.E.</td>
<td>Traffic Planning Engineer</td>
<td>ODOT, District-12</td>
</tr>
<tr>
<td>Lou Hazapis</td>
<td>District Design Engineer</td>
<td>ODOT, District-12</td>
</tr>
<tr>
<td>Michael Kubek</td>
<td>District Planning Engineer</td>
<td>ODOT, District-12</td>
</tr>
<tr>
<td>Travis Bonnett</td>
<td>Traffic Engineer</td>
<td>ODOT, District-12</td>
</tr>
<tr>
<td>Mahmoud Al-Lozi</td>
<td>Principal Planning Engineer</td>
<td>NOACA</td>
</tr>
<tr>
<td>Mona Aziz</td>
<td>Senior Transportation Engineer</td>
<td>NOACA</td>
</tr>
<tr>
<td>Maher Holozadah</td>
<td>Senior Transportation Engineer</td>
<td>NOACA</td>
</tr>
<tr>
<td>Sahar Tawfiq</td>
<td>Transportation Engineer</td>
<td>NOACA</td>
</tr>
</tbody>
</table>

Pre-Audit and Post-Audit Meetings

Pre-audit and post-audit meetings among the team members were held on May 30 and May 31, 2012 in the City of Lyndhurst. The team shared their experiences and knowledge about the intersection of Brainard Road/Cedar Road and other intersections in the vicinity of the I-271 Interchange ramps that are affected by it, as shown in Figure 2 above. Lead members in the audit team presented information to the team about crash data, graphs, and collision diagrams. A description of the crash information presented at the pre-audit meeting is shown in the next section titled “Crash History”. The field audit for the intersections was conducted in the interim between the two audit meetings and presented in detail in the following section titled “The Audit”. The field work was conducted for mid-day, evening peak periods, and after-dark hours. The after-dark field review was made to observe traffic movements and conditions during night time to determine whether the present lighting conditions appear adequate, and whether there were any visibility issues that might be contributing factors in the occurrence of crashes. The team returned to the site on the following day to make observations regarding the operation of the intersection during the morning peak period to compare traffic patterns in the morning peak period with patterns during other peak periods. The team convened a post audit meeting to share and discuss its observations and findings and to prepare for writing a draft report.
Crash History

A review of the most recent three-year crash history at and within the area of the I-271/Brainard Road/Cedar Road Interchange, which encompasses four intersections, was conducted to establish a profile for the types and patterns of crashes in this area of the I-271 Interchange. Crash records for years 2009, 2010, and 2011 were obtained from the Ohio Department of Transportation and studied to determine, among other things, the types, proximate locations, and severity of crashes. Records show there were a total of 279 crashes at and near the four intersections in the three-year period. Location 1 has 86 crashes, location 2 has 101, location 3 has 48, and location 4 has 44. The graphs presented below for each location show the various types of crashes, crash severity, crashes by month of year, day of week, and time of day of their occurrence. Graphs also show pavement conditions at the time of crash occurrence. Presented also are collision diagrams that show crash types and their approximate location with crash record reference numbers.

Rear-end, sideswipe-passing, and angle collisions were the predominant types of crashes in this area of the interchange. The occurrence of a significant number of sideswipe-passing collisions supports the notion that interference in the stream of traffic or encroachment upon the paths of travel of other vehicles causes these collisions, as sideswipe-passing collisions often occur when drivers attempt to either avoid such interferences, encroach upon adjacent lanes, or change lanes when they are in a path of travel they did not intend to be in.

LOCATION 1: Cedar Road/Brainard Road
There were 86 crashes at the Cedar Road/Brainard Road intersection (Location 1). The majority of them were rear end collisions. Charts one through nine show a profile of the crash history.

![Chart 1-1: Frequency of Crashes by Type of Crash](image)

Chart 1-1 shows the various types and number of crashes at this intersection. There were 86 crashes at this location.
Chart 1-2 shows the distribution of crashes by hour of day. The frequency of crashes shows an increase during the mid-day period between about noon to about 6 pm. Freewaybound traffic movements through this intersection are heavy during the evening commute.

Chart 1-3 shows the distribution of crashes by day of the week.

Chart 1-4 shows an increase in crashes during the month of December due to the shopping season. Beachwood Mall, Legacy Village, and other attractions in the area generate heavier traffic volumes and congestion.
Chart 1-5 shows fluctuation of crash frequency in the three-year period.

Chart 1-6 shows the distribution of crashes by severity over the three-year period. Injury crashes were about 30 percent in year 2011 compared with about 20 percent in 2009 and about 8 percent in 2010.

Chart 1-7 shows the percent of injury crashes to be approximately 21 percent. No fatal crashes in the three-year period studied were reported at this intersection.
Chart 1-8 shows that 35 percent of the crashes occurred on adverse pavement conditions. Bad road surfaces exacerbate the potential occurrence of crashes.

Chart 1-9 shows that during the analysis period 16 percent of the crashes occurred during dark-lighted conditions. Eight one percent occurred during daylight conditions.
Environmental conditions such as light conditions and road surface conditions are important elements in the occurrence of crashes. An examination of lighting conditions during non-daylight hours was made in order to ascertain whether adequate lighting conditions exist. It was determined that lighting conditions were adequate as street lights provide adequate illumination.

A collision diagram for Location 1 shows the types, severity and approximate locations of the reported crashes. The diagram shows that most of the crashes at this location are sideswipe-passing, rear end, and left-turn angle collisions. They occurred mostly within the intersection and at the intersection approaches.
Collision Diagram for Location 1 (The intersection of Cedar Road/Brainard Road)
LOCATION 2: Brainard Road/I-271 Northbound Exit Ramp-Northbound Entrance Ramp
There were 102 crashes at the Brainard Road/I-271 northbound exit ramp intersection (Location 2). The majority of these crashes, as in location 1, were rear-end collisions. Charts one through nine show a profile of the crash history. A collision diagram, shown below, was constructed to show the types of crashes, their approximate locations, and the crash records reference numbers.

Chart 2-1 below shows the various types and number of crashes at this intersection. There were 101 crashes at this location in the three-year period studied.

Chart 2-2 shows the distribution of crashes throughout the day.
Chart 2-3 shows the distribution of crashes by day of the week.

Chart 2-4 shows a remarkably typical or usual pattern of increase in crashes during the month of December due to the shopping season that generates heavier traffic volumes and congestion.
Chart 2-5 shows no significant variation in crash frequency in the three-year period.

Chart 2-6 shows the distribution of the severity of crashes over the three-year period. The percentage of injury crashes remained relatively constant.
Chart 2-7 shows the percent of injury crashes and property damage crashes. No fatal crashes in the three-year period studied were reported at this intersection. The percentage of injury crashes is notably high.

Chart 2-8 shows that 47 percent of the crashes occurred on adverse pavement conditions. Bad road surfaces exacerbate the potential occurrence of crashes.
Chart 2-9 shows that during the analysis period 26 percent of the crashes occurred during dark-lighted conditions. Environmental conditions such as light conditions and road surface conditions are important elements in the occurrence of crashes. An examination of lighting conditions during non-daylight hours was made in order to ascertain whether adequate lighting conditions exist. It was determined that lighting conditions were adequate as street lights provide adequate illumination.
Collision Diagram for Location 2 (The Intersection of Brainard Road with I-271 Northbound Exit and Entrance Ramps)
LOCATION 3: Cedar Road/I-271 Southbound Entrance Ramp
There were 48 crashes at the Cedar Road/I-271 southbound entrance ramp intersection (Location 3). The majority of the crashes, as in locations 1 and 2, were rear-end collisions. Charts one through nine show a profile of the crash history. A collision diagram, shown below, was constructed to show the types of crashes, their approximate locations, and the crash records reference numbers.

Chart 3-1: Frequency of Crashes by Type of Crash

Chart 3-2: Frequency of Crashes by Hour

Chart 3-1 shows the various types and number of crashes at this intersection. There were 48 crashes at this location in the three-year period examined.

Chart 3-2 shows the distribution of crashes throughout the day.
Chart 3-3 shows the distribution of crashes by day of the week.

Chart 3-4 shows a noticeable, typical or usual pattern of increase in crashes during the month of December due to the shopping season which generates heavier traffic volumes and congestion.

Chart 3-5 shows no significant variation in crash frequency in the three-year period.
Chart 3-6 shows the distribution of crashes over the three-year period. The percentage of injury crashes did not show a significant change throughout the three-year period.

Chart 3-7 shows the percent of injury crashes and property damage crashes. No fatal crashes in the three-year period studied were reported at this intersection.
Chart 3-8 shows that 35 percent of the crashes occurred on adverse pavement conditions. Bad road surfaces exacerbate the potential occurrence of crashes.

Chart 3-9 shows that during the analysis period 17 percent of the crashes occurred during dark-lighted conditions. Environmental conditions such as light conditions and road surface conditions are important elements in the occurrence of crashes. An examination of lighting conditions during non-daylight hours was made in order to ascertain whether adequate lighting conditions exist. It was determined that lighting conditions were adequate as street lights provide adequate illumination.
LOCATION 4: Brainard Road/I-271 Southbound Exit Ramp

There were 44 crashes at the Brainard Road/I-271 southbound exit ramp intersection (Location 4). The majority of the crashes, as in locations 1, 2, and 3, were rear end collisions. Charts one through nine show a profile of the crash history.

Chart 4-1 below shows the various types and number of crashes at this intersection. There were 44 crashes at this location in the three-year period examined.

Chart 4-2 shows the distribution of crashes throughout the day.
Chart 4-3 shows the distribution of crashes by day of the week.

Chart 4-4 shows the frequency of crashes by month in the three-year period analyzed.
Chart 4-5 shows a significant, inexplicable increase in crash frequency in the third year (2011) of the three-year period.

Chart 4-6 shows the distribution of crashes over the three-year period. The percentage of injury crashes did not show a significant change throughout the three-year period.

Chart 4-7 shows the percent of injury crashes and property damage crashes. No fatal crashes in the three-year period studied were reported at this intersection.
Chart 4-8 shows that 36 percent of the crashes occurred on adverse pavement conditions. Bad road surfaces exacerbate the potential occurrence of crashes.

Chart 4-9 shows that during the analysis period 23 percent of the crashes occurred during dark-lighted conditions. Environmental conditions such as light conditions and road surface conditions are important elements in the occurrence of crashes. An examination of lighting conditions during non-daylight hours was made in order to ascertain whether adequate lighting conditions exist. It was determined that lighting conditions were adequate as existing street lights to provide adequate illumination.
Collision Diagram for Location 4 (The Intersection of Brainard Road with the I-271 Southbound Exit Ramp)

Brainard Road at I-271 Southbound Exit Ramp
2009-2011 Crash Data

Legend:
- **Symbols**
  - Others
  - Backing Vehicle
  - Frontal
  - Parked Vehicle
  - Fixed Object

- **Types of Collisions**
  - 360° Turn
  - Head On
  - Hit the Guardrail
  - Sliding/Drifting
  - Angle

Diagram Label Key:
Crash Reference Number

[Diagram of the intersection with numbers and symbols indicating crash data]
The Audit

The Road Safety Audit (RSA) for this intersection was conducted on May 30 and May 31, 2012. It is part of the Northeast Ohio Areawide Coordinating Agency’s (NOACA’s) safety studies program for FY 2012.

A Road Safety Audit (RSA) is a formal examination by an independent audit team of the performance of an existing or future road or intersection with respect to safety. The RSA team usually considers the safety of all road users, qualitatively estimates and reports on road safety issues, and makes suggestions and recommendations regarding safety improvements. The steps for a road safety audit¹ are:

1. Identify the project or the road-in-service to be audited.
2. Select the RSA team.
3. Conduct pre-audit and post-audit meetings.
4. Perform field observations under various conditions.
5. Conduct an audit analysis.
6. Present the audit findings to the project owner/design team.
7. Project owner/design team prepares a formal response.
8. Incorporate findings within the project when appropriate.

The above-stated steps were followed in conducting this road safety audit.

¹ FHWA Road Safety Audit Guidelines, FHWA-SA-06-06
Finding of Issues and Recommended/Suggested Remedial Measures

The audit team made observations regarding many elements of the intersections. The safety issues identified are listed under the following categories: traffic control signals, geometry and alignment, pavement condition, pavement marking, and pedestrian movement.

Location 1 (Intersection of Brainard Road and Cedar Road):

The intersection is a four-approach intersection serving high volumes of traffic, particularly regional traffic to and from I-271 Freeway. The outlying area near and around the subject intersection is host to many commercial sites and office parks. Year 2012 average daily traffic on Brainard Road north of the intersection is about 31,700 vehicles per day (VPD) and south of the intersection is about 7,130 VPD. Year 2012 average daily traffic on Cedar Road is about 23,000 vehicles per day (VPD) east of Brainard Road and about 30,000 VPD west of Brainard Road. Brainard Road is classified as a minor urban arterial and Cedar Road is classified as a principal urban arterial west of Brainard Road and a collector east of Brainard Road.

The characteristics of and issues at this intersection are:

- The traffic signal is controlled and maintained by the City of Lyndhurst
- A long cycle length during peak periods, measured in the field, was approximately 175 seconds
- The Brainard Road southbound approach at Cedar Road caters to two different platoons. One platoon comes from the northbound I-271 Exit Ramp and the other platoon comes from the Brainard Road southbound approach (combined traffic from Brainard Road and exiting traffic from the southbound I-271 exit ramp). Some of the green time at this intersection is not used efficiently due to the difference in demand by the two platoons
- The southbound outer left-turn lane is underused due to the merging that takes place on Cedar eastbound.
- The intersection with all of its four approaches is flat (has no vertical curves), and does not create any vertical visibility problems
- While all traffic movements are heavy, traffic movements on southbound Brainard Road are heaviest.
- There were 90 crashes at this intersection in the three-year period but no fatal crashes. Over 50 percent of the crashes were rear end collisions
- The heavy traffic movement from I-271 northbound to Cedar Road westbound is not controlled by a traffic control signal
Brainard Road, southbound approach, looking north

Brainard Road southbound approach looking north

Cedar Road, eastbound approach looking east

Cedar Road, eastbound approach looking west

Cedar Road, westbound approach, looking west

Brainard Road, northbound approach, looking south
Existing pavement condition, view 1

Existing pavement condition, view 2

Existing pavement condition, view 3

Existing pavement condition, view 4

Existing pavement condition, view 5

Existing pavement condition, view 6
Recommended/suggested remedial measures

Traffic Control Signal Operation:
- Conduct a traffic signal progression study to examine the timing and phasing of the traffic control signals along Brainard Road in order to provide coordination to facilitate better traffic flow and reduce delay
- Perform capacity analysis to:
  - Provide a shorter cycle length
  - Introduce a phasing sequence that includes a phase for an exclusive, protected left-turn movement from the Brainard Road northbound approach to eliminate potential conflicts of traffic movements
  - Study the possibility of using a leading and lagging protected left-turn phase for the Brainard Road southbound approach to serve traffic movement heading eastbound
  - Convert the through lane at the southbound approach to a through- and right-turn lane (Diagram 1-1)
- Provide a signal head for each lane
- Retrofit signal heads with back-plates

Road User Signs:
- Remove the prohibition sign “do not cross here” at the southeast corner of the intersection

Pavement Markings:
- Set back the stop line for the westbound approach left-turn bay
- Remove the pedestrian crosswalk for Cedar Road from the west side of the intersection as heavy right-turn traffic movements prevent pedestrians from attempting to cross the road even during the recall pedestrian crossing phase
- Consider converting the southbound through-lane on the Brainard Road southbound approach at Cedar Road from an exclusive through-lane to a shared through- and right-turn lane as shown in Diagram 1-1
- Provide lane extension pavement markings through the intersection for all left-turn traffic movements, as shown in Diagram 1-1
- Examine the width of the roadway and receiving lanes of Cedar Road on the east side of Brainard Road and widen if necessary to ensure or provide adequate curvature for lane extension lines to enable a smoother transition for the left-turn traffic movements, and to encourage more use of the outer left-turn lane on the southbound approach of Brainard Road
Pavement Condition:
- Improve the condition of the pavement to provide for better traction and a surface conducive to receiving pavement markings paint for longer durability and visibility

Alternative Points of Access/ Modification of Travel Path:
- Consider providing a northbound I-271 exit ramp connected directly to eastbound Cedar Road to prevent queuing on the I-271 northbound mainline, and to alleviate the impact of the existing heavy traffic volumes on the intersections of Brainard Road with I-271 northbound exit ramp and Brainard Road with Cedar Road due to the present pattern of traffic movements, particularly during the morning peak period. The present traffic pattern consists of heavy traffic volumes exiting I-271 northbound at Brainard Road, turning right onto Brainard Road southbound, and then turning left onto Cedar Road eastbound utilizing two left-turn lanes
Location 2 (Intersection of Brainard Road and I-271 northbound Exit Ramp-northbound Entrance Ramp):

The main characteristics of and issues at this intersection are:

- There is a high number of angle crashes at the exit ramp approach with Brainard Road
- There are a high number of sideswipe passing crashes at the Brainard Road northbound approach, involving vehicles turning right onto the I-271 northbound entrance ramp
- The interval for the protected left-turn movement at the southbound approach of the Brainard Road/Cedar Road intersection provides needed time to allow for the execution of the left-turn movement at the southbound approach of this intersection
- The distance between the stop line at the Brainard Road southbound approach near the I-271 northbound exit ramp and the signal heads located beyond the mouth of the exit ramp is too long. The signal heads appear to be too far for a more reasonable driver perception and reaction time
- The bridge parapet and fence obstruct the line of sight on the northbound I-271 exit ramp to Brainard Road.
- Queue overflows to the I-271 mainline
- The shoulder of I-271 in the northbound direction is being used by vehicles to slip through by passing the queue to exit to westbound Cedar Road
I-271 northbound/Brainard Road exit ramp junction with the freeway mainline showing traffic backup during the morning peak period

Brainard Road Bridge over I-271, looking south

Brainard Road Bridge over I-271, looking south

Brainard Road Bridge over I-271, looking north
Recommended/suggested remedial measures

**Traffic Control Signal Operation and Location:**
- Perform capacity analysis to optimize the traffic control signal timing and consider the following:
  - Providing for dual left-turn and right-turn movements on the approach of I-271 northbound exit ramp at Brainard Road to increase the storage capacity and to minimize or eliminate reoccurring traffic backups that often reach the freeway mainline, particularly in the morning peak period
  - Changing the leading protected southbound left-turn phase to lagging or to permissive left-turn.
  - Providing an exclusive right-turn bay at the northbound approach of Brainard Road/I-271 northbound exit and entrance ramps (Diagram 2-1)

![Existing Configuration Schematic Diagram of Suggested Configuration](Image)

**Diagram 2-1:** Schematic Diagram of Suggested Lane Configuration

- Install a supplementary post-mounted set of traffic control signal heads on Brainard Road located nearer the southbound approach at the mouth of the I-271 northbound exit ramp
Line of Sight:
- Remove all obstructions to the line of sight, especially a part of the vandal prevention chain-link fence on the bridge parapet, and all nearby shrubberies that block the line of vision of vehicle drivers stopped at the traffic control signal for the I-271 northbound exit ramp. Drivers’ attempt to look to their left to check for oncoming southbound traffic on Brainard Road is hampered by the presence of such obstructions.

Pavement Markings:
- Restripe the stop line for the southbound approach and make it perpendicular to the roadway instead of the present slanted stop line.
- Set back the stop bar for the exclusive left-turn bay on the Brainard Road southbound approach.
- Provide lane line extensions through the intersection when dual left- or right-turns are introduced.

Pavement Condition:
- Improve pavement conditions, especially any crumbling or rutted pavements, to provide for better traction, smoother ride, and a pavement condition conducive to proper and longer lasting marking.

Alternative Points of Access/Travel Path Modification:
- Conduct capacity analyses and feasibility studies to consider building either a one-way or two-way marginal road from Brainard Road to Lander Road commencing at the opposite side of the I-271 northbound exit ramp, aligned with its middle through-lane, and relatively near the I-271 northbound entrance ramp, to help take traffic directly to Lander Road, Lander Brook Drive, and Lander Haven Drive. This marginal road will carry or service traffic bound for Lander Brook Drive and Lander Haven Drive to alleviate the traffic demand on the Cedar Road/Brainard Road intersection caused by the zigzag traffic movement pattern created by traffic exiting I-271 at the northbound exit ramp to Brainard Road which then turns right to proceed to Cedar Road to turn left to reach Lander Road, Landerbrook Drive, and Lander Haven Drive (Diagram 2-2). Depending, ultimately, on an estimate of traffic generation and distribution, and the results of a capacity analysis study for both the intersection and the marginal road, the needed number of lanes and lane configuration will be determined. A possible lane configuration and a recovery slip ramp may, for example, be like that shown in schematic Diagram 2-3 for a one-way marginal road or Diagram 2-4 for a two-way marginal road. The purpose of a ‘recovery’ slip ramp from the marginal road to the I-271 northbound entrance ramp is to provide an opportunity for recovery for vehicles that may unintentionally turn onto the marginal road but intend to go to I-271 northbound instead. The location of the slip ramp may be adjusted and could be moved up or farther down on the marginal road if such slip ramp is deemed helpful and feasible. Layout and right-of-way acquisition may be determined via preliminary design.
- Consider providing a northbound I-271 exit ramp connected directly to eastbound Cedar Road, provided that the minimum distance required between successive ramps can be achieved, to alleviate the impact of existing traffic volumes due to the present pattern of traffic movements. The present pattern of traffic movements consists of a significant volume of traffic exiting I-271 northbound at Brainard Road, turning right onto Brainard Road southbound, and then turning left onto Cedar Road eastbound utilizing two exclusive left-turn lanes. The diversion of traffic via the suggested exit ramp will reduce the demands on the intersection of Brainard Road with the I-271 northbound exit and entrance ramps, and the intersection of Brainard Road with Cedar Road.
Diagram 2-2: Suggested marginal road along I-271 between Brainard Road and Lander Road

Diagram 2-3: Possible configuration of the Intersection of Brainard Road with the I-271 Exit and Entrance ramps and a proposed one-way marginal road

Number of lanes on this link and on the marginal road to be determined via a capacity analysis study and preliminary design.
- Improve the pavement condition on Brainard Road
- Improve pavement markings
- Add overhead lane use signs on the Brainard Road Bridge over I-271. The present sign is erected on the bridge parapet and cannot be seen by traffic coming from the I-271 southbound exit ramp
- Remove the pedestrian crosswalk across Brainard Road. It is very unlikely pedestrians will cross to or from the southern side of the Brainard Road Bridge. That side of the bridge is not connected with or serviced by any sidewalks. Keep the pedestrian crosswalk across the I-271 northbound entrance ramp as pedestrians will more likely use it because the sidewalk on the northern side of the bridge is connected to sidewalks along Brainard Road
- Reexamine the need to maintain the closure of the outer northbound through lane on Brainard Road Bridge presently closed-by-hatching. This through lane may be reinstated if a tapering northbound receiving lane is built on Brainard Road as shown in Diagram 2-1 above. The tapered through lane may also serve traffic exiting at the I-271 southbound exit ramp that turns right
Location 3 (Intersection of Cedar Road and I-271 Southbound Entrance Ramp):

The main characteristics of and issues at this intersection are:
- The traffic control signal cycle length is too long. It increases congestion and queuing, especially during the pm peak period
- Absence of adequate lane use signs and markings on and along Cedar Road and the bridge over I-271 in the westbound direction between Brainard Road and the I-271 southbound entrance ramp
- The bridge curb in the southeast corner does not have enough curvature to enable a smoother traffic turning movement

Recommended/suggested remedial measures:
- Perform capacity analysis and consider shortening the traffic control signal cycle length to reduce queuing on the Cedar Road eastbound approach
- Improve the curvature of the southeast corner of the I-271 southbound entrance ramp
- Provide additional overhead lane use signs for the Cedar Road westbound approach
- Provide additional lane use pavement markings and improve existing ones
- Provide dotted lane line extensions for the left-turn lanes of the westbound approach
- Revisit and take notice of any viability Alternative #10 may offer (Exhibit A), presented in the I-271–Cedar/Brainard Access Point Modification Study prepared by Burgess & Niple in 2002 for ODOT District-12 under PID #21029. This Alternative provides for a free-flow entrance ramp to I-271 southbound, and a fourth approach opposite the I-271 southbound entrance ramp from a marginal road alongside the I-271 southbound mainline between Brainard Road and Cedar Road. The free-flow ramp may reduce or prevent queuing on the Cedar Road eastbound approach that often reaches Richmond Road. The addition or restoration of this free-flow entrance ramp, however, must not degrade the operation of I-271 mainlines. The marginal road can service traffic from the I-271 southbound exit ramp at Brainard Road and traffic from the Brainard Road southbound approach seeking to be on Cedar Road westbound (Diagram 3-1). A slip entrance ramp from the marginal road (Diagram 3-1 and Appended Exhibit A) may be considered or added provided that it does not degrade the operation of the I-271 mainlines by significantly increasing the rate of traffic flow to the freeway
Cedar Road Bridge westbound over I-271 at the southbound entrance ramp

Add curvature to this protruding sharp curb, broken due to vehicles overrunning it

The southwest corner of Cedar Road at the I-271 southbound entrance ramp
Appended Exhibit-A: Alternative #10 presented in the 'I-271--Cedar/Brainard Access Point Modification Study' prepared by Burgess & Niple in 2002 for ODOT District-12 under PID #21029

Suggested slip entrance-ramp from the marginal road to I-271 southbound (Diagram 3-1)
Diagram 3-1: A suggested exit ramp from I-271 northbound to Cedar Road eastbound, and an entrance ramp from Brainard Road to I-271 southbound, with a possible marginal road from Brainard Road to Cedar Road westbound.
Location 4 (Intersection of Brainard Road and I-271 Southbound Exit Ramp):

The main characteristics of and issues at this intersection are:
- No clear lane use and destination signs on the I-271 southbound exit ramp
- Occasional queuing of traffic that extends to the freeway main line
- There is no pedestrian crossing for Brainard Road
- There is a “no-turn-on-red” sign for the exit ramp approach

Recommended/suggested remedial measures:
- Conduct traffic capacity analysis study to consider widening the I-271 southbound exit ramp to provide for double left-turn lanes and one exclusive right-turn bay (Diagram 4-1)
- Add a tapered receiving lane on northbound Brainard Road to serve as a receiving lane for the reinstated through-lane on the Brainard Road Bridge that had been closed-by-hatching, and to service a possible new right-turn bay configuration on the exit ramp (See Diagram 2-1 presented earlier)
- Add overhead lane-use and destination signs on the exit ramp to show proper lane occupancy for specific destinations
- Provide a pedestrian crossing for Brainard Road on the northern side of the I-271 southbound exit ramp.
- Reevaluate the need for the “no-right-turn-on-red” sign at this location and remove if not needed.
- Consider adding an entrance ramp to I-271 southbound commencing either at the intersection of Brainard Road with the I-271 southbound exit ramp, as shown in Diagram 4-1, or as a slip entrance ramp from the marginal road presented in Alternative-10 in the Burgess & Niple Point of Access Study (Exhibit-A) in the event the concept of such marginal road is reexamined and deemed viable and feasible, and provided that the addition of the ramp does not degrade the freeway mainline by significantly increasing the rate of traffic flow to the freeway (Appended Exhibit-A, and Diagram 3-1)
Diagram 4-1: Suggested entrance ramp to I-271 southbound from Brainard Road

Consider widening to provide exclusive double left-turn lanes and one exclusive right-turn bay
Global Recommendations Regarding Modifications to the Interchange and Intersections

Consider the following intermediate and long-term modifications to the Interchange, adjacent intersections, and thoroughfares:

1. Building a simple diamond northbound exit ramp connected directly to Cedar Road eastbound only, shown in Appended Exhibit-A, to serve Cedar Road eastbound traffic that presently exits at Brainard Road, turns right onto Brainard Road, and then turns left onto Cedar Road to proceed eastward.

2. Building a marginal road, if feasible, along the I-271 southbound mainline between Brainard Road and Cedar Road, presented in the Burgess & Niple Point of Access Study Report and shown here as Exhibit-A, commencing at the intersection of Brainard Road and the I-271 southbound exit ramp and terminating at the intersection of Cedar Road and the I-271 southbound entrance ramp. Consider providing a slip on-ramp from this marginal road to I-271 southbound as indicated on the Appended Exhibit-A.

3. Building a marginal road commencing at Brainard Road across from the I-271 northbound exit ramp, adjacent to the I-271 northbound entrance ramp, terminating at Lander Road with a spur to Landerbrook, shown in schematic Diagram 2-3 if one-way, or Diagram 2-4 if two-way, and described in the narrative for location 2 (Brainard Road at the I-271 northbound Exit & Entrance Ramps).

4. Conducting evaluation of the various improvement scenarios presented in this RSA report to produce a most viable solution alternative.
Appended Exhibit-A: Alternative #10 presented in the 'I-271--Cedar/Brainard Access Point Modification Study' prepared by Burgess & Niple in 2002 for ODOT District-12 under PID #21029

Diagram showing a suggested 'on-ramp' from Brainard Road to I-271 southbound (Diagram E-1)
Conclusion

This Road Safety Audit (RSA) for the intersections of Brainard Road/Cedar Road (referenced Location-1), Brainard Road/I-271 northbound Exit Ramp (referenced Location-2), Cedar Road/I-271 southbound Entrance Ramp (referenced Location-3), and Brainard Road/I-271 southbound Exit Ramp (referenced Location-4) in the Cities of Lyndhurst and Pepper Pike was conducted by the Northeast Ohio Areawide Coordinating Agency (NOACA) as part of NOACA’s Safety Studies Program for Fiscal Year (FY) 2012. The intersections were identified as high-crash locations based on NOACA’s 2009 Crash Report titled: ‘Accident Characteristics & Intersection Accident Analysis’.

An independent, ad-hoc Road Safety Audit team (RSA team) was assembled to examine the particulars of these intersections. The RSA team suggested several short-term, low cost safety improvements to increase the level of safety at these intersections, improve the overall level of operation of this vast interchange, and prevent or reduce potential traffic queues from reaching the freeway mainline. Medium and longer-term, higher-cost suggestions that may help reduce congestion, improve traffic flow, and reduce potential crashes were also made. They include possible modifications to the I-271 Interchange to address traffic demands and movement patterns using ramps spread over an expansive landscape. Suggested high-cost, long-term improvements presented in this study, that are outside the scope of ordinary safety improvements (greater than $5,000,000 in total cost) and not fundable with safety funds, are conceptual in nature and require further analysis and evaluation.

Stakeholders and municipalities affected by the prevailing traffic conditions are encouraged to evaluate these high-cost, long-term conceptual alternatives and develop or identify a preferred alternative that provides a comprehensive solution to improve access in addition to improving safety. Stakeholders, in concert with the municipalities, should consider establishing a special improvement district to fund studies to develop and evaluate improvement alternatives, and ultimately perhaps, fund or contribute toward funding the design and construction of a preferred alternative.

As a result of field observations, ODOT District-12 initiated a signal progression study for the three traffic control signals along Brainard Road (Locations 1, 2, and 4). ODOT District-12 is working with the City of Lyndhurst on making some modest improvements in signal timing, and possibly phasing, to reduce delays and traffic queues.

The City of Lyndhurst asked ODOT District-12 to install delineators near the junction of the I-271 northbound Cedar Road exit loop-ramp (Diagram C-1, below) to prevent slow downs and reduce or eliminate rear end collisions on Cedar Road near that junction in order to facilitate continuous, steady traffic flow. ODOT has agreed to purchase the delineators using safety funds and is working with the City of Lyndhurst to coordinate implementation. ODOT has also made this interchange a formal study location in its 2011 Annual Safety Work Plan. This effort will include more quantitative analysis of the short- to medium-term qualitative recommendations presented in this RSA report.

Review and general comments from ODOT District-12 are attached with this study report, upon ODOT’s request, in Appendix D.
The main recommendations described for each intersection separately were presented and illustrated in more detail in this report. While the aforementioned recommendations and suggestions might help alleviate the congestion and crash problems, a more thorough and global evaluation of the entire interchange and surrounding areas should be undertaken in order to introduce elements in the roadway network to influence or change the overall traffic patterns. Past studies researched contain suggestions and solution alternatives that are consistent with the thrust of this RSA and the findings presented in this report. It would be prudent to revisit past such studies to reconsider the viability of some of the alternatives and integrate them into the suggestions presented in this study report. In light of this RSA report, consider, for example, borrowing ideas, suggestions, and recommendations from the I-271–Cedar/Brainard Access Point Modification Study.
Appendix A:
Glossary

An Actuated Traffic Control Signal: A traffic control signal that operates based on actual, real time vehicular demand.

Actuation: Initiation of a change in or extension of a traffic signal phase through the operation of any type of detector.1

Adaptive Traffic Signal Control: The process by which the timing of a traffic signal is continuously adjusted based on the changing arrival patterns of vehicles at an intersection, usually with the goal of optimizing a given measure of effectiveness. The characteristics of a traffic signal cycle are optimized at the conclusion of every phase based on the vehicle arrival times.

Backplate: A thin strip of material that extends outward from and parallel to a signal face on all sides of the signal housing to provide a background for improved visibility of the signal indications.1

Capacity: Traffic-carrying ability of a facility over a range of defined operational conditions. Capacity analysis provides tools to assess facilities and to plan and design improved facilities.2

Crash Reduction Factor: The percentage of crash reduction expected after implementing the recommended countermeasure.

Detector: A device that detects the presence of a vehicle and actuates the demand for a green signal.

Green Time: The duration of the green indication for a given movement at a signalized intersection.

Permitted Turn: Left or right turn at a signalized intersection that is made against an opposing or conflicting vehicular or pedestrian flow.2

Protected Turn: The left or right turns at a signalized intersection that are made with no opposing or conflicting vehicular or pedestrian flow allowed.2

Signal Phasing: The way in which the right of way is allocated among conflicting traffic movements that seek to use the same space.

Split Phasing: A signal phasing where each two opposing traffic movements have a completely separate phase.

Stop Line: A solid white line extending across approach lanes to indicate the point behind which vehicles are required to stop.1

1 Manual on Uniform Traffic Control Devices
2 Highway Capacity Manual
Appendix B: Methodology for Ranking High-Crash Locations

Crash locations are ranked based on a composite index derived from the four different ranking aspects, described below. The Composite Index for a location is the sum of the four ranks the location has according to crash frequency, equivalent property damage only, average equivalent property damage only and crash rate.

1. **Frequency of Crashes**
   
   Rank 1 means the location has the highest crash frequency.

2. **Equivalent Property Damage Only Index (EPDO)**
   
   This index uses a formula to convert crashes of all severities to the equivalent of property damage-only crashes. It is calculated by weighing crashes as follows, where the cost of property damage only (PDO) crash is given a weight of 1:
   
   - The number of fatal crashes multiplied by 122.75 (the cost of a fatal crash is $1,199,558).
   - The number of injury crashes multiplied by 7.30 (the cost of an injury crash is $71,343).
   - The number of property damage only (PDO) crashes multiplied by 1.0 (the cost of a PDO crash is $9,772).

   \[
   \text{EPDO} = (\# \text{ of fatal crashes} \times 122.75) + (\# \text{ of injury crashes} \times 7.30) + \text{property damage-only crashes}
   \]

   Rank 1 means the location has the highest EPDO.

3. **The average Equivalent Property Damage Only** (EPDO per crash) is calculated for each intersection by taking the EPDO index calculated in step 2 above divided by the number of crashes occurring at the intersection. The highest EPDO per crash is ranked number 1.

4. **Crash Rate (Crashes per million entering vehicles):**
   
   \[
   \text{Crash Rate} = \frac{(\# \text{ of crashes} \times 1,000,000)}{[(\text{years of data}) \times (365) \times (\text{daily traffic volume entering the intersection})]}
   \]

   Rank 1 means the location has the highest crash rate.

5. **Composite Index** = Frequency Rank + EPDO rank + EPDO per crash rank + Crash rate rank

   (Ranking of crash locations will be according to the value of the composite index in descending order: a location having the lowest composite index ranks at the top)
### Appendix C:
#### ODOT Cost-Range Categories

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Cost Range in Dollars</th>
<th>Time Range in Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Less than $100,000</td>
<td>One year or less</td>
</tr>
<tr>
<td>Medium</td>
<td>$100,000-$5,000,000</td>
<td>One year - 5 years</td>
</tr>
<tr>
<td>High</td>
<td>Greater than $5,000,000</td>
<td>More than 5 years</td>
</tr>
</tbody>
</table>
Appendix D: ODOT's Review and General Comments
(Enclosed Upon ODOT District-12 Request)

interoffice communication

TO: Maher Holuzadah, Senior Transportation Engineer, NOACA
FROM: Brian Blayney, PE, District Traffic Planning Engineer
DATE: December 10, 2012
SUBJECT: Review and Comment on NOACA Road Safety Audit for Intersection of Cedar and Brainard Roads

This office is in receipt of the subject draft Road Safety Audit transmitted October 9, 2012. This office offers the following comments to be considered in the preparation of the final report:

1. See attached markup for minor suggestions on report content.
3. As a result of field observations, ODOT District 12 initiated a signal progression study of the three signals on Brainard in the vicinity of the interchange. ODOT is working with the City of Lyndhurst on making some modest improvements in signal timing and possibly phasing to reduce delays and queues.
4. Please acknowledge the recent request by the City of Lyndhurst to add delineators to the bottom of the I-771 NB exit to Cedar Road loop ramp to improve traffic flow. ODOT has agreed to purchase the delineators using state safety funds. ODOT and the City are working together to coordinate implementation.
5. ODOT District 12 made this interchange a formal study location for its 2011 Safety Annual Workplan. This effort will include more quantitative analysis of the short-term qualitative recommendations presented in the RSA.
6. Long-term countermeasure to add a directional exit from I-771 NB to Cedar EB (part of “Alternative 10” presented in PID 21029 Interchange Modification Study): The Department will evaluate the expected impact of this concept on traffic flow as part of the formal study prepared for the Annual Workplan. This office suspects that reconstruction of this exit as a 2-lane collector-distributor ramp is a more appropriate long-term treatment given the traffic volumes and need to service multiple destinations from a single exit.
7. Long-term countermeasure to add a marginal road along I-771 SB to connect the SB exit and on Brainard to the SB entrance on Cedar. (part of “Alternative 10” presented in PID 21029 Interchange Modification Study): The Department believes this proposal is not feasible by inspection due to environmental impacts, physical obstructions, and the associated high cost of RW acquisition. The Department is not interested in pursuing this concept and objects to showing it as an exhibit in the RSA because it may cause confusion. This office prefers that this aspect of the figure be modified to hatch out or erase the marginal road.
8. Long-term countermeasure to improve the NB exit by building a marginal road (Diagrams 2-2 and 2-3): ODOT will not sponsor the effort to plan or design the construction of a new local road (a marginal road) as suggested in this concept; however, ODOT agrees to coordinate the review of this proposal if a local sponsor wishes to initiate project development, secure funding and sponsor all phases of project development (planning, design, construction). One major hurdle to implementation is gaining approval of FHWA for the modification of the existing interstate access point. This policy is attached for reference. This office foresees potential hurdles to implementation, but it is willing to work with local sponsors if they choose to pursue this concept.
a. Diagram 2-3: This office suggests showing the short link of the marginal between Braiaard and the NB entrance ramp be three lanes wide to accommodate fluctuating demand between AM and PM peak movements to improve lane utilization through at the diverge. In conjunction, this office suggests shared lane use on two exiting lanes on the NB exit, a left/through and a through right. Those would appear to be adequate service demand under this reconfiguration.
b. This office believes it will be necessary for the marginal to be two lanes wide between the NB entrance ramp and Lander Road, not a single lane as shown.

This office recommends identifying the following items of work for further investigation and potential implementation. This office believes these are reasonable and is willing to cooperate with locals to coordinate implementation or further study as noted. Please include these recommendations in the RSA by appending this IOC to this report.

1. Consider modifying coordination timings as recommended by signal progression study prepared by TEC and DLZ for ODOT and Lyndhurst.
2. Add delineators to NB exit to Cedar to encourage motorists to enter Cedar WB without slowing.
3. Request that District 12 maintenance forces remove several panels of vandal protection fence at southwest corner of Brainard overpass to improve sight distance for NB exit right turn on red.
4. Consider modifying phasing at intersection of I-271 NB exit and Brainard as follows: Convert the SB left to I-271 NB a lag left turn instead of a lead left turn.
5. Further evaluate lane use signing recommended for Cedar WB to consider whether it is possible to retrofit existing bridge structure to accommodate a large mast arm sign support.
6. Consider modifying phasing at intersection of Brainard and Cedar to make the NB left turn fully protected and overlapped on the SB lead left. Pavement marking on the NB approach and the EB approach must be modified to allow opposing NB and SB left turns without a physical conflict. In the medium term, it would be more desirable to improve the offset of the NB left turn by widening the NB approach.
7. Consider modifying phasing at intersection of Cedar and Brainard to implement lead-lag phasing as Brainard SB left turn to Cedar EB for weekday AM peak hour operation only. The recommendation to make the NB fully protected must be implemented in order to carry out this recommendation.
8. Conduct further re-evaluation of pedestrian access throughout interchange area. Consider improvements to sidewalk, pedestrian signal heads, and ped signal timings.
9. Evaluate a potential minor widening to brainard GB between Cedar and I-271 NB to improve traffic flow.
10. Evaluate a potential minor widening to Brainard SB between the SB exit and Cedar to improve traffic flow.
11. Evaluate traffic operation of a potential directional exit to Cedar EB next to First Energy substation.

Please contact me at 216-584-2102 if you have any questions.

BMB

c. L. Hazapis; M. Kubek; T. Bonnett; RSA File

Enclosures
FHWA 8-Point Policy
Marked-Up Draft Study