Washington County

Uncontrolled Multi-Lane Crosswalks: Hazards, Screening, and Prioritization

Joe Gustafson, PE, PTOE
Minnesota Toward Zero Deaths Conference
October 23rd, 2018

Multiple Threat Crashes

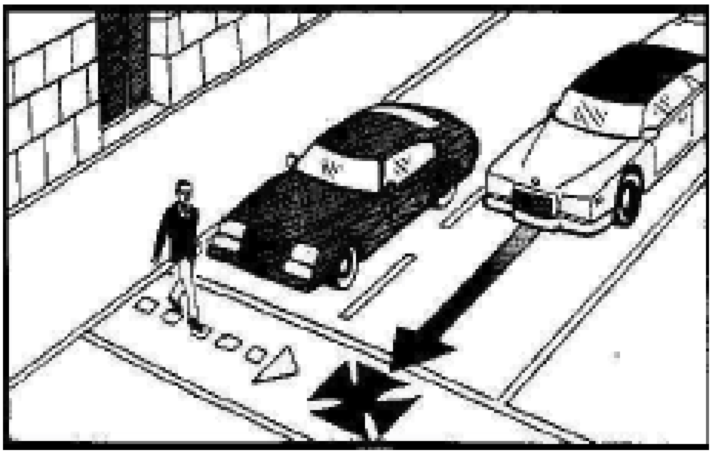


Image from Zegeer, et. al, 2005 - https://www.fhwa.dot.gov/publications/research/safety/04100/

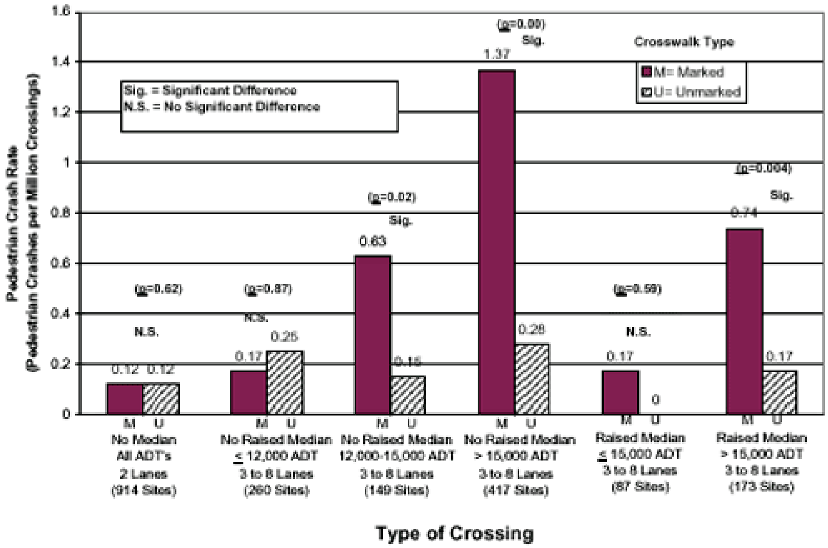
Multiple Threat Crashes

US50 at Tedford Ln, Fallon, Nevada ("From World's Wildest Police Videos")

Multiple Threat Crashes

- Pedestrians, too often, do NOT adequately check the next lane
- Usually the inner lane, but not always
- Most crosswalks are <u>at intersections</u>
  - State law prohibits passing another vehicle that is yielding to a pedestrian, but the pedestrian may not be visible
  - Stopping vehicles can be, and are, mistaken for turning vehicles

Markings Reduce Safety



Zegeer, et. al, 2005 - https://www.fhwa.dot.gov/publications/research/safety/04100/

"We need to reduce speeds"

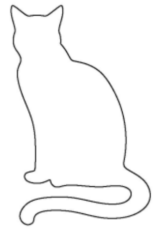
"We need more education"

"We need more enforcement"

"We need narrower crossings"

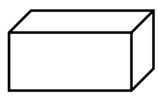
Multiple Threat Crosswalk Analysis Tool (MTCAT)

The MTCAT spreadsheet
makes it possible to calculate
the maximum vehicle speed
at which a driver is able to react
and avoid colliding with a pedestrian
who is crossing at a constant speed.



How Slow is Slow Enough?

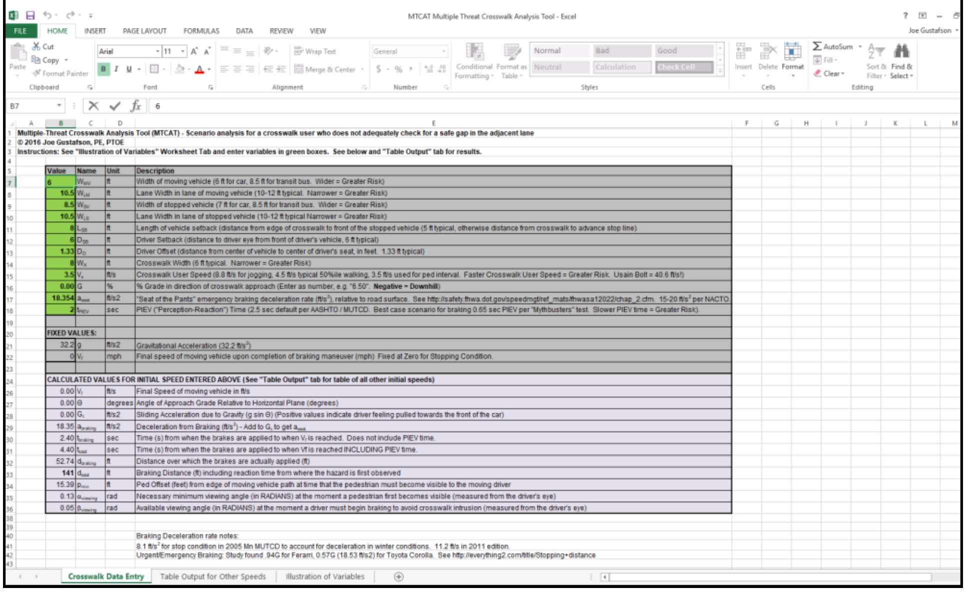
- MTCAT spreadsheet uses a few basic assumptions:
  - Vehicles are box-shaped, and tall
    - Ignores rounded vehicle corners.
    - Assumes it's not possible to see under or over.
    - BUT, many vehicles do fit this description.
  - The pedestrian crosses at a constant speed and does not check the adjacent lane for traffic.
  - Any crosswalk intrusion = presumed crash



How Slow is Slow Enough?

- MTCAT spreadsheet allows for numerous variables:
  - PIEV (“perception-reaction”) time
  - Deceleration rate
  - Crosswalk user speed
  - Crosswalk width
  - Lane Width
  - Vehicle width
  - Advance stopping position
  - And more

Input Screen



Multiple-Threat Crosswalk Analysis Tool (MTCAT) - Scenario analysis for a crosswalk user who does not adequately check for a safe gap in the adjacent lane

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Instructions: See "Illustration of Variables" Worksheet Tab and enter variables in green boxes. See below and "Table Output" tab for results.

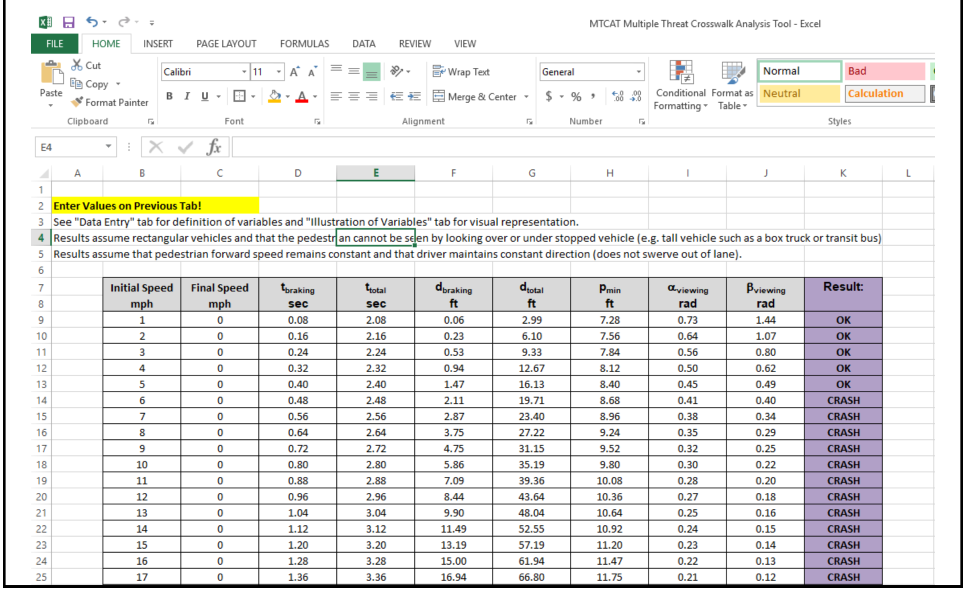
Value	Name	Unit	Description
6	W_{MV}	ft	Width of moving vehicle (6 ft for car, 8.5 ft for transit bus. Wider = Greater Risk)
10.5	W_{LM}	ft	Lane Width in lane of moving vehicle (10-12 ft typical. Narrower = Greater Risk)
8.5	W_{SV}	ft	Width of stopped vehicle (7 ft for car, 8.5 ft for transit bus. Wider = Greater Risk)
10.5	W_{LS}	ft	Lane Width in lane of stopped vehicle (10-12 ft typical Narrower = Greater Risk)
8	L_{SB}	ft	Length of vehicle setback (distance from edge of crosswalk to front of the stopped vehicle (5 ft typical, otherwise distance from crosswalk to advance stop line)
6	D_{SB}	ft	Driver Setback (distance to driver eye from front of driver's vehicle, 6 ft typical)
1.33	D_O	ft	Driver Offset (distance from center of vehicle to center of driver's seat, in feet. 1.33 ft typical)
8	W_X	ft	Crosswalk Width (6 ft typical. Narrower = Greater Risk)
3.5	V_x	ft/s	Crosswalk User Speed (8.8 ft/s for jogging, 4.5 ft/s typical 50%ile walking, 3.5 ft/s used for ped interval. Faster Crosswalk User Speed = Greater Risk. Usain Bolt = 40.6 ft/s!)
0.00	G	%	% Grade in direction of crosswalk approach (Enter as number, e.g. "6.50". **Negative = Downhill**)
18.354	a_{seat}	ft/s2	"Seat of the Pants" emergency braking deceleration rate (ft/s^2), relative to road surface. See http://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa12022/chap_2.cfm. 15-20 ft/s^2 per NACTO
2	t_{PIEV}	sec	PIEV ("Perception-Reaction") Time (2.5 sec default per AASHTO / MUTCD. Best case scenario for braking 0.65 sec PIEV per "Mythbusters" test. Slower PIEV time = Greater Risk).
FIXED VALUES:			
32.2	g	ft/s2	Gravitational Acceleration (32.2 ft/s^2)
0	V_f	mph	Final speed of moving vehicle upon completion of braking maneuver (mph) Fixed at Zero for Stopping Condition.
CALCULATED VALUES FOR INITIAL SPEED ENTERED ABOVE (See "Table Output" tab for table of all other initial speeds)			
0.00	V_f	ft/s	Final Speed of moving vehicle in ft/s
0.00	Θ	degrees	Angle of Approach Grade Relative to Horizontal Plane (degrees)
0.00	G_s	ft/s2	Sliding Acceleration due to Gravity (g sin Θ) (Positive values indicate driver feeling pulled towards the front of the car)
18.35	$a_{braking}$	ft/s2	Deceleration from Braking (ft/s^2) - Add to G_s to get a_{seat}
2.40	$t_{braking}$	sec	Time (s) from when the brakes are applied to when V_f is reached. Does not include PIEV time.
4.40	t_{total}	sec	Time (s) from when the brakes are applied to when Vf is reached INCLUDING PIEV time.
52.74	$d_{braking}$	ft	Distance over which the brakes are actually applied (ft)
141	d_{total}	ft	Braking Distance (ft) including reaction time from where the hazard is first observed
15.39	p_{min}	ft	Ped Offset (feet) from edge of moving vehicle path at time that the pedestrian must become visible to the moving driver
0.13	$\alpha_{viewing}$	rad	Necessary minimum viewing angle (in RADIANS) at the moment a pedestrian first becomes visible (measured from the driver's eye)
0.05	$\beta_{viewing}$	rad	Available viewing angle (in RADIANS) at the moment a driver must begin braking to avoid crosswalk intrusion (measured from the driver's eye)

Braking Deceleration rate notes:

8.1 ft/s^2 for stop condition in 2005 Mn MUTCD to account for deceleration in winter conditions. 11.2 ft/s in 2011 edition.

Urgent/Emergency Braking: Study found .94G for Ferarri, 0.57G (18.53 ft/s2) for Toyota Corolla. See http://everything2.com/title/Stopping+distance

Output Screen



Enter Values on Previous Tab!

See "Data Entry" tab for definition of variables and "Illustration of Variables" tab for visual representation.

Results assume rectangular vehicles and that the pedestrian cannot be seen by looking over or under stopped vehicle (e.g. tall vehicle such as a box truck or transit bus)

Results assume that pedestrian forward speed remains constant and that driver maintains constant direction (does not swerve out of lane).

Initial Speed	Final Speed	$t_{braking}$	t_{total}	$d_{braking}$	d_{total}	p_{min}	$\alpha_{viewing}$	$\beta_{viewing}$	Result:
mph	mph	sec	sec	ft	ft	ft	rad	rad	
1	0	0.08	2.08	0.06	2.99	7.28	0.73	1.44	OK
2	0	0.16	2.16	0.23	6.10	7.56	0.64	1.07	OK
3	0	0.24	2.24	0.53	9.33	7.84	0.56	0.80	OK
4	0	0.32	2.32	0.94	12.67	8.12	0.50	0.62	OK
5	0	0.40	2.40	1.47	16.13	8.40	0.45	0.49	OK
6	0	0.48	2.48	2.11	19.71	8.68	0.41	0.40	CRASH
7	0	0.56	2.56	2.87	23.40	8.96	0.38	0.34	CRASH
8	0	0.64	2.64	3.75	27.22	9.24	0.35	0.29	CRASH
9	0	0.72	2.72	4.75	31.15	9.52	0.32	0.25	CRASH
10	0	0.80	2.80	5.86	35.19	9.80	0.30	0.22	CRASH
11	0	0.88	2.88	7.09	39.36	10.08	0.28	0.20	CRASH
12	0	0.96	2.96	8.44	43.64	10.36	0.27	0.18	CRASH
13	0	1.04	3.04	9.90	48.04	10.64	0.25	0.16	CRASH
14	0	1.12	3.12	11.49	52.55	10.92	0.24	0.15	CRASH
15	0	1.20	3.20	13.19	57.19	11.20	0.23	0.14	CRASH
16	0	1.28	3.28	15.00	61.94	11.47	0.22	0.13	CRASH
17	0	1.36	3.36	16.94	66.80	11.75	0.21	0.12	CRASH

The results are frightening

- Consider the following situation:
  - **12** ft lanes
  - **6 ft** wide moving car, **6.5 ft** stopped SUV
  - Stopped SUV is 5 ft from the crosswalk
  - Crosswalk is 6 ft wide
  - Pedestrian moving at **4.5** ft/s
  - Flat grade, locked-wheel braking (0.57G)
  - **2.5** second PIEV (Normal value = 2.5 sec)
  - A driver traveling at just **3 MPH** will be unable to avoid hitting the pedestrian!

The results are frightening

- Urban example:
  - **10.5** ft lanes
  - **6 ft** wide moving car, **8.5** ft stopped bus
  - Stopped bus is **8 ft** from the crosswalk
  - Wider crosswalk – **8 ft** wide
  - Slower pedestrian - **3.5** ft/s
  - Flat grade, locked-wheel braking (0.57G)
  - **1.0** second PIEV (Normal value = 2.5 sec)
  - A driver traveling at just **13 MPH** will be unable to avoid hitting the pedestrian!

We need to ask…

Is it realistic to expect
that we can condition drivers
through education and/or enforcement
to slow down enough every time that
they pass a stopped vehicle?

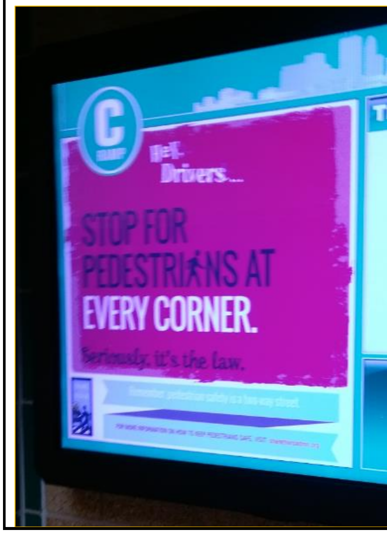
To 13 mph?

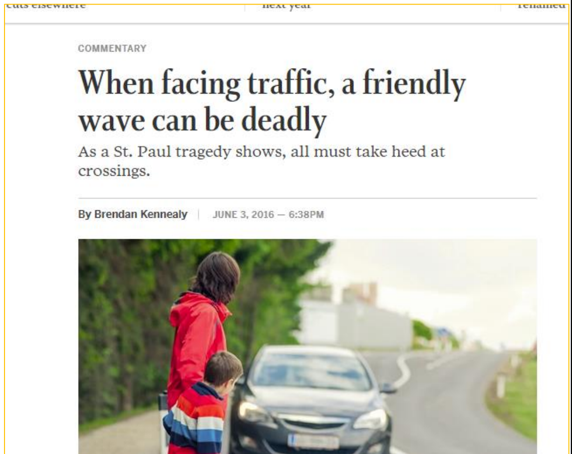
To 3 mph?

Some Key Takeaways

- Reaction time has a large effect
- The stopping setback from the crosswalk has a large effect
- Pedestrian speed has a large effect
- Narrower lanes worsen this scenario
  - Creates a tighter sight triangle
  - Minimal effect on speeds
- Many such crossings are “induced”

Induced Crossings





COMMENTARY

When facing traffic, a friendly wave can be deadly

As a St. Paul tragedy shows, all must take heed at crossings.

By Brendan Kennealy | JUNE 3, 2016 — 6:38PM

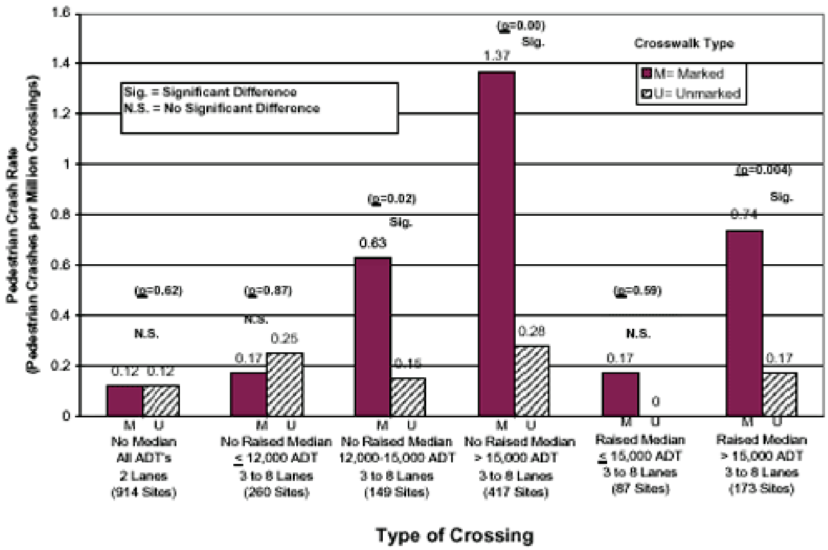
http://www.startribune.com/when-facing-traffic-a-friendly-wave-can-be-deadly/381831081/

The Agency Dilemma

- At intersections, the rules of right-of-way are the same, with or without markings.
- The multiple-threat crash can occur even without markings.
  - But markings DO influence crash rates.
  - Removing the markings should reduce crashes by about 75%
  - Leaving “as-is” is not a good strategy
  - Removing markings is better, still not good.

County-Wide Screening

- Washington County has 42 marked uncontrolled multi-lane crosswalks on our system
- <u>All but 11</u> of these are on roundabout entries or exits (low speed + refuge)
- Crosswalk user counts not available
- Point system developed



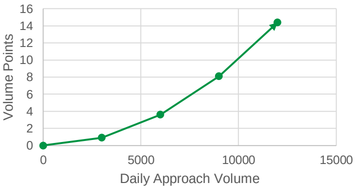
Zegeer, et. al, 2005 - https://www.fhwa.dot.gov/publications/research/safety/04100/

County-Wide Screening

- Risk points assigned as follows:
  - Lane Points (per direction):
    - Turn lanes = 1 pt each (low speed & volume)
    - One thru lane = 2 pts
    - Plus 4 pts for each additional thru lane
      - Example: 3 thru lanes = 10 pts
  - Speed Points:
    - 15 mph = 0 pts
    - Add 1 pt for each 5 mph above 15 mph

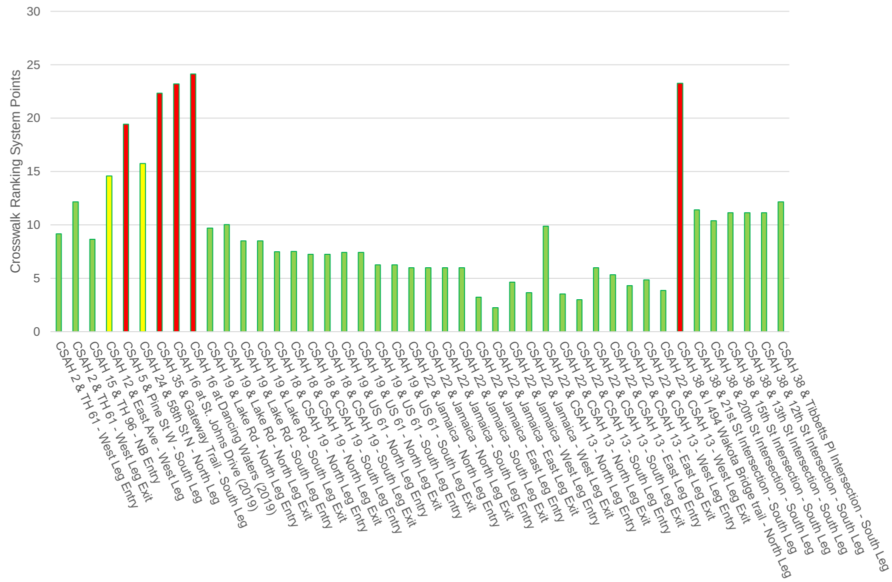
County-Wide Screening

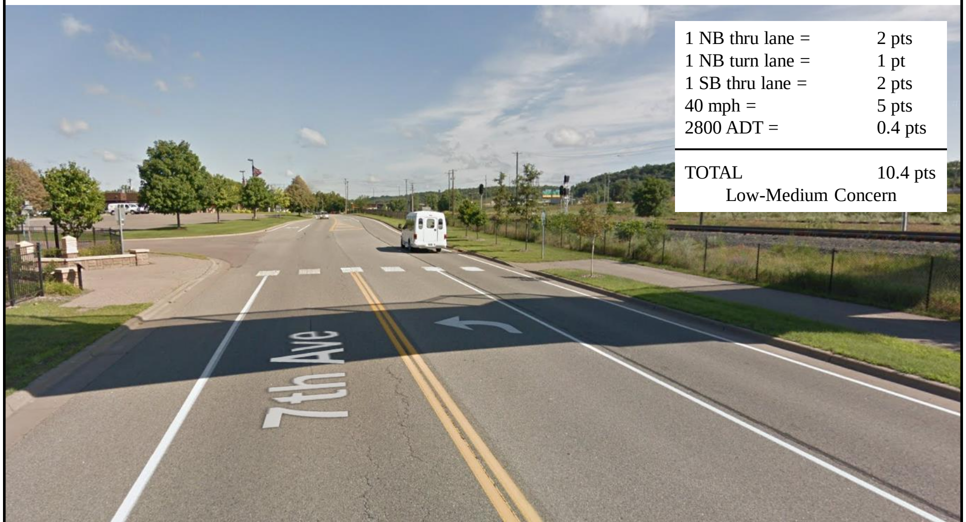
- [Continued]
  - Volume Points assigned <u>per approach</u> using a formula ($ADT^2 / 10^7$)
    - 3000 ADT = 0.9 pt
    - 6000 ADT = 3.6 pts
    - 9000 ADT = 8.1 pts
    - 12,000 ADT = 14.4 pts
    - 15,000 ADT = 22.5 pts

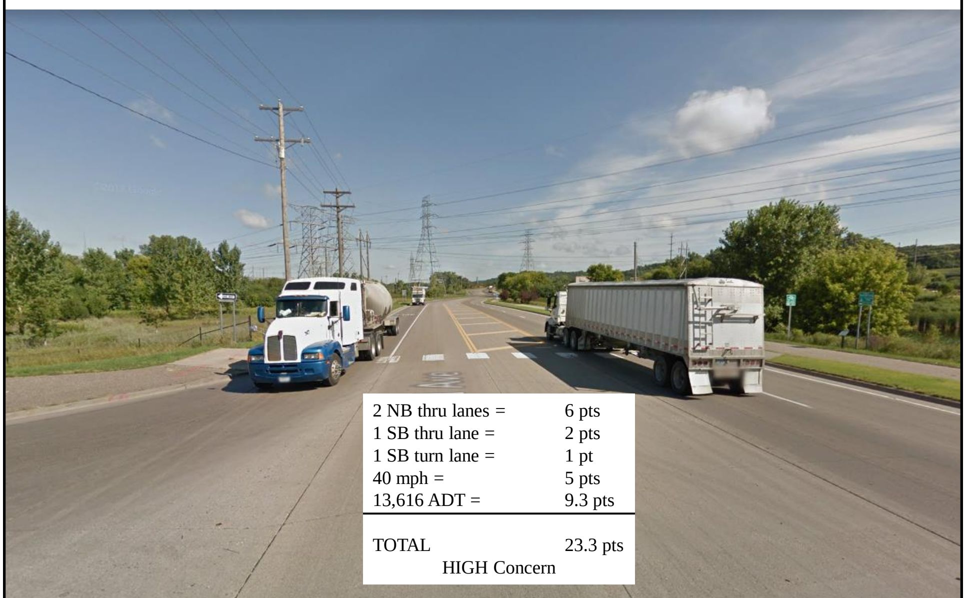


  - Crosswalks with refuge islands are scored as two separate crosswalks

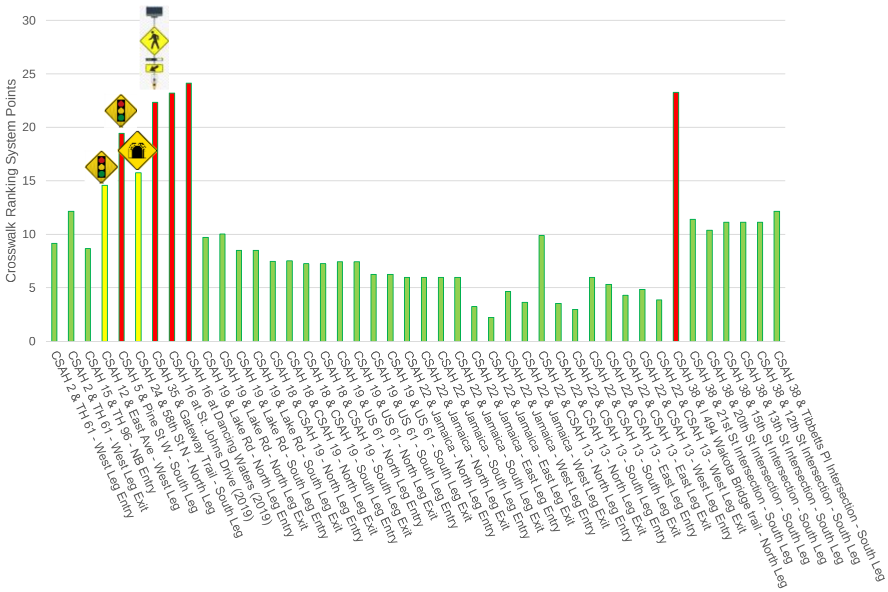
County-Wide Screening




1 NB thru lane = 2 pts
1 NB turn lane = 1 pt
1 SB thru lane = 2 pts
40 mph = 5 pts
2800 ADT = 0.4 pts
TOTAL 10.4 pts
Low-Medium Concern
7th Ave


2 NB thru lanes = 6 pts
1 SB thru lane = 2 pts
1 SB turn lane = 1 pt
40 mph = 5 pts
13,616 ADT = 9.3 pts
TOTAL 23.3 pts
HIGH Concern

Planned Improvements



Thank you!

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