APPENDIX G

Design Memos
This memo summarizes our Phase II 95% Horizontal Geometric design for the Dowling Rd. and Seward Hwy. interchange. The Phase II horizontal geometric design work builds upon our previous Phase I operational analysis and highly developed concept/preliminary design work which is summarized in our memo dated June 6, 2018.

It is noted that the Phase II 95% horizontal design substantially adheres to the Phase I Preliminary Design as it relates to the operational analysis completed in Phase I. Therefore, no changes are necessary to the previously completed operational analysis nor are those findings and results effected.

The Phase II design is focused on development of 95% horizontal geometrics based upon the Phase I preliminary design. This effort includes final design refinements and optimization based upon the updated survey, to include tie-In points for all ramps and frontage roads and their associated transitions for these connections to existing and proposed infrastructure. Additionally, this effort included access management considerations as it relates to length of medians along Dowling Road.

A. Horizontal Design

The horizontal geometric design of roundabouts and their associated safety and operational performance are highly interdependent, particularly in constrained high-flow conditions. Building upon our Phase I Preliminary Design we have prepared a 95% horizontal design.

**Key Issues**

The 95% horizontal geometric design is based upon the following project objectives:

- Meet roadway and roundabout specific safety criteria for all modes
- Ensure all sight distances requirements are met for both pedestrians and vehicles
- Speed control and sight lines necessary for pedestrian/non-motorized facilitation
- Improve large truck accommodations; WB-67 design vehicle designed to stay in lane and minimize vehicle overlap to the extent feasible
  - The 95% design widened the approach painted gore to accommodate the WB-67 at entry, and widened the outside circulating lane to avoid where possible and minimize overlap into adjacent lane while circulating. The Phase I design used a WB-62 for entry design.
- Maintain same impacts to sensitive rights-of-way and environmental constraints, to include:
  - Overhead utility poles adjacent to southern alignment of Dowling Road
  - School property located along west edge of the northbound off-ramp
- Include cross-section transitions to existing and proposed roadways to ensure optimal operations and safety, to include provisions for business and side street access/circulation for ease of driveway ingress and egress.
B. Safety and Design Checks Criteria
The 95% horizontal geometric designs have been developed to adhere to FHWA Performance Checks (NCHRP Report 672, Roundabouts: An Informational Guide), to include:

- 6.7.1 Fastest Path
- 6.7.3 Sight Distance Envelopes
  - Stopping sight distance
  - Intersection sight distance
- 6.7.4 Entry/view angles – angles of visibility
- 6.5.7 Design vehicle considerations (WB-67)

C. Pedestrian Safety
We have calculated pedestrian sight lines utilizing the methodology from NCHRP 834 – Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities: A Guide Book. The sight lines are predicated on speed calculations. We have analyzed free-flow speed calculations by lane not using fast path speed calculations. The speed calculations and resulting sight line exhibits are attached.

A key element of NCHRP 834 is the objective to achieve vehicular speeds at pedestrian crossing locations near or below 20 mph. The 95% horizontal design accomplishes this goal with all crossings close to 20 mph, with the highest speed calculation at a pedestrian crossing being 20.85 mph (NB Off-Ramp).

Please see attached 11 x 17 design performance check exhibits documenting adherence to these principles and criteria.

It is noted that research and practice shows that additional speed control and associated safety benefits may be derived from implementing sight preclusion design features to preclude unnecessary sight distance for both approaches and the circulating roadway. Design elements may include landscaping features such as fences and/or plantings.

As always, if there are questions please do not hesitate to contact me.

Sincerely,

Mark T. Johnson

Appendices - Design and Performance Checks
- Appendix A
  - 95% Horizontal Design – Colorized
  - Key Pavement Marking Dimensions
- Appendix B - NCHRP 674 Design Performance Checks
  - Fast Paths
  - Intersection Sight Distance and Stopping Sight Distance Envelopes
  - Phi and View Angle
  - Truck (WB-67) Turning Movement Envelopes
- Appendix C - NCHRP 834 Pedestrian Analysis
  - Speed Analysis
  - Sight Distance Envelopes
Appendix A:

- 95% Horizontal Design – Colorized
- Key Pavement Marking Dimensions
Appendix B - NCHRP 674 Design Performance Checks:

- Fast Paths
- Intersection Sight Distance and Stopping Sight Distance Envelopes
- Phi and View Angle
- Truck (WB-67) Turning Movement Envelopes
FHWA DESIGN PRINCIPLES

6.7.1 - Speed Control aka Fast Path Analysis

Two-Lane not to exceed 30mph
**Intersection and Stopping Sight Distance**

- **Stopping Sight Distance (SSD):**
  - 20 mph = 120'
  - 15 mph = 75'

- **Intersection Sight Distance (ISD):**
  - ISD = \( d_1 = 1.468 \times (R1 + R2) \times 5 \text{ sec} \)
  - ISD = \( d_2 = 1.468 \times R2 \times 5 \text{ sec} \)

**FHWA Design Principles**

- 6.7.3.1 - Stopping Sight Distance
  - 30 mph = 198'
  - 40 mph = 303'
  - 45 mph = 362'
  - 50 mph = 427'
  - 55 mph = 497'

- 6.7.3.2 - Intersection Sight Distance
  - ISD = \( d_1 = 1.468 \times (R1 + R2) \times 5 \text{ sec} \)
  - ISD = \( d_2 = 1.468 \times R2 \times 5 \text{ sec} \)

- 6.7.3.3 - Sight Distance Triangle
  - For stopping distance calculations, the height of the driver's eye is 3.5 feet above the roadway and the object height is 2 feet above the roadway surface. To determine whether an object is a sight obstruction consider both the horizontal and vertical alignment of both roadways as well as the height and position of the object (AASHTO, Green Book).

- Objects within the Sight Distance Envelope must be < 2.5' or > 6' in height.
**FHWA Design Principles**

6.5.4 - Entry Geometry & Approach Alignment

*VIEW ANGLES RECOMMENDATION*

<table>
<thead>
<tr>
<th>View Angle</th>
<th>Preferred Minimum</th>
<th>Preferred Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phi = 44°</td>
<td>40°</td>
<td>42°</td>
</tr>
<tr>
<td>Phi = 41°</td>
<td>22°</td>
<td>21°</td>
</tr>
<tr>
<td>Phi = 40°</td>
<td>20°</td>
<td></td>
</tr>
<tr>
<td>Phi = 42°</td>
<td>20°</td>
<td></td>
</tr>
</tbody>
</table>

*Preferred Minimum* = Actual measured entry angle / 2

*Absolute Minimum* = 16°

*Preferred Maximum* = 12°
Scale = 1:80

MTJ DESIGNS

WB-67 TRUCKS THRU B

Tractor Width 8'

Lock to Lock Time 6.0

Trailor Width 8.5'

Steering Angle 28.4

Tractoc Track 8'

Articulating Angle 75.0

Footnote:

45.5' 15'

3' 19.5'
MTJ DESIGNS

WB-67 TRUCKS LEFT A

Tractor Width 8'
Lock to Lock Time 6.0
Trailer Width 8.5'
Steering Angle 28.4
Tractor Track 8'
Articulating Angle 75.0
Tractor Track 8.5'
53'
45.5'
3'
4'
19.5'
15'
Appendix C - NCHRP 834 Pedestrian Analysis:

- Speed Analysis
- Sight Distance Envelopes
The sight distance (d) is calculated as a function of the conflicting vehicle speed (V) and the pedestrian critical headway (tc).

\[ d_{n} = (1.467)(V_{n})(t_{n,c}) \]

- \( d_{n} \) = distance along approach leg n upstream of the crosswalk for crossing, ft.
- \( V_{n} \) = free flow speed of conflicting vehicle movement on approach n, mph.
- \( t_{n,c} \) = critical headway required by a pedestrian crossing approach n.

Speed for distance calculation based on typical vehicle free flow speeds not fast path speeds.
The sight distance ($d_n$) is calculated as a function of the conflicting vehicle speed ($V_n$) and the pedestrian critical headway ($t_{n,c}$)

$$d_n = (1.467)(V_n)(t_{n,c})$$

$d_n$ = distance along approach leg upstream of the crosswalk for crossing, ft.

$V_n$ = free-flow speed of conflicting vehicle movement on approach $n$, mph.

$t_{n,c}$ = critical headway required by a pedestrian crossing approach $n$.

The critical headway describes the minimum amount of time necessary for a pedestrian to cross the roadway. The critical headway calculation is directly derived from the pedestrian analysis method covered in the two-way stop-controlled intersection methodology of the Highway Capacity Manual 2010.

Equation 7-3 Estimating pedestrian critical headway

$$t_{n,c} = \left(\frac{L_n}{S_p}\right) + t_s$$

$L_n$ = crosswalk length for a specific traffic stream, ft;

$S_p$ = average pedestrian walking speed, ft/s (default = 3.5 ft/s);

$t_s$ = pedestrian start-up time and end clearance time, s (default = 2 s).

**Crossing Sight Distance (CSD)**

Objects within the Sight Distance Envelope must be < 2.5' or > 6' in height

<table>
<thead>
<tr>
<th>Pedestrian Critical Headway(s)</th>
<th>Calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_{n,c} = (29'/3.5) + 2 s$</td>
<td>10.3 s</td>
<td></td>
</tr>
<tr>
<td>$t_{n,c} = (16'/3.5) + 2 s$</td>
<td>6.6 s</td>
<td></td>
</tr>
<tr>
<td>$t_{n,c} = (24'/3.5) + 2 s$</td>
<td>8.9 s</td>
<td></td>
</tr>
</tbody>
</table>
This memo summarizes our Phase II Signing and Pavement Marking recommendations for the Dowling Rd. and Seward Hwy Interchange. These concept-level design plans are meant to inform the implementation of signing and markings in the final “plans in hand” 65% submittal.

This memo summarizes our Signing and Pavement Markings recommendations for the following primary signing and markings, to include:

- Wayfinding Signing
  - Advance Directional
  - Lane Use Assignment
  - Exit Signs at Splitter Islands
- Pavement Markings
  - Approaches
  - Entry
  - Circulating lane lines

**Recommended design exhibits are included in the attached appendices for both signing and pavement markings**

These recommendations and are anchored in the following research, engineering science and state-of-practice documents:

- NCHRP Report 672, Roundabouts: An Informational Guide
- NCHRP Report 600, Human Factors Guidelines for Road Systems, 2nd ed. TRB, 2012
- Safety Impacts of Signing and Pavement Markings on Property-Damage-Only Crashes at Multi-Lane Roundabouts, TRR 2019
- FHWA MUTCD 2009
INTRODUCTION

Driver Messaging and Information Processing
The safety and operational performance of roundabouts is strongly anchored in human factors, i.e., how drivers receive the visual information of the geometrics, signing, and pavement markings and how they react to it. For optimal safety and operations, the visual information must be designed to both simplify decision-making and provide clear, concise information on the correct way to drive the roundabout.

High traffic flow multi-lane roundabouts introduce complexity for a driver navigating the roundabout. More traffic requires more lanes which adds complexity for information processing. While this is true for all intersection types, roundabouts rely more heavily on these visual cues than other intersection types. The traffic and transportation engineering practice is becoming increasingly aware of how important the geometric, signing and pavement marking design specifications are related and affect how drivers receive, process and react to this visual information at roundabouts. Negotiating intersections involves the absorption and processing of visual information presented to the driver, primarily by the signs and pavement markings. Design should reduce demand made on drivers to improve comprehension. Line types, weight and arrangement are vital to driver comprehension and optimizing these design elements has been shown to reduce minor crashes.

Research states that when there is too much information presented in too short a space the information is then ineffective. In order to be effective, pavement markings and signs must be conspicuous, easily understood and legible from a distance that allows drivers to read them in time to initiate any required action. When poorly understood symbols, confusing word messages, and undersized print is utilized, this may lead to poor legibility distance (the time available vs. time required to read the information) the resulting information overload has been shown to confuse rather than inform drivers. Please see specific recommendations discussed below along with the corresponding design exhibits which are attached in the Appendices.

SIGNING
We have developed signing recommendations for these primary wayfinding information signs:
- Advance Directional
- Lane Use Assignment
- Exit Signs at Splitter Islands

To assist in determination of final signing recommendations we developed a Signing Alternatives Evaluation document that provides potential alternative signs at key decision points, and this is attached in Appendix A.

These incorporate preliminary review comments and feedback by the Department Traffic Section of the Signing Alternatives analysis document.

The final signing recommendations are attached in Appendix B, with excerpts shown below, along with short descriptions and brief background information that forms the basis for these recommendations.
**Advance Directional Signing**

The recommended advance directional information sign is consistent with other interchanges along the Seward Hwy. This includes a standard directional sign to indicate the approaching intersection and primary directions or destinations.

**Standard Advance Directional Signing Westbound Dowling**

**Northbound Off-Ramp Advance Sign**
**Lane-Use Assignment Signing**

Consistent with other interchanges along the Seward Hwy., the lane-use assignment signing recommendations implement standard arrows vs. fish-hook style. We have shown an overhead sign along Dowling Road (east and westbound) for the RT Only lane and ground-mounted for the straight ahead Thru Lanes (shown below). Whereas, the off-ramps have more complex lane use assignments, with shared and dual lane use, and therefore we have recommended overhead placement for lane use assignment for both off-ramps (shown below).
Drivers Perspective View Renderings of Lane-Use assignment Signing

Eastbound Dowling Road

SB Off-Ramp (same for NB Off-Ramp – except dual RT signs necessary)
Exit Signing

- The recommended Exit Signs incorporate 9” lettering and 9” shield and chevron end to maximize information delivery and minimize overall sign size to fit context. It is noted that chevron end (versus a tilt arrow) facilitates these objectives.
  - The tilt arrow is borrowed from a low angle high speed off-ramp gore areas signing convention. Whereas, the context of a roundabout exit is quite different operating at low speeds and different angles. Research indicates that the chevron end improves driver messaging. Many agencies in the U.S. have implemented the chevron end to maximize information delivery and positive driver guidance. It is noted that the MUTCD does not preclude the use of a chevron end sign.
Other Signing Recommendations for Consideration:

- Replace W11-2 standard “pedestrian crosswalk warning” sign with the R1-6 pedestrian sign on both the main splitter islands and aux splitter islands. This allows for retaining the outside standard W11-2 with the RRFB as proposed for the outside locations. This will assist in mitigating the information overload that is created by too many signs, which is common at roundabouts.

Discussion

The R1-6 sign was developed for low-speed applications (25 mph) to improve driver attention to the presence of a pedestrian crossing. Research from a multi-lane high-flow roundabout with moderately high pedestrian activity in the City of Richfield, MN, showed a ~40% improvement in driver yield rates with its implementation (30% pre- and 70% post-installation). These results are predicated on the higher target value and reduced sign clutter.

<table>
<thead>
<tr>
<th>Sign Clutter</th>
<th>R1-6 Pedestrian Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Sign Clutter" /></td>
<td><img src="image2.png" alt="R1-6 Pedestrian Sign" /></td>
</tr>
</tbody>
</table>
**PAVEMENT MARKINGS**

**Lane Use Assignment Arrows (Signs and Pavement Markings)**

*Discussion*

We recommend standard-lane use arrows for signing and the associated pavement markings to maintain consistency within our transportation system. Many agencies have adopted standard lane-use arrows for their standard. It is noted that there is no research basis indicating that the fish-hook style lane-use sign provides improved decision making.

**PROBLEM:** Fish hook arrows

**NEW/UNFAMILIAR CONVENTION**
- Inconsistent approach and circulating
- Does not adhere to driver expectancy
- Research does not show benefit

**SOLUTION:** Standard arrows

**FAMILIAR DRIVER CONVENTION**
- Consistent approach and circulating
- Adheres to driver expectancy
- Experience shows benefit
**Recommendation**
Implement Standard Arrows for markings and signing.

**Yield Line**

**Discussion**
The 2009 MUTCD definition of the yield line as a dotted edge line extended infers that the extended edge line must lie along the ICD, tangential to downstream exit. On multi-lane approaches this pulls the driver forward, creating sub-standard view angle left for outside approach to outside circulating lanes. Research indicates that flat entries with high view angles send an incorrect message to drivers to merge rather than the correct priority message of yield-at-entry to circulating traffic.

The dotted edge line extended definition is not consistent with historical (pre-2009 MUTCD) or international practice for roundabouts, but is derived from standard highway engineering. It is noted that a roundabout entry is not a standard roadway or highway, but rather is a specific intersection type, with the yield line to provide indication to approaching drivers. Circulating drivers do not utilize the edge line extension for guidance but rather queue off of information to the left, e.g., the central island curb for inside lane and circulatory stripe for outside lane.

However, if the yield line is described as the **priority demarcation line with its intent to inform approaching drivers to yield, and not an extended edge line to provide guidance to circulating drivers**, this then allows the yield line to be placed accordingly, **pulled back away from the ICD (not extensions of the edge line)**. This revised layout improves the view angle left and may reduce the associated merging problems. Additionally, this reduces clutter through the entry area by removing the need to implement the additional sharks-teeth style yield markings.

**Recommendation**
Use singular heavy demarcation, not edge line extended with sharks-teeth.

**Circulatory Roadway Markings**

**Discussion**
Drivers are conditioned to understand that solid followed by a skip line type is a lane change/weave opportunity in all other roadway/highway uses. Research conducted on U.S. roundabouts shows substantial reduction in lane discipline and side-swipe type crashes with implementation of a consistent circulatory line type.

**Recommendation**
Use a consistent line (6’ seg, 3’ gap) to improve lane discipline and reduce side-swipe type crashes associated with a solid then skip line type.

**SUMMARY**
Driver comprehension and safety benefits are derived from presenting a simplified messaging to more effectively communicate the desired information for both signing and markings via line types, weight, and arrangement of information to achieve:

1. Clearer and more easily understood information
2. Minimize detection, reading and processing time
3. Maximize comprehension

The recommended signing and pavement markings are predicated on Department review comments of the signing alternatives document as well as human factors research and our application experience.
I look forward to discussing this review summary with the project team as necessary.

Sincerely,

Mark T. Johnson  
MTJ Roundabout Engineering

**Attachments**

- Appendix A – Signing Alternatives
- Appendix B – Signing Plan Recommendation
- Appendix C – Pavement Marking Recommendation
Appendix A:

Signing Alternatives
Appendix B:

Signing Plan Recommendation
Appendix C:

- Pavement Marking Recommendations
- Key Dimensions
Proposed Dowling Road Seward Hwy (US 1) Interchange Perspective Views

Proposed Signing Images From 3D Model

By: MTJ Roundabout Engineering

5 17 19
Dowling Road Seward Hwy (US 1) Interchange
EB Dowling Rd
SB Off Ramp
SB Off Ramp
Circulating Roadway – Eastbound-East Rndbt
MEMORANDUM

Date: March 7, 2019                        Project #: CFHWY00359

To: Joe Taylor, PE
    Susan Acheson, PE
    Lounsbury & Associates, Inc.

From: Andrew Ooms, PE and Claire Dougherty, EIT

Project: Dowling Road / Seward Highway Interchange Reconstruction

Subject: Pedestrian Accommodations and Crossing Analysis

INTRODUCTION

The design of the proposed Dowling Road and Seward Highway Interchange roundabouts, as detailed in the Preliminary Engineering Report (PER) and shown in Exhibit 1, has geometric improvements to slow speeds and improve sight distances at pedestrian crossing locations. The crossing locations include marked crosswalks and signage; however, despite pedestrians having the right-of-way at the crossings, driver yielding has been documented to be poor at the existing roundabouts, particularly at the exit crossings.

The purpose of this memo is to present an analysis of enhanced pedestrian crossing applications for the multilane roundabouts to facilitate discussions with the Department of Transportation and Public Facilities (DOT&PF) and the Municipality of Anchorage (MOA) regarding potential crossing treatments. Pedestrian crossing treatments, such as rectangular rapid flashing beacons (RRFB) and raised crosswalks, serve sighted and visually impaired pedestrians, as well as cyclists using the sidewalks and pathways.

The analysis is based on the guidance and methodology provided in:

- Alaska Traffic Manual (ATM)
- NCHRP Report 834, Guidebook for the Application of Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities
PEDESTRIAN CROSSING TREATMENT ANALYSIS

Alaska Traffic Manual Assessment

The Alaska Traffic Manual (ATM) includes recommended practices for treatments at uncontrolled or midblock crossing locations in two tables:

- Section 4A.100, Table 4A-101. Grouping of Traffic Control Device Alternatives Based on Conditions at Uncontrolled Crossing Locations
- Section 4A.100, Table 4A-102. Recommended Order of Selection for Traffic Control Devices or Strategies at Uncontrolled Crossing Locations

Tables 4A-101 and 4A-102 are included as an attachment to this memorandum.

Key attributes of each crossing location that the ATM crossing warrant tables consider include:

1. Entry versus Exit crossing (determination of vehicle speed at crossing varies by crossing type)
2. Vehicle and Pedestrian Volumes
3. Pedestrian Sight Distance (PSD) and Stopping Sight Distance (SSD)
4. Safety history of crossing location
5. Observed Gaps in Vehicle Traffic
The gaps and sight distance thresholds of the ATM crossing treatment guidance do not apply to the complex and dynamic roundabout crossings as cleanly as to other midblock or uncontrolled crossings. For these multilane crossings, the complexity of circulating vehicles hinders pedestrian gap evaluation. The pedestrian sight distance needed to determine available crossing gaps extends beyond the roundabout circulating roadway, meaning that when pedestrians attempt to assess a crossing gap, they are not able to determine which vehicles may conflict with the crossing movement. As a result, pedestrians may enter the crosswalk during an apparent gap and depend on conflicting drivers to yield while approaching the crosswalk to avoid a collision. Additionally, vehicle speeds are more dynamic in a roundabout situation than a typical roadway crossing. This crossing complexity is even more apparent for roundabout exit crossings, where higher vehicle speeds are anticipated due to driver acceleration while exiting the circulating flow.

A key threshold for the crossing warrants in the ATM is more than 20 pedestrians per hour, with a reduction to 15 or 10 pedestrians per hour if elderly and/or child pedestrians recur frequently. A similar warrant in NCHRP 562, Improving Pedestrian Safety at Unsignalized Crossings, also reduces pedestrian thresholds to 14 per hour when vehicle speeds exceed 35 mph. Counts conducted in March 2018 showed low pedestrian volumes during vehicle peak hours (less than five crossing per hour); however, these counts are not representative of summer seasonal pedestrian volumes. Additional pedestrian counts should be conducted in May 2019 to account for schools being in session and seasonal recreational activity to establish the typical summer pedestrian demand. New pedestrian counts would also reflect current pedestrian patterns, considering the recent construction of non-motorized facilities on Homer Drive and Brayton Drive adjacent to the interchange.

The roundabout exit crossings assessment per the ATM is summarized below in Table 1.

Table 1. Summary of ATM Crossing Assessment - Roundabout Exit Crossings

<table>
<thead>
<tr>
<th>Crossing Location</th>
<th>ATM Table 4A-101 Warrant Results¹</th>
<th>PSD</th>
<th>SSD</th>
<th>GAPS</th>
<th>ATM Table 4A-102 Warrant Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Westbound Dowling Road, West Roundabout Exit</td>
<td>Electrical Warning Devices²</td>
<td>Below Minimum³</td>
<td>Above Minimum⁴</td>
<td>&lt;1 per 2 minute average</td>
<td>RRFB¹</td>
</tr>
<tr>
<td>Southbound On-ramp / Homer Drive, West Roundabout Exit</td>
<td>Non-Electrical Devices</td>
<td>Below Minimum³</td>
<td>Above Minimum⁴</td>
<td>&gt;1 per minute average</td>
<td>High visibility warning signs, markings delineators or post reflectors</td>
</tr>
<tr>
<td>Eastbound Dowling Road, East Roundabout Exit</td>
<td>Electrical Warning Devices²</td>
<td>Below Minimum³</td>
<td>Above Minimum⁴</td>
<td>&lt;1 per 2 minute average</td>
<td>RRFB¹</td>
</tr>
<tr>
<td>Northbound On-ramp / Brayton Drive, East Roundabout Exit</td>
<td>Non-Electrical Devices</td>
<td>Below Minimum³</td>
<td>Above Minimum⁴</td>
<td>&gt;1 per minute average</td>
<td>High visibility warning signs, markings delineators or post reflectors</td>
</tr>
</tbody>
</table>

Notes:
1. Assuming crossing volume >20 per hour.
2. Electrical Warning Device thresholds met, assuming AADT > 15,000 and speeds above 30 mph (acceleration controlling speeds).
3. Pedestrian sight distance needed to determine available crossing gaps extends beyond the roundabout circulating roadway, meaning pedestrians can’t fully assess vehicle gaps, as the intended movement of vehicles approaching the roundabout is not clear from afar.
4. SSD above minimum, assuming circulating vehicles recognize the need to yield at or before the typical exit acceleration point.
5. Table 4A-102 specifically refers to RRFBs at roundabout exits.
Considering the lower vehicle volumes and vehicle speeds less than 30 mph, the roundabout entry crossings do not meet the electrical warning thresholds listed in ATM Tables 4A-101 and 4A-102. Additionally, driver yielding at entry crossings is less complicated, as crossing locations are in the direction drivers are looking, in anticipation of yielding to circulating vehicles.

In summary based on the ATM Crossing Assessment, though lacking conclusive seasonal pedestrian volumes at this time, the limited number of gaps (up to 5 minutes between gaps assuming no yielding) and greater than 30 mph controlling speeds at the Dowling Road roundabouts eastbound and westbound exit crossings are challenging for both sighted and visually impaired pedestrians and meet the Electrical Devices (RRFB) warrant per the ATM gap thresholds.

The northbound and southbound on-ramps exit gaps are “sufficient” and do not meet ATM electrical warrants, assuming sight distance is provided as discussed above. No additional treatments are warranted on the entry crossings beyond the detailed refuges, striping and signing, and lighting. If active crossing treatments are installed on the roundabout exits, those treatments should be considered on the entry legs for consistency.

Americans with Disabilities Act Assessment

Beyond volume warrants, the Americans with Disabilities Act (ADA) of 1990 requires that all new and altered facilities be accessible to and usable by people with disabilities. The United States Access Board has proposed rulemaking for Public Rights of Way Accessibility Guidelines (PROWAG) recommends a minimum specification of a pedestrian-activated signal for all multilane crossings at roundabouts. While not finalized at the time of this writing, the draft recommendations have been recommended by FHWA as a best practice.

Each of the proposed roundabout pedestrian crossings was reviewed for potential treatment to make them accessible to all users. The analysis is based on the methodology from NCHRP Report 834 as amended under the ongoing NCHRP Project 03-78c effort, which has slightly modified some of the prediction equations. The crossing assessment method estimates the crossing sight distance, crossing delay and the expected level of risk for the visually impaired. This analysis focused on the risk assessment for each proposed crossing, as summarized in Table 2.
Table 2. Summary of NCHRP 834 Crossing Assessment Results

<table>
<thead>
<tr>
<th>Crossing Location</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southbound Off-ramp / Homer Drive, Entry</td>
<td>7.6%</td>
</tr>
<tr>
<td>Southbound Off-ramp / Homer Drive, Right Turn By-Pass</td>
<td>6.2%</td>
</tr>
<tr>
<td>Westbound Dowling Road, West Roundabout Exit</td>
<td>11.9%</td>
</tr>
<tr>
<td>Eastbound Dowling Road, West Roundabout Entry</td>
<td>7.2%</td>
</tr>
<tr>
<td>Eastbound Dowling Road, Right Turn By-Pass</td>
<td>5.7%</td>
</tr>
<tr>
<td>Southbound On-ramp / Homer Drive, West Roundabout Exit</td>
<td>9.5%</td>
</tr>
<tr>
<td>Northbound Off-ramp / Brayton Drive, Entry</td>
<td>7.6%</td>
</tr>
<tr>
<td>Northbound Off-ramp / Brayton Drive, Right Turn By-Pass</td>
<td>6.2%</td>
</tr>
<tr>
<td>Eastbound Dowling Road, East Roundabout Exit</td>
<td>11.4%</td>
</tr>
<tr>
<td>Westbound Dowling Road, East Roundabout Entry</td>
<td>7.2%</td>
</tr>
<tr>
<td>Westbound Dowling Road, Right Turn By-Pass</td>
<td>6.2%</td>
</tr>
<tr>
<td>Northbound On-ramp / Brayton Drive, East Roundabout Exit</td>
<td>7.4%</td>
</tr>
</tbody>
</table>

The risk assessment analysis shows that all crossings are above a 5 percent risk, and the Dowling Road roundabout eastbound and westbound exit crossings are above a 10 percent risk. A 10 percent crossing risk suggests that one out of every ten crossing attempts by a visually impaired pedestrian may result in an unsafe condition. Generally, a greater than 5 percent risk is concerning and presents a significant barrier for blind travelers, and greater than 10 percent risk represents a challenging and risky crossing environment, though NCHRP 03-78c defaults to agencies to set risk thresholds. Potential treatments to address high crossing risks include electrical beacons, such as RRFB, with accessible pedestrian signals (APS) and/or raised crosswalks.

ATTACHMENTS

ATM Tables 4A-101 and 4A-102
CHAPTER 4A. GENERAL

Section 4A.100 Traffic Control Device Alternatives for Crossings

Guidance:

01 Traffic control devices or strategies for improving higher use crossing locations should be selected to provide warning to motorists or to assist pedestrians with gaps for crossing. Traffic control devices or strategies should be matched to conditions at the crossing location with consideration of the following factors associated with the potential for vehicle-pedestrian conflict: pedestrian volume, traffic volume, roadway width, and traffic speed.

02 Table 4A-101 should be used to evaluate conditions at crossing locations to determine the grouping of traffic control devices (non-electrical, electrical warning, or electrical regulatory) which most efficiently meets the level of conflict. Pedestrian volumes used in Table 4A-101 should be frequent and routinely occurring, such as an average annual peak hourly volume which recurs on a daily or weekly basis or a seasonal peak hourly volume which recurs over three or more months. Where the operating speed of traffic has been studied and found to be significantly different from the posted speed limit (such as a posted advisory speed, an entry to a roundabout, or a segment with good sight distance and little roadside activity), the operating speed should be used in Table 4A-101, otherwise the posted speed limit should be used.

03 Table 4A-102 should be used to select traffic control devices or strategies within the grouping of traffic control devices identified in Table 4A-101. Performance of traffic control devices or strategies should be evaluated with engineering judgment before moving to a device grouping with higher command of motorist attention. Option:

04 Crash history, walking speed, pedestrian age, and maintenance and operations needs may also be considered when selecting traffic control devices or strategies. These additional factors may be used with engineering judgment to adjust upward or downward from the initial traffic control device selection.
### Table 4A-101. Grouping of Traffic Control Device Alternatives Based on Conditions at Uncontrolled Crossing Locations

<table>
<thead>
<tr>
<th>Recurring Hourly Pedestrian (PED) Crossing Volume</th>
<th>Vehicular Traffic Volume and Speed</th>
<th>Speed (MPH)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vehicle AADT (vpd)</td>
<td>&lt;4500</td>
</tr>
<tr>
<td>No. of Lanes</td>
<td>Raised Median or Refuge?</td>
<td>All</td>
</tr>
<tr>
<td>&lt; 20 /hr</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>&gt;=20 /hr</td>
<td>2,3</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>&gt;=4</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>&gt;=4</td>
<td>No</td>
</tr>
</tbody>
</table>

**School Crossing**
- EW - See Part 7 for school routes, beacon systems, and Part 4 for Signal Warrants
- ER - See Part 4 for Pedestrian Hybrid Beacon Guidelines and School Crossing Warrants (Engineering Study required)

**Device Grouping**
- NE: Non-electrical devices (sight distance, signs, striping, medians, etc.)
- EW: Electrical warning devices (beacons, lighting, sign borders, in-pavement lights, etc.)
- ER: Electrical regulatory devices (hybrid beacons, signals)

**Abbreviations**
- vpd: vehicles per day (typically annual average daily traffic or ADT)
- AADT: Annual Average Daily Traffic (volume in vehicles per day)
- MPH: Miles per hour

**PED Crossing Volume:** Frequent and recurring, e.g. average annual peak hourly volume or seasonal peak hourly volume over three months or more
- Reduce PED volume to 15 / hr for NE, EW devices, or by by 50% for ER devices if elderly and/or child pedestrians recur frequently.
### Table 4A-102. Recommended Order of Selection for Traffic Control Devices or Strategies at Uncontrolled Crossing Locations

<table>
<thead>
<tr>
<th>PED VOLUME</th>
<th>SAFETY HISTORY</th>
<th>SIGHT DISTANCE</th>
<th>GAPS</th>
<th>TRAFFIC CONTROL STRATEGIES FOR A CROSSING LOCATION</th>
<th>ORDER OF DEVICE SELECTION</th>
<th>OPTIONAL DEVICES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NE - Non-electrical&lt;sup&gt;1&lt;/sup&gt;</td>
<td>&gt; 20/hr and factors 2, 3, or 4</td>
<td>&gt; 75 %ile crash history, primarily crossing related</td>
<td>Above Minimum SSD</td>
<td>Devices not provided for sites with adequate gaps, good visibility, low pedestrian volume or low crash history</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;= 20/hr factors 2, 3, or 4</td>
<td>&gt; 75 %ile crash history, primarily crossing related</td>
<td>Above Minimum SSD, Above minimum SSD</td>
<td>Locate or provide alternative crossing location (primarily to improve sight distance)</td>
<td>Increasing Command of Attention/Respect</td>
<td>LED bollards for walkways (primarily used in transit areas)</td>
</tr>
<tr>
<td>EW - Electrical Warning</td>
<td>&gt;20/hr factors 2, 3, or 4 OR &gt;75/hr</td>
<td>&gt; 75 %ile crash history, primarily crossing related</td>
<td>Below Minimum PSD, Above minimum SSD with high visibility devices</td>
<td>Pedestrian street lighting electrolier(s)</td>
<td>Ped Activated Rectangular Rapid Flashing Beacons RRFB (when &gt;=40 MPH; &gt;2 lanes; or roundabout exits)</td>
<td>Continuous single roundel LED beacon above sign&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>&gt;= 20/hr factors 2, 3, or 4 OR &gt;75/hr</td>
<td>&gt; 75 %ile crash history, primarily crossing related</td>
<td>Below Minimum PSD, Above minimum SSD</td>
<td>Overhead active alternating LED beacon with camera detection&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Continuous single Overhead LED beacon</td>
<td>Continuous single LED flashing borders in-sign&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>ER - Electrical Regulatory&lt;sup&gt;4&lt;/sup&gt;</td>
<td>&gt;= 20/hr</td>
<td>&gt; 95 %ile crash history, primarily crossing related</td>
<td>Below Minimum SSD, Above minimum SSD</td>
<td>Pedestrian Hybrid Beacon (Engineering Study required)</td>
<td>Signal, Midblock signal, or Half-signal (Engineering Study required)</td>
<td>Other electrical warning devices</td>
</tr>
<tr>
<td></td>
<td>&gt;= 75/hr</td>
<td>&gt; 95 %ile crash history, primarily crossing related</td>
<td>Below Minimum SSD</td>
<td>Pedestrian Hybrid Beacon (Engineering Study required)</td>
<td>Signal, Midblock signal, or Half-signal (Engineering Study required)</td>
<td>Other electrical warning devices</td>
</tr>
</tbody>
</table>

**FOOTNOTES to Table 4A-102**

1. NE - non-electrical project solutions are acceptable until an electrical project can be determined as needed
2. Median refuge may be used to convert undesirable gaps into adequate two stage gaps
3. Consider portable in-street signs primarily for special events and school control. These require active on-site oversight.
4. Provide overhead lighting at marked crosswalks when feasible to address nighttime pedestrian issues
5. Active flashing beacon systems are preferable to passive beacon systems<sup>2</sup>
6. Flashing beacon systems may be used to mark zones not identifiable as a single crossing, or areas without overhead lighting
7. In pavement lights should only be considered in a low risk environment for damage, where there is extensive maintenance capability
8. Should be 1/4 mile or more from existing signals on arterial 2 way roadways, unless coordinated with existing signals

**DEVICE GROUPING**

- NE: Non-electrical devices. (See Section 3B.18.)
- EW: Electrical warning devices - use at unsignalized, midblock locations where conflict with signals is not a concern.
- ER: Electrical regulatory devices.
- OP: Optional devices which are low priority enhancements due to frequent maintenance and resource limitations

**SAFETY HISTORY**

- %ile: Percentile grouping of locations based on analysis of statewide crossing-related ped-vehicle crash data
- Analysis of ped-vehicle crash data related to crossing attempts, including experience at locations with similar characteristics

**SIGHT DISTANCE**

- Visual: Unobstructed road distance visible to a pedestrian or motorist providing time necessary to execute crossing or driving maneuvers
- Motorist Stopping Sight Distance (SSD) = (2.5 x Crossing Distance/3.5 fps) x Posted Speed fps

**GAPS**

- %ile: Percentile grouping of locations based on analysis of statewide crossing-related ped-vehicle crash data
- Pedestrian Safety Distance (PSD) = (2.5 s + Crossing Distance x 3.5 fps) x Posted Speed fps

**LED**

- Average measurement per hour
- Light Emitting Diode or alternative light source

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**ATMS to the 2009 MUTCD, with Rev. 1 & 2**

**Sec.4A.100**