# So You Want to Build a Cross Section

Concepts, Principles, and Practices

## Balancing a Multimodal Design:
## *A new challenge for designers*

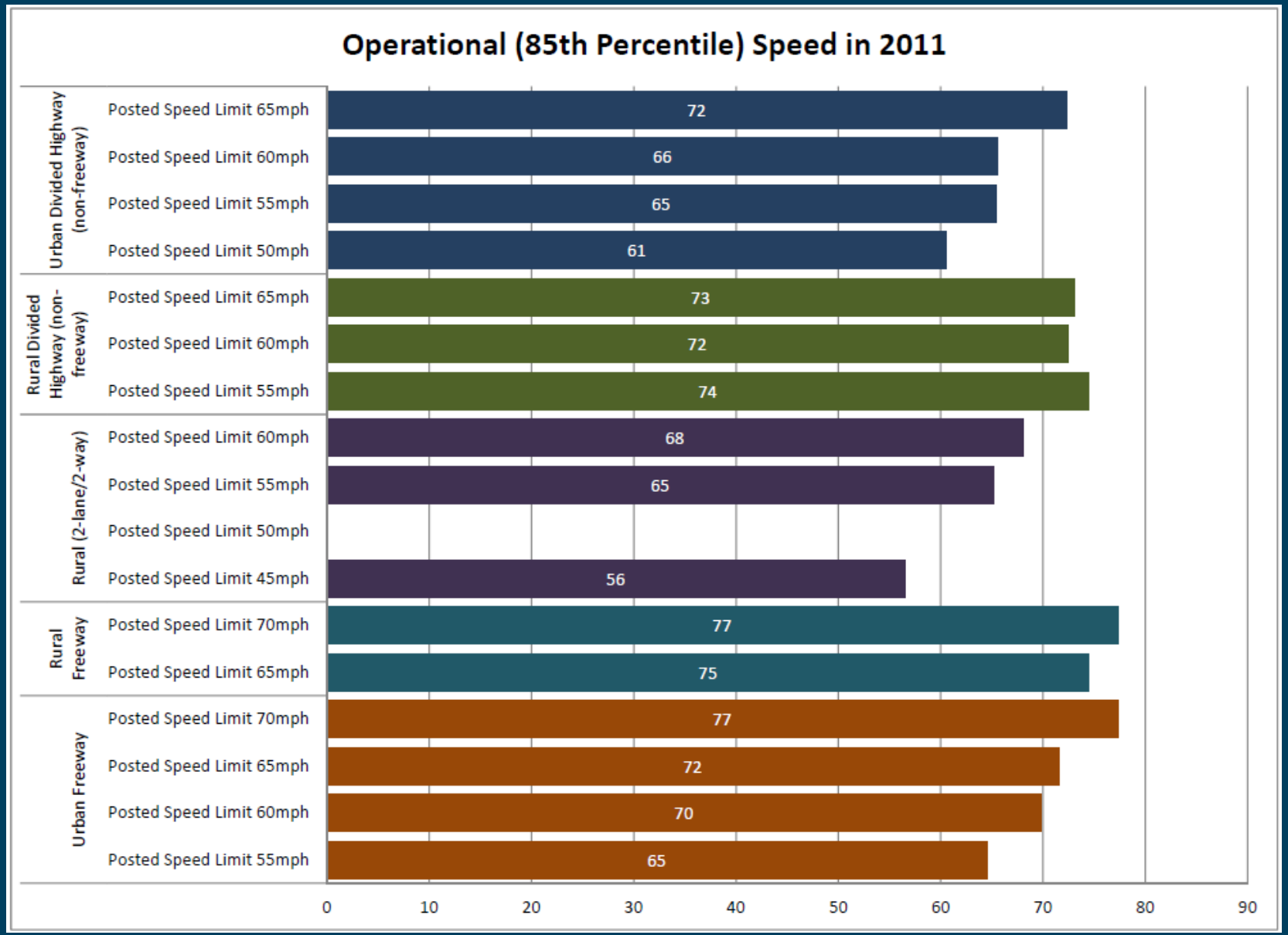
**2013–2014 MnDOT Context Sensitive Solutions**

**Webinar**

**February 18, 2014**

# Chat Page

- Online participants are encouraged to engage in and add to the discussion.
- Submit comments and questions any time by clicking the upper left gold box on your screen – this will take you to the chat page: www.cts.umn.edu/contextsensitive/workshops/crosssection/
- Sign in to your Chatroll account, or sign in using your Facebook or Twitter account. We have asked pre-registrants to create a chat log in ahead of time. It simple to create an account.


Operational (85th Percentile) Speed in 2011
Urban Divided Highway (non-freeway)
Posted Speed Limit 65mph
72
Posted Speed Limit 60mph
66
Posted Speed Limit 55mph
65
Posted Speed Limit 50mph
61
Rural Divided Highway (non-freeway)
Posted Speed Limit 65mph
73
Posted Speed Limit 60mph
72
Posted Speed Limit 55mph
74
Rural (2-lane/2-way)
Posted Speed Limit 60mph
68
Posted Speed Limit 55mph
65
Posted Speed Limit 50mph
Posted Speed Limit 45mph
56
Rural Freeway
Posted Speed Limit 70mph
77
Posted Speed Limit 65mph
75
Urban Freeway
Posted Speed Limit 70mph
77
Posted Speed Limit 65mph
72
Posted Speed Limit 60mph
70
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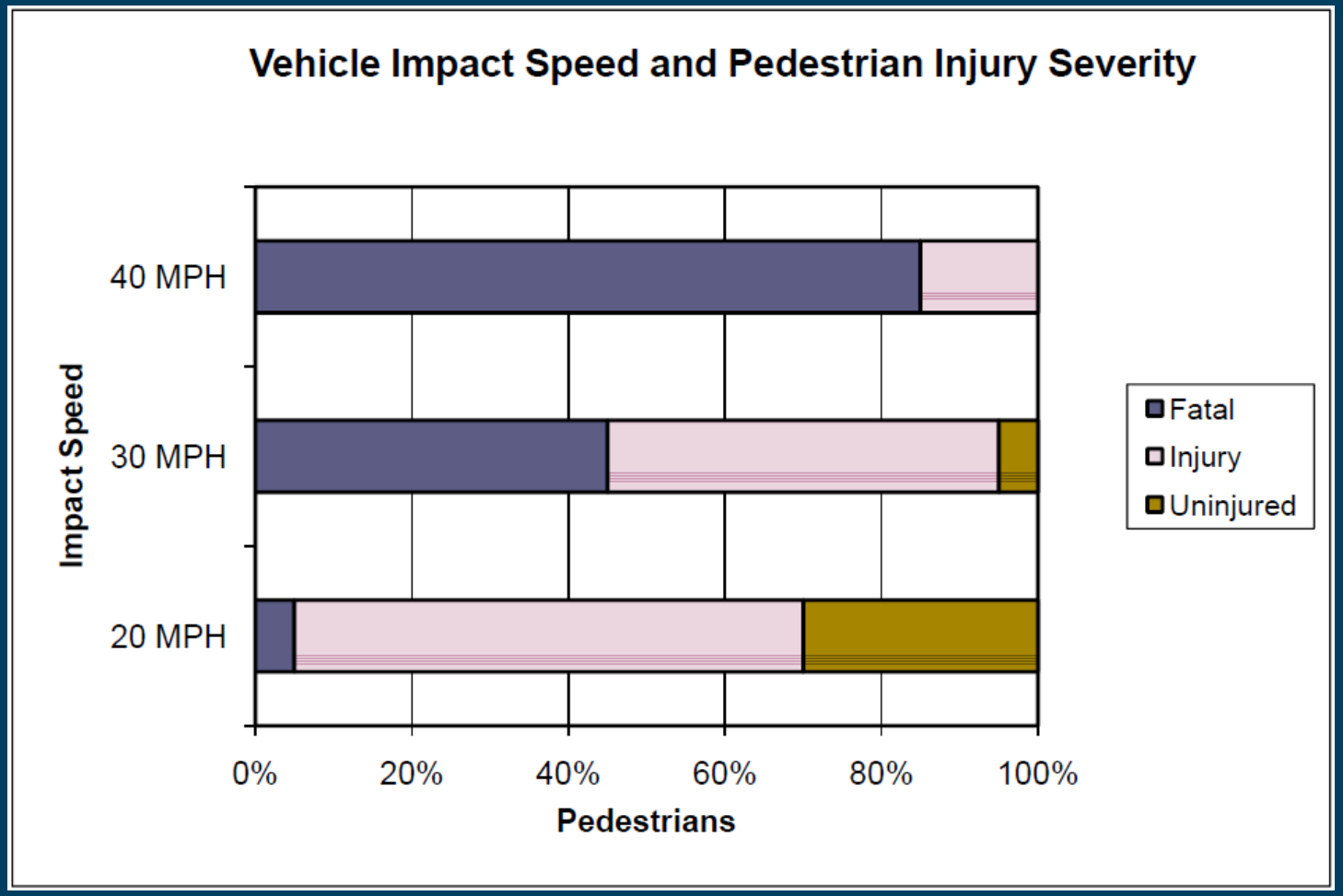
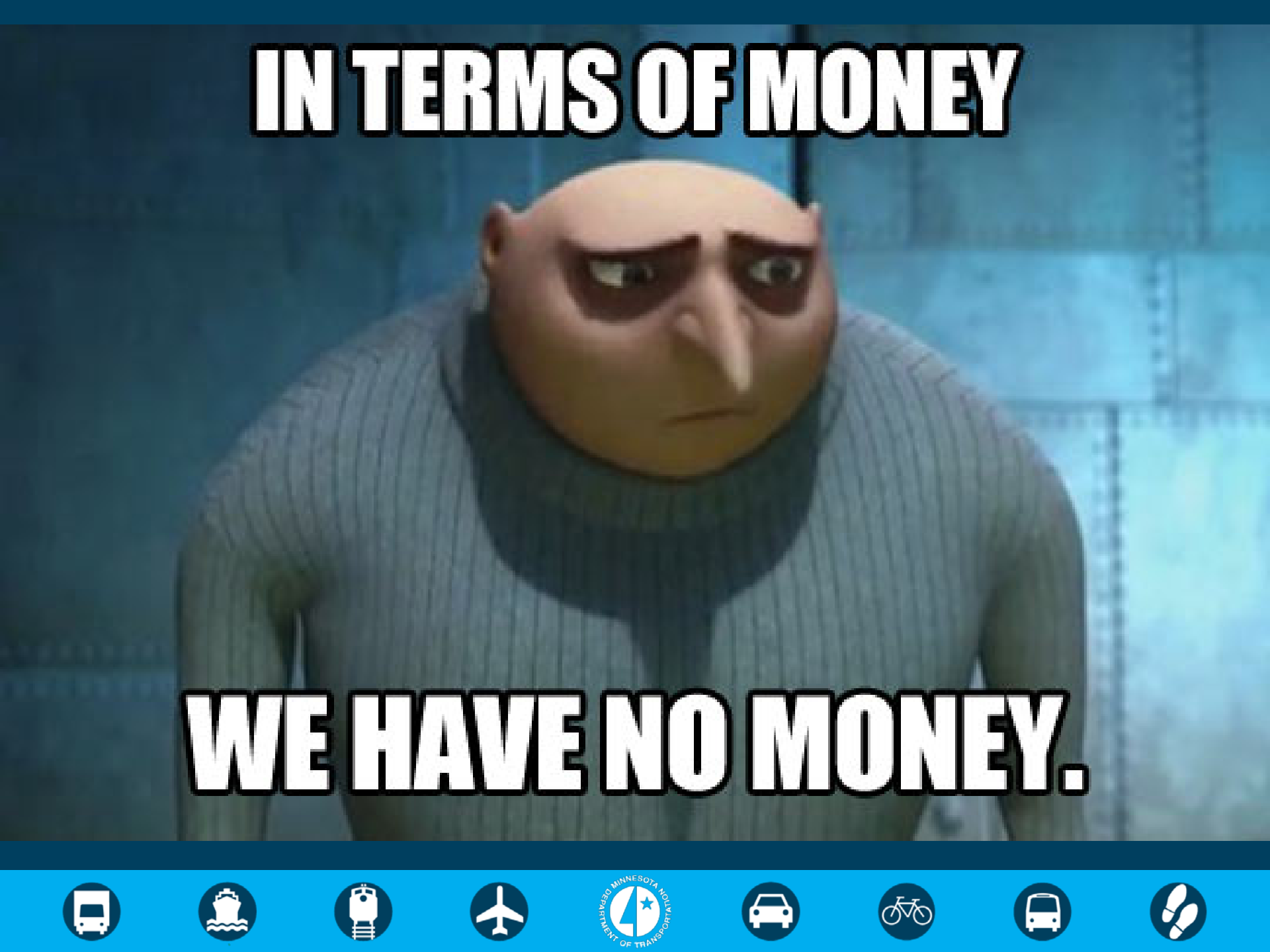
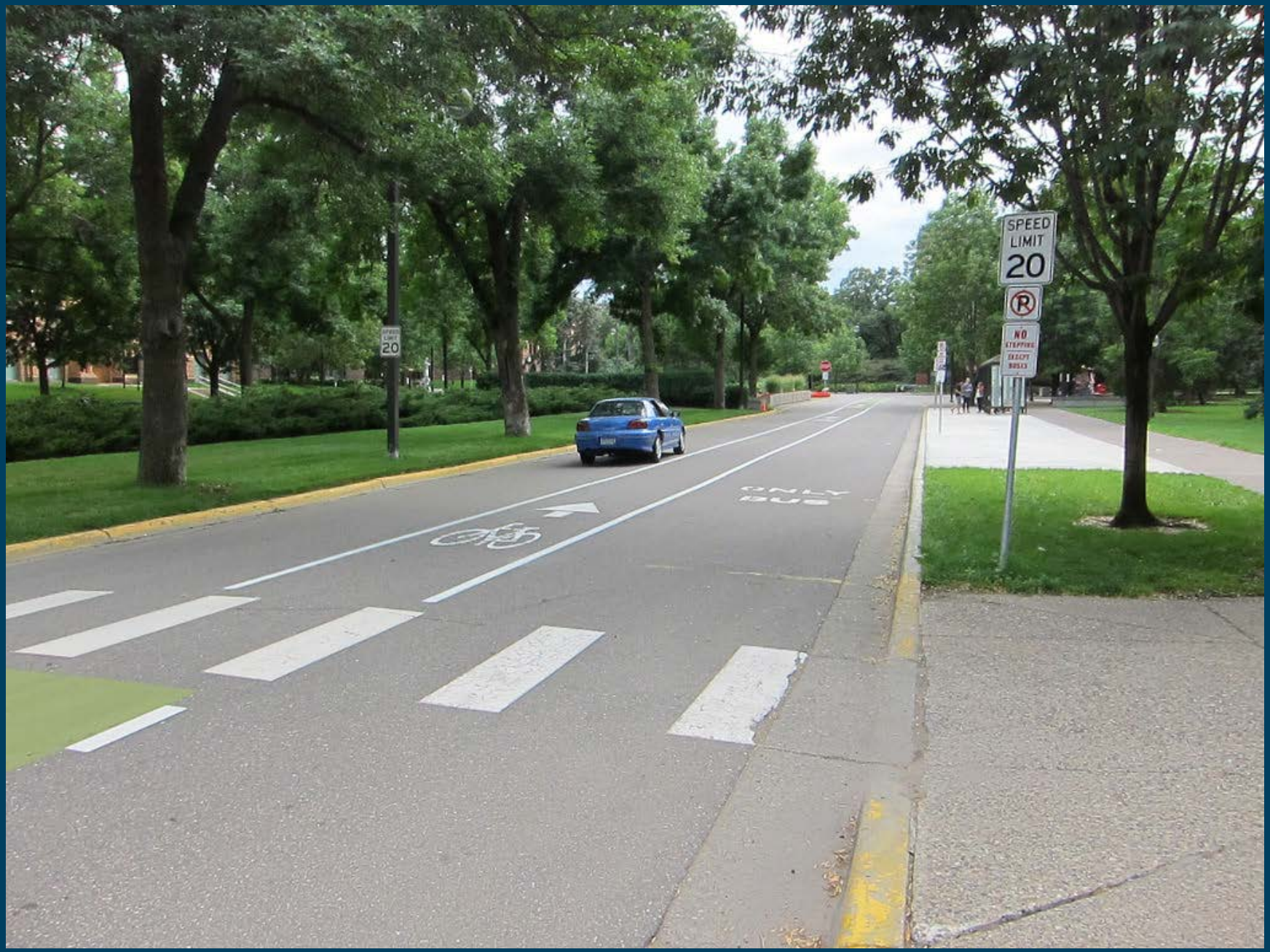
90




# The cost of speed in towns and cities

Source: UK Department of Transport


IN TERMS OF MONEY
WE HAVE NO MONEY.


SPEED
LIMIT
20
NO
STOPPING
EXCEPT
BUSES
ONLY
BUS



Jim Rosenow
Flexible Design Engineer

Derek Leuer
Traffic Safety Engineer

David Larson
Principal Landscape Architect




Charleen Zimmer
Transportation Planner



*Appropriate Transportation Solutions*


Jack Broz
Transportation Engineer


# Agenda

- Overview Complete Street Design Process
- Rural Main Streets
- Constrained Urban Streets

# Complete Street Design Process


- Iterative Process
- Major Challenges
  - Community
  - Traffic Analysis
  - Target Operating Speed
  - Allocation of Space
  - Intersections

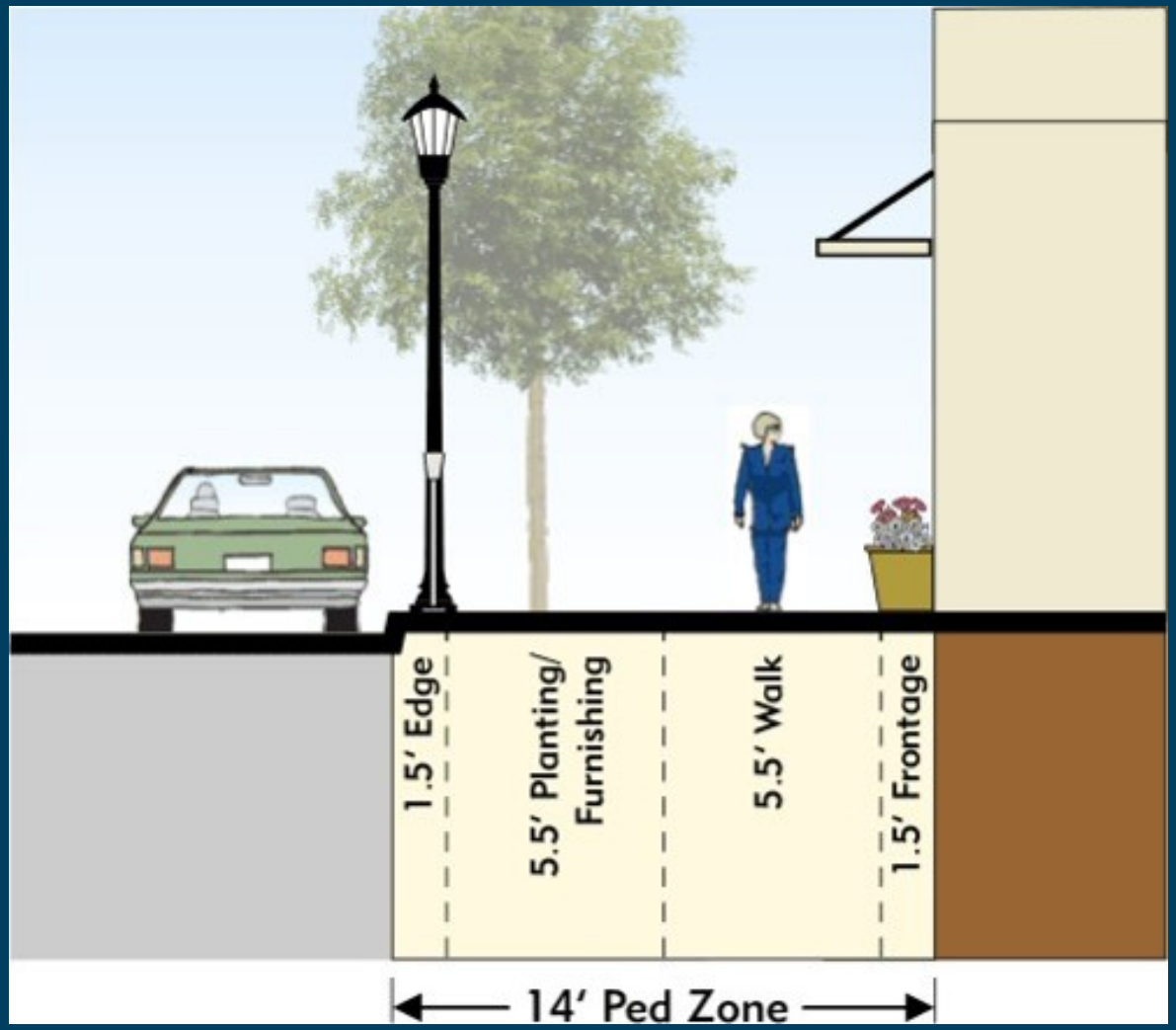
# Key Principles

- Think “type of community” – not “type of roadway” – give community values and needs a high priority

# Key Principles

- Think “outside in” rather than “inside out”
- Allocate space first to most vulnerable users

# Components of Pedestrian Realm



# Design Element Spotlight

## Bicycle Lanes


CHEVROLET

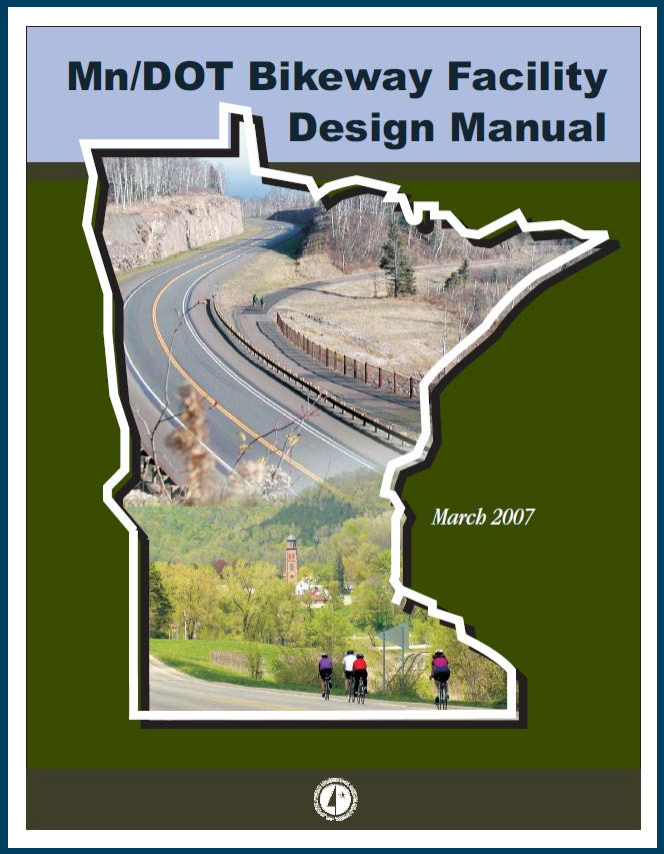



**Table 4-1: Bikeway Design Selection for Urban (Curb and Gutter) Cross Section – English Units**

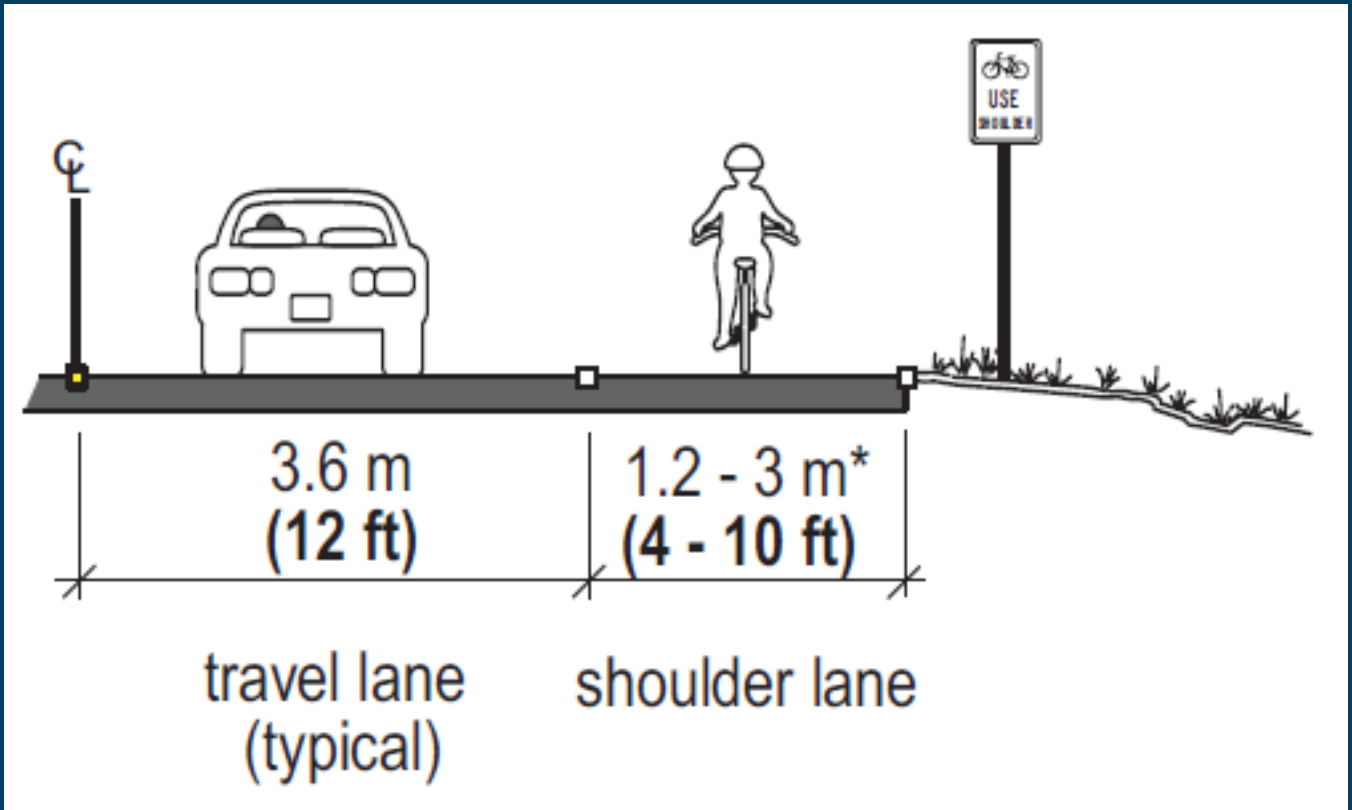
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Motor Vehicle ADT (2 Lane)** | | <500 | 500-1,000 | 1,000-2,000 | 2,000-5,000 | 5,000-10,000 | >10,000 |
| **Motor Vehicle ADT (4 Lane)** | | N/A | N/A | 2,000-4,000 | 4,000-10,000 | 10,000-20,000 | >20,000 |
| **Motor Vehicle Speed** | 25 mph | SL | WOL | WOL | WOL | BL = 5 ft | Not Applicable |
| | 30 mph | SL with sign | WOL | BL = 5 ft | BL = 5 ft | BL = 6 ft | BL = 6 ft |
| | 35 - 40 mph | WOL | BL = 5 ft | BL = 5 ft | BL = 6 ft | BL = 6 ft | BL = 6 ft or PS = 8 ft |
| | 45 mph and greater | BL = 5 ft | BL = 5 ft | BL = 6 ft | BL = 6 ft | BL = 6 ft or PS = 8 ft | SUP or PS= 10 ft |

BL = Bicycle Lane, SL = Shared Lane, WOL = Wide Outside Lane, SUP = Shared-Use Path, PS = Paved Shoulder

**Table 4-2: Bikeway Design Selection for Rural (Shoulder and Ditch) Cross Section – English Units**

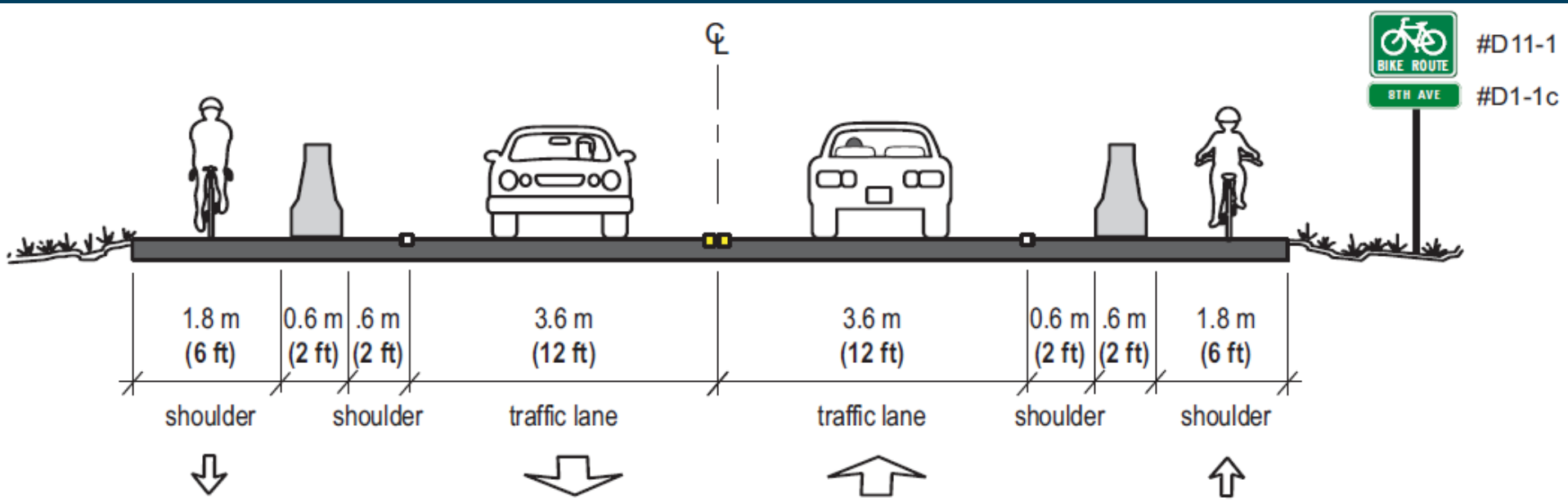
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Motor Vehicle ADT (2 Lane)** | | <500 | 500-1,000 | 1,000-2,000 | 2,000-5,000 | 5,000-10,000 | >10,000 |
| **Motor Vehicle ADT (4 Lane)** | | N/A | N/A | 2,000-4,000 | 4,000-10,000 | 10,000-20,000 | >20,000 |
| **Motor Vehicle Speed** | 25 mph | PS = 4 ft* or SL | PS = 4 ft* or SL | PS = 4 ft* or WOL | PS = 4 ft* | PS = 4 ft* | Not Applicable |
| | 30 mph | PS = 4 ft* or SL | PS = 4 ft* or WOL | PS = 4 ft* | PS = 4 ft* | PS = 6 ft | PS = 6 ft |
| | 35 - 40 mph | PS = 4 ft* or SL | PS = 4 ft* or WOL | PS = 6 ft | PS = 6 ft | PS = 6 ft | PS = 8 ft |
| | 45 mph and greater | PS = 4 ft* | PS = 4 ft* | PS = 6 ft | PS = 8 ft | PS = 8 ft | SUP or PS= 10 ft |

* See discussion in Section 4-3.1 regarding rumble strips on 4-foot shoulders.
PS = Paved Shoulder, SL = Shared Lane, SUP = Shared-Use Path, WOL = Wide Outside Lane



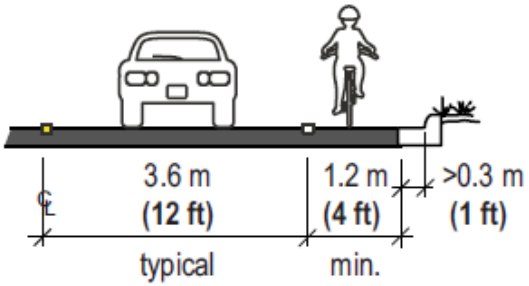

# Rural highway shoulder

MnDOT Bikeway Facility Design Manual

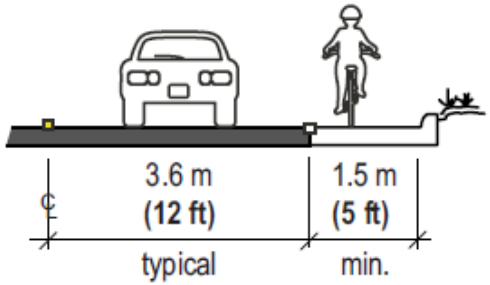



# Rural highway shoulder

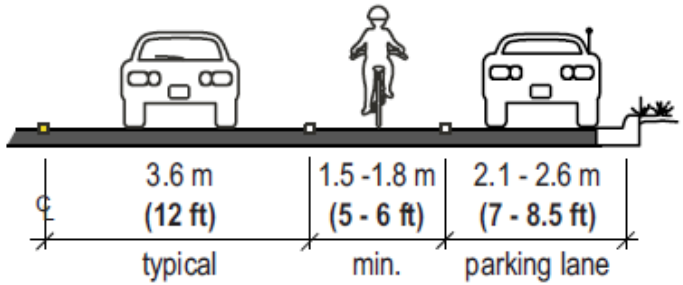
MnDOT Bikeway Facility Design Manual




NO PARKING
WITH STANDARD
GUTTER PAN



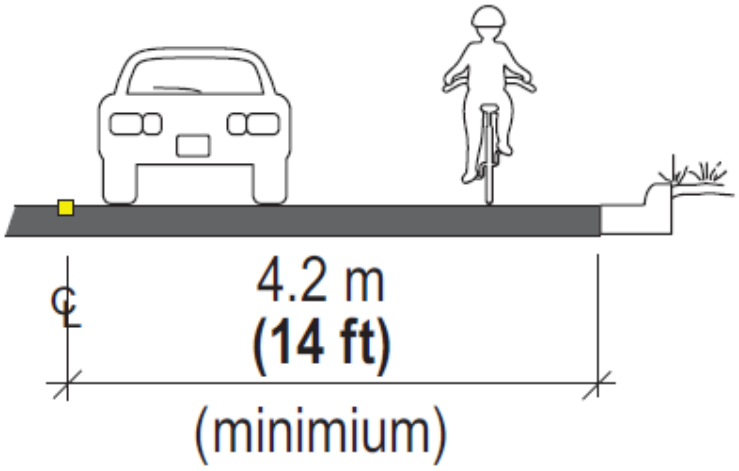

NO PARKING
WITH NO GUTTER SEAM
IN BIKE LANE



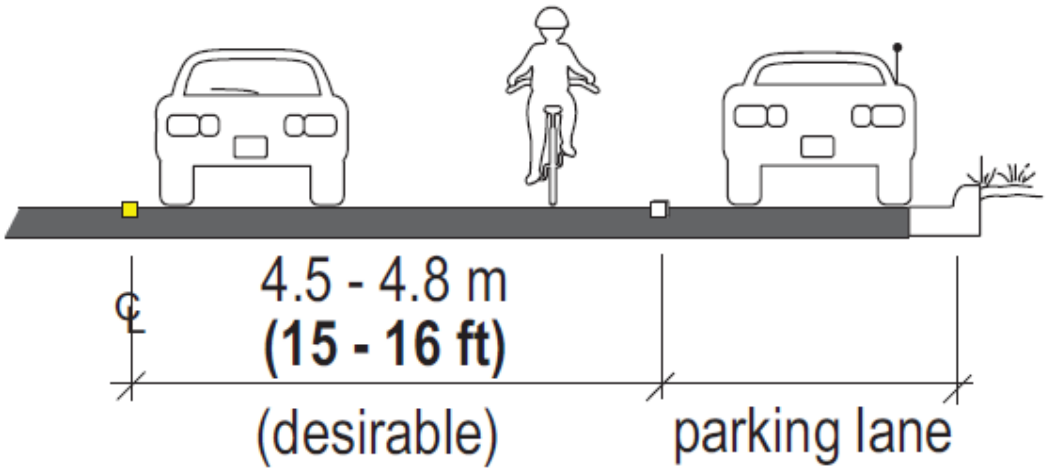

WITH ON STREET
PARKING ALLOWED

# Classical bicycle lanes

MnDOT Bikeway Facility Design Manual



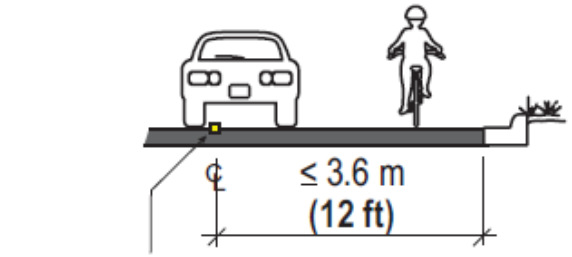

**WIDE OUTSIDE LANE**
**NO PARKING**



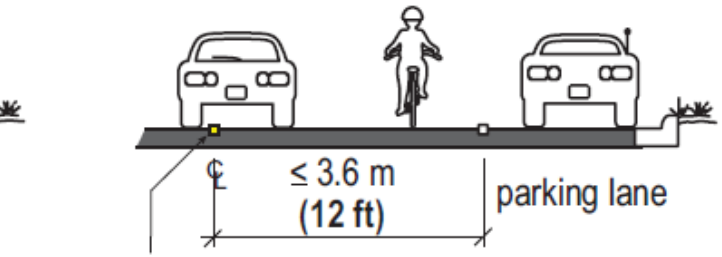

**WIDE OUTSIDE LANE**
**WITH PARKING LANE**

# Wide outside lane treatment

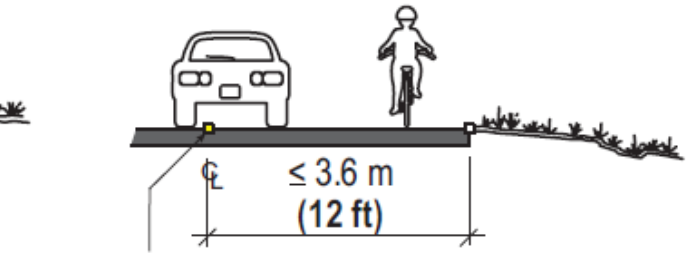
MnDOT Bikeway Facility Design Manual




URBAN CROSS SECTION
NO PARKING




URBAN CROSS SECTION
WITH PARKING LANE




RURAL CROSS SECTION
NO PARKING

# Shared lane

MnDOT Bikeway Facility Design Manual

Shared lane marking (aka sharrow)

# Key Principles

- Think “slow” – not “fast” – select the lowest reasonable targeted operating speed

# Key Principles

- Think differently about traffic impacts
  - Corridor travel time/delay not time/delay at individual intersection
  - Number of hours of congestion not minutes during the peak hour
  - Mid-day not peak hour

# Design Element Spotlight

## Traffic

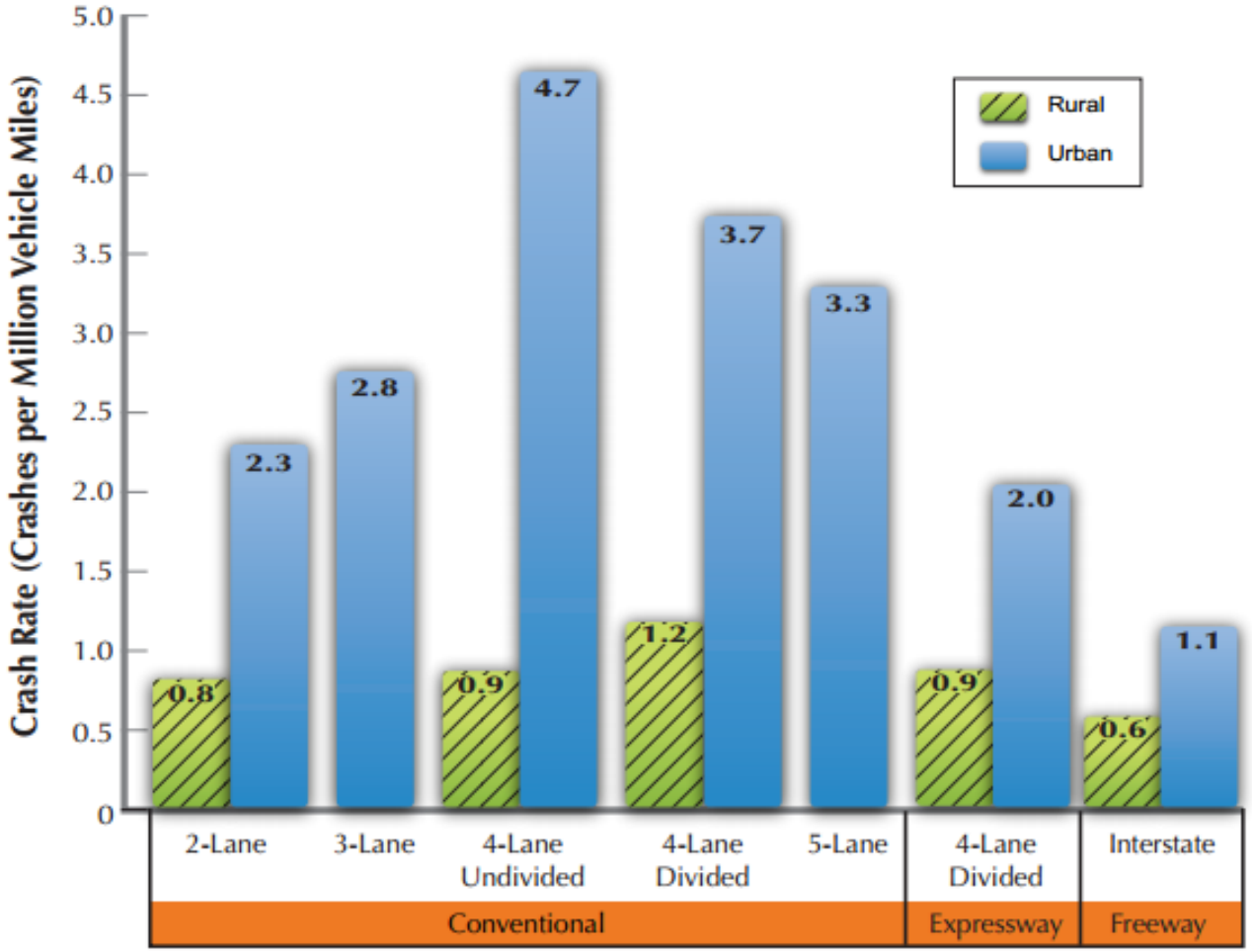
# 2 miles of Urban Arterial
# ADT = 10,000
# 36 Access Points

| | Crashes | Upper Boundary |
|---|---|---|
| 2 Lane Undivided | 5.7 | 32,600 |
| 3 Lane, Two Way Turn Lane | 5.5 | 32,900 |
| 4 Lane, Undivided | 6.5 | 40,100 |
| 4 Lane Divided | 3.5 | 66,000 |
| 5 Lane, Two Way Turn Lane | 9.9 | 53,800 |

# 2 miles of Urban Arterial
# ADT = 32,600
# 36 Access Points

| | Crashes | Upper Boundary |
|---|---|---|
| 2 Lane Undivided | 26.5 | 32,600 |
| 3 Lane, Two Way Turn Lane | 23.8 | 32,900 |
| 4 Lane, Undivided | 27.4 | 40,100 |
| 4 Lane Divided | 14.2 | 66,000 |
| 5 Lane, Two Way Turn Lane | 34.7 | 53,800 |

# Minnesota Crash Rates



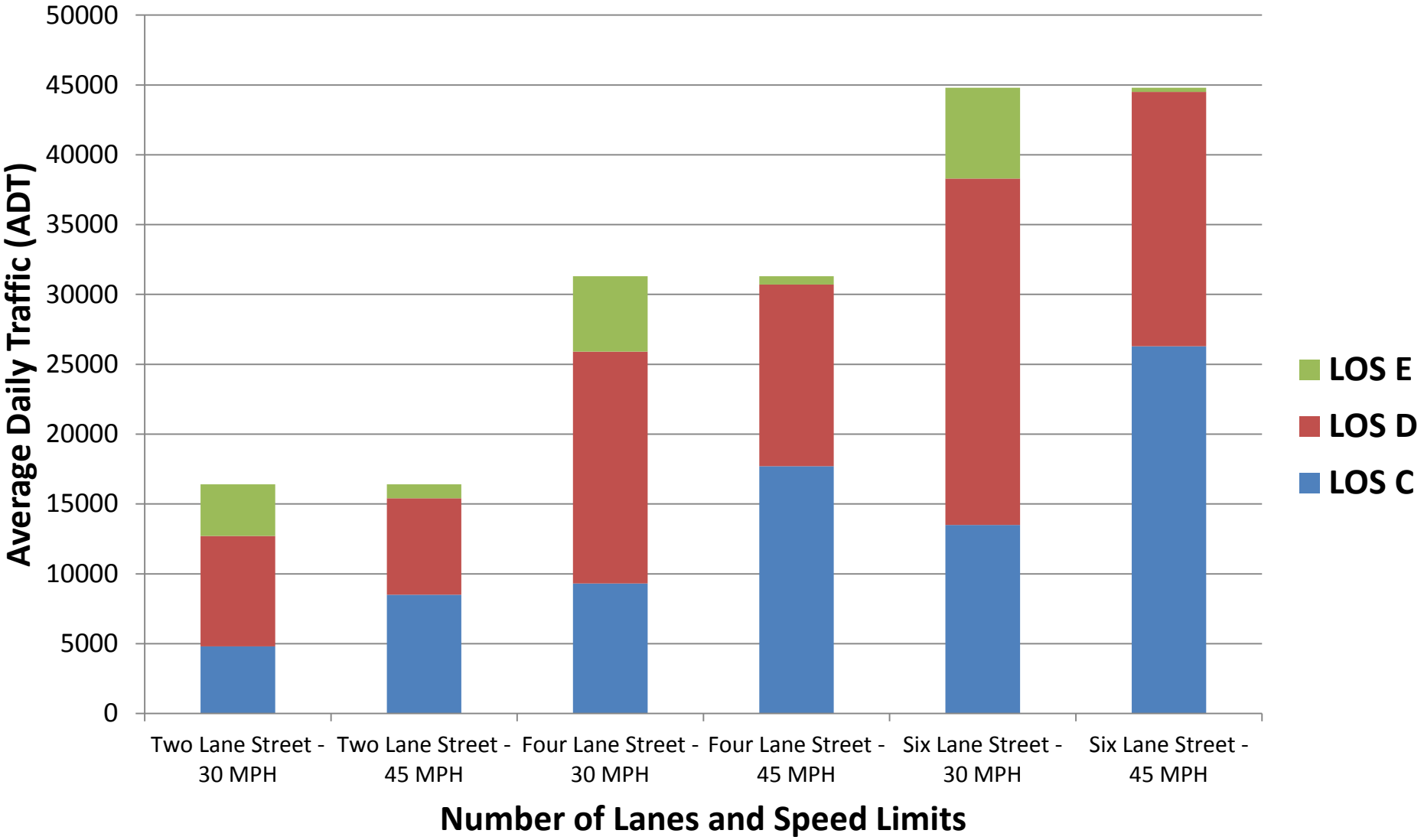

Note: Only for Trunk Highway Segments

"Rural" Refers to a non–municipal area and cities with a population less than 5,000.

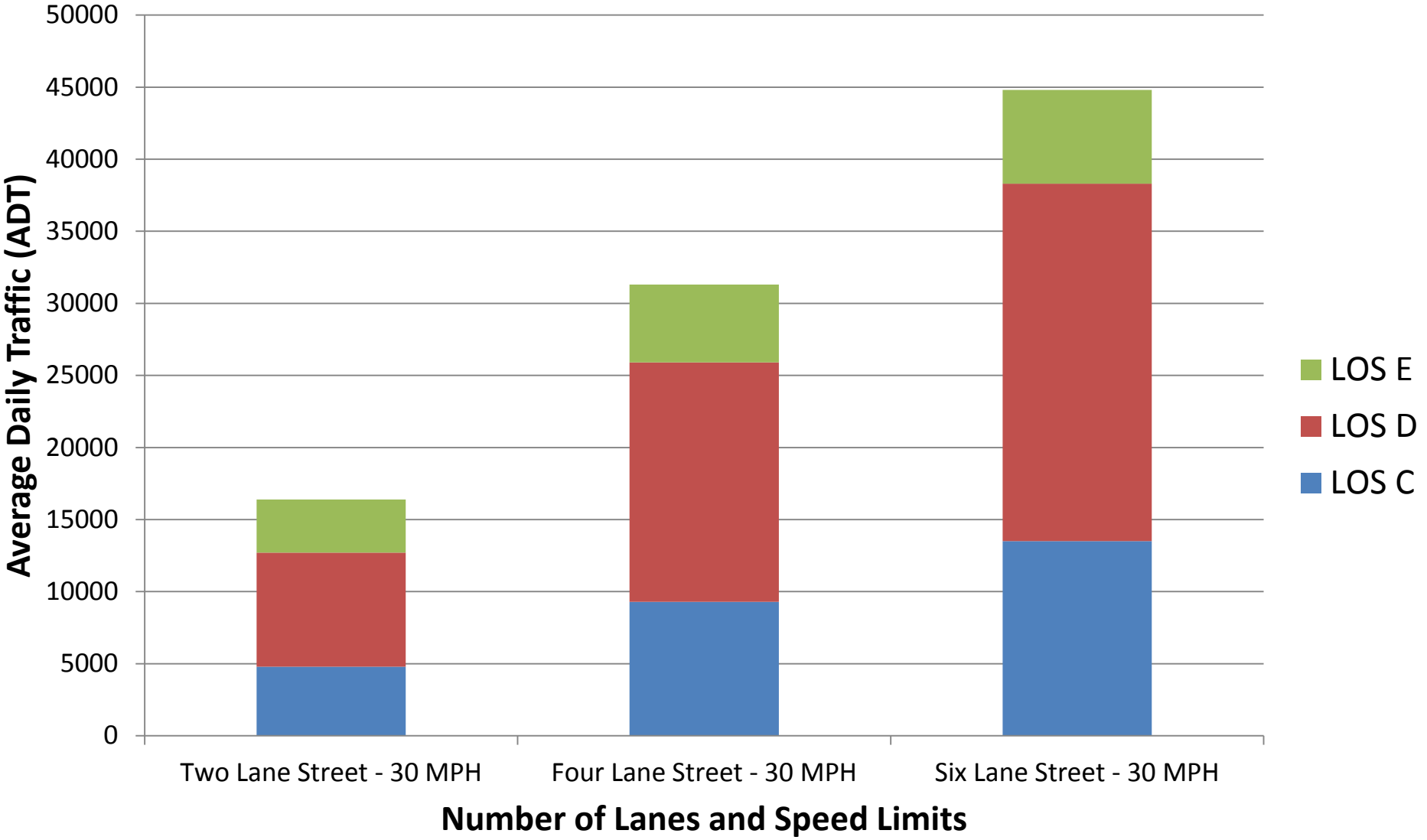
# Minnesota Crash Rates

| Five Years of Crash Data (2007-2011) | All Crashes | | | |
|---|---|---|---|---|
| | Crash Rate | Sever. Rate | Fatal Rate | F+A Rate |
| Urban 2-lane : ADT∈[0,1500) | 1.71 | 2.86 | 3.08 | 9.23 |
| Urban 2-lane : ADT∈[1500,5000) | 1.43 | 2.03 | 0.76 | 2.57 |
| Urban 2-lane : ADT∈[5000,8000) | 2.00 | 2.82 | 0.47 | 3.36 |
| Urban 2-lane : ADT∈[8000,∞) | 2.05 | 2.92 | 0.65 | 2.64 |
| Urban 4-lane Undivided | 3.86 | 5.23 | 0.59 | 4.75 |
| Urban 4-lane Divided | 2.81 | 3.83 | 0.57 | 2.70 |
| 3-lane Undivided | 2.10 | 2.95 | 0.63 | 2.38 |
| 5-lane Undivided | 3.06 | 4.24 | 0.57 | 2.65 |

# Level of Service vs. Traffic Volume
# (From HCM ex. 16-14)



# Level of Service vs. Traffic Volume (From HCM ex. 16-14)

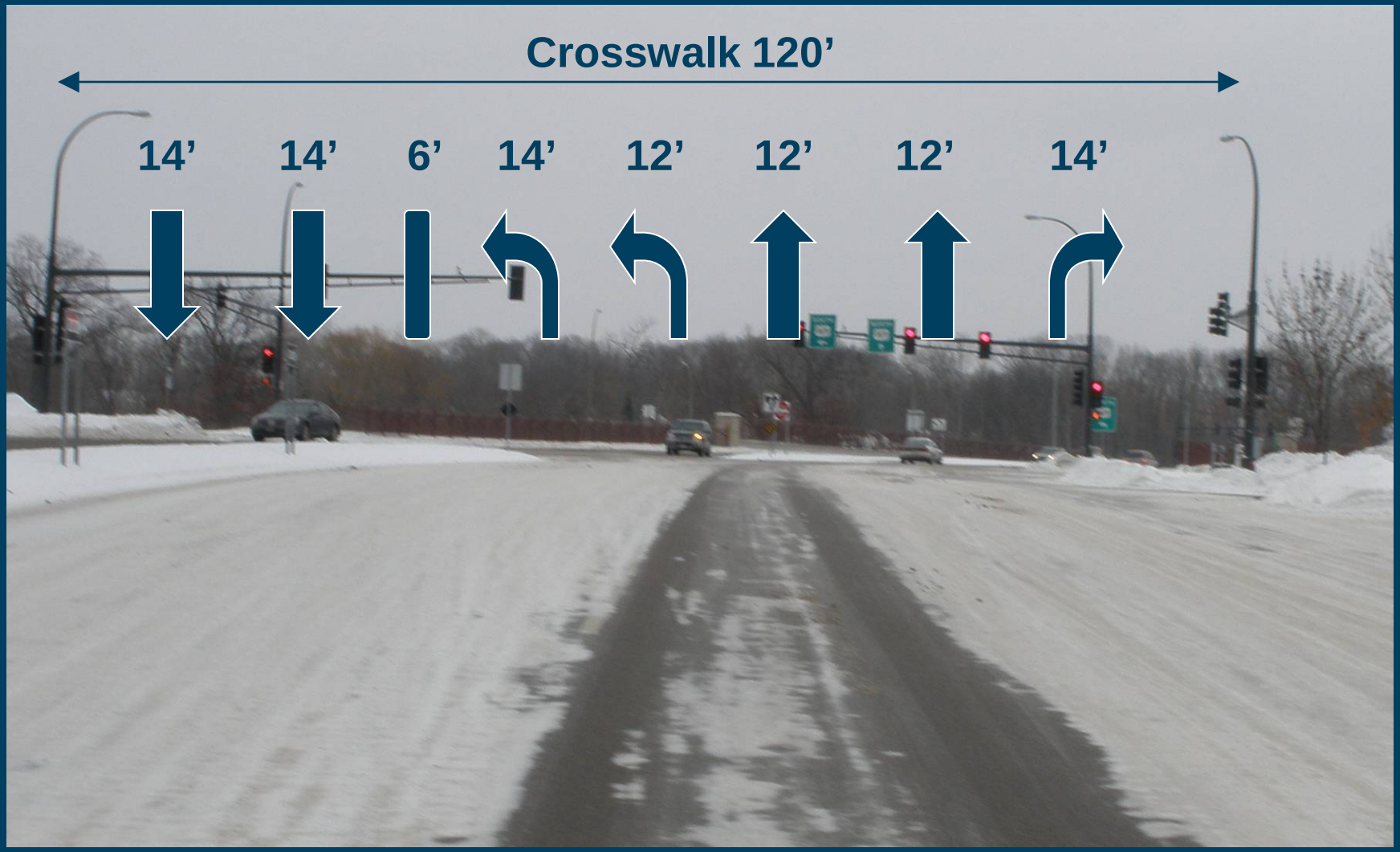


# Key Principles

- Start with smallest number of lanes – reducing width by a single lane can free up space for other modes

- Think “minimums” not “desirables” – start with the smallest dimensions

# We Over-Build Way Too Often



# Designing a "main street"

- Low Speed (45 mph or less) vs. High Speed
- Major Challenges
  - Community
  - Traffic Analysis
  - Target Operating Speed
  - Allocation of Space
  - Intersections

# Where is the Most Design Flexibility?

- Vehicle Design Considerations
  - Lower Speeds are appropriate
  - Number of Lanes
  - Lane width
  - Change in cross section elements along corridor

- Allocation of space
  - Sidewalks
  - Parking
  - Bicycles


Cosmos

# Downtown Cosmos

# Old TH4 Roadway

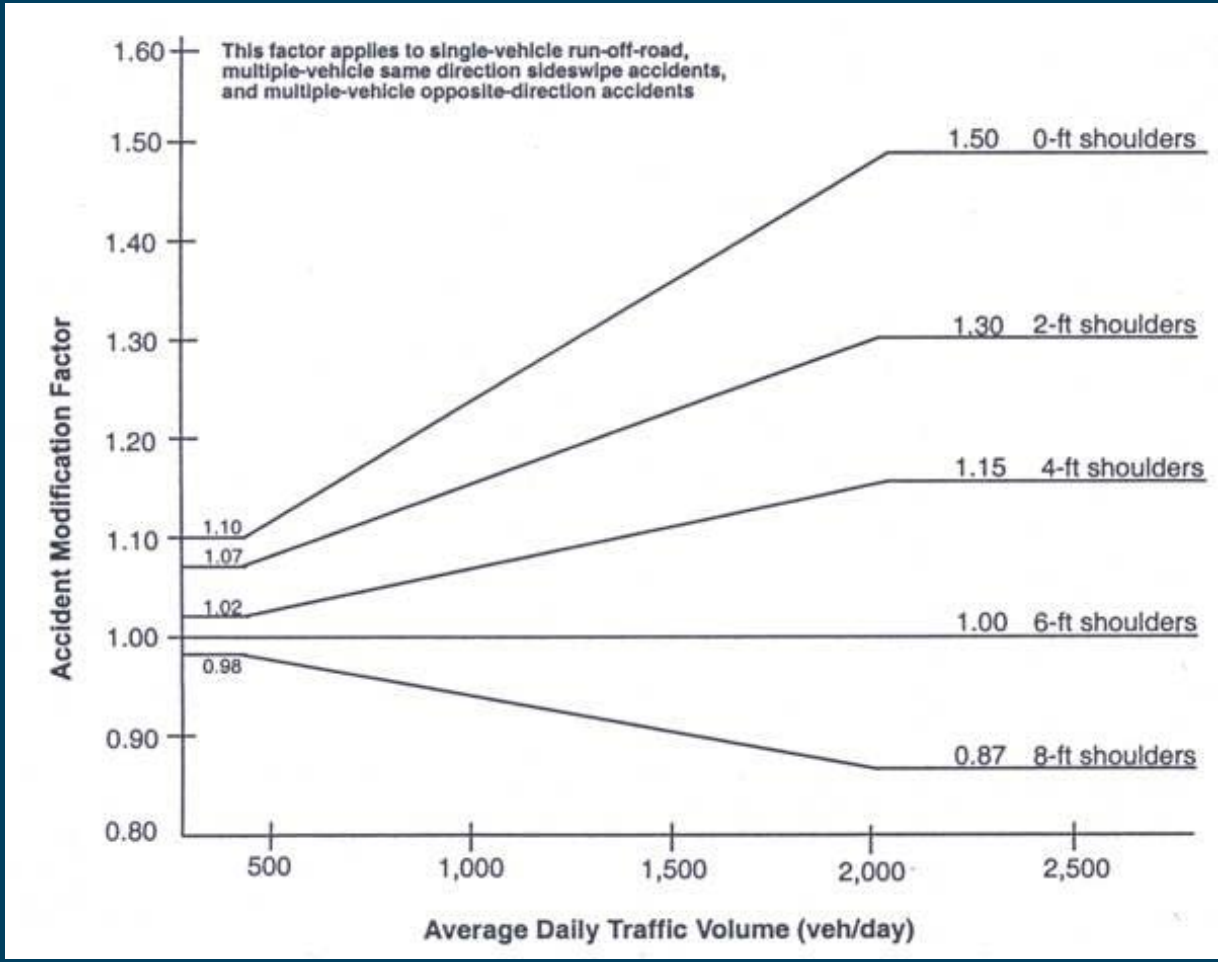
# Design Element Spotlight

## Shoulder / Parking Lane Width

| HIGHWAY TYPE | | | MINIMUM WIDTH (FEET) [1] | | | |
|---|---|---|---|---|---|---|
| | | | Median (or Left) | | Outside (or Right) [10] | |
| | | | Usable | Paved | Usable | Paved [2][3] |
| **Arterials (Rural)** [4] | 2 Lanes | ADT < 400 | | | 4 | 2 |
| | | ADT 400 - 1500 | | | 6 | 2 - 6 |
| | | ADT 1500 - 2000 | | | 6 | 4 - 6 |
| | | ADT > 2000 | | | 8 | 8 [5] |
| | Divided 4-lanes | | 4 | 4 | 8 | 8 [5] |
| | Divided 6-lanes | | 8 | 8 [5] | 8 | 8 [5] |

# MnDOT rural arterial shoulder widths

Technical Memo No. 12-12-TS-06




# Rural two-lane: shoulder width safety effects

From AASHTO Highway Safety Manual

# Highway Safety Manual

## 2-Lane Rural Highway – Crashes/Year

| | Shoulder Width | | | | | |
|---|---|---|---|---|---|---|
| **Lane Width** | **0'** | **1'** | **2'** | **4'** | **6'** | **8'** |
| **9'** | 5.3 | 5.1 | 4.8 | 4.5 | 4.1 | 3.8 |
| **10'** | 4.8 | 4.6 | 4.4 | 4.1 | 3.8 | 3.5 |
| **11'** | 4.2 | 4.1 | 3.9 | 3.6 | 3.3 | 3.1 |
| **12'** | 4.1 | 3.9 | 3.8 | 3.5 | 3.2 | 3.0 |

*2 mile segment, ADT = 6,000 veh/day, paved shoulders, RHR =3, 5 access points/mile

Gravel shoulders will add 0% to 2% increase in crashes

| | | | | | | |
|---|---|---|---|---|---|---|
| **Arterials (Urban / Suburban)** [8] | 2 Lanes | ≤ 45 mph | With Parking [9] | | | 7 - 10 [6] |
| | | | Without Parking | | | Curb Reaction [7] |
| | | > 45 mph | Without Parking | | | 8 [5] |
| | 4 + Lanes | ≤ 45 mph | With Parking [9] | | | 7 - 10 [6] |
| | | | Without Parking | | | Curb Reaction [7] |
| | | > 45 mph | Without Parking | | | 8 [5] |
| | Divided (4 or more lanes) | | | Curb Reaction [7] | | (See Above) |

# MnDOT urban arterial shoulder widths

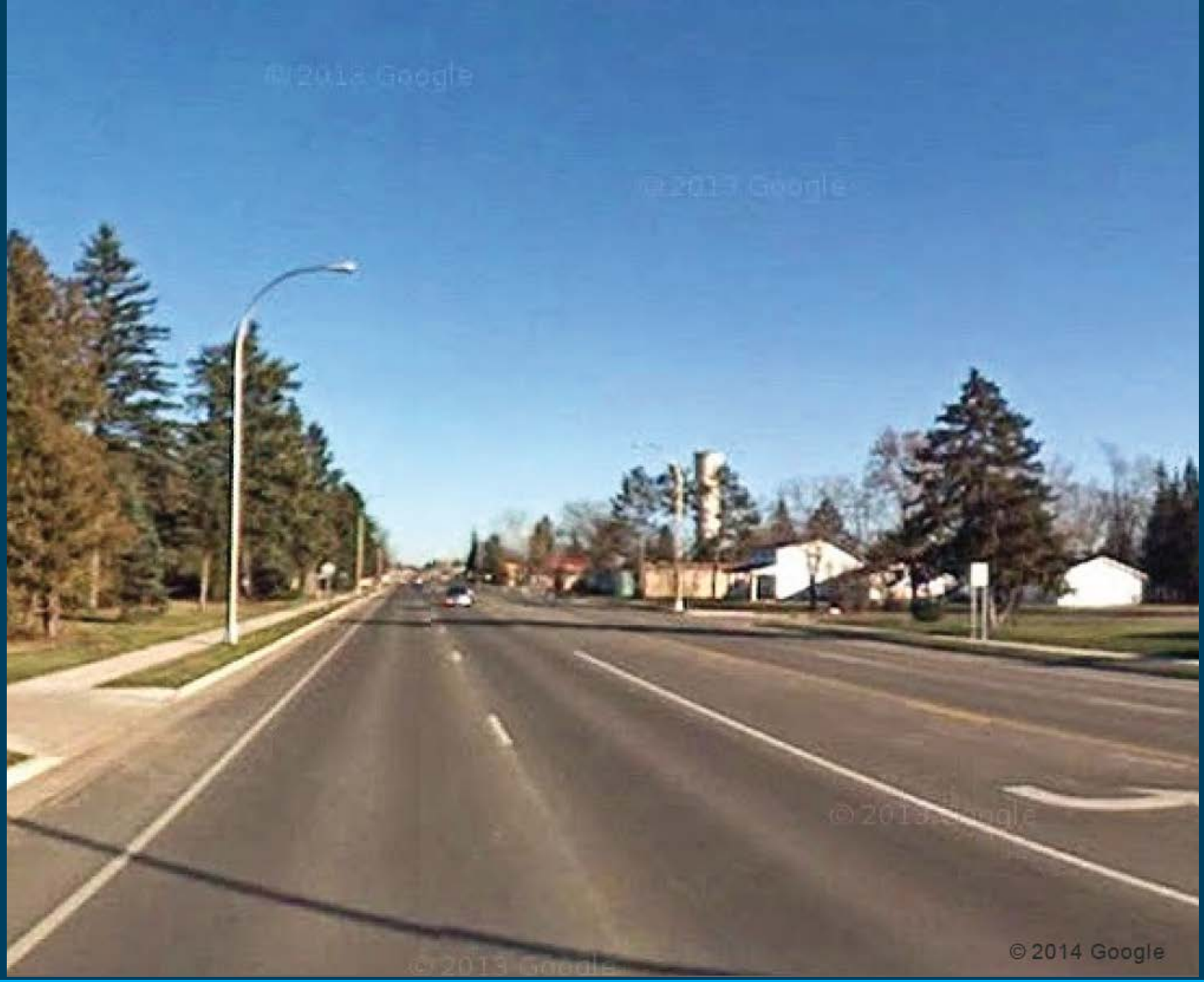
Technical Memo No. 12-12-TS-06

**TABLE 4**
**Standard Curb Reaction Dimensions**

| Design Speed | Curb Reaction Width for Indicated Curb Types (feet) | |
|---|---|---|
| | B, V or vertical monolithic | D, S or sloped monolithic |
| ≤ 45 mph | 1-2 | 0-2 |
| > 45 mph | 2-3 | 1-3 |

# Variable curb reaction widths

Technical Memo No. 12-12-TS-06


© 2014 Google

| | | | | | | |
|---|---|---|---|---|---|---|
| **Arterials (Urban / Suburban)** [8] | 2 Lanes | ≤ 45 mph | With Parking [9] | | | 7 - 10 [6] |
| | | | Without Parking | | | Curb Reaction [7] |
| | | > 45 mph | Without Parking | | | 8 [5] |
| | 4 + Lanes | ≤ 45 mph | With Parking [9] | | | 7 - 10 [6] |
| | | | Without Parking | | | Curb Reaction [7] |
| | | > 45 mph | Without Parking | | | 8 [5] |
| | Divided (4 or more lanes) | | | Curb Reaction [7] | | (See Above) |

# MnDOT urban arterial shoulder widths

Technical Memo No. 12-12-TS-06


12-foot parking lane

T.H. 60 (ADT 5,200)


10-foot parking lane

Residential collector

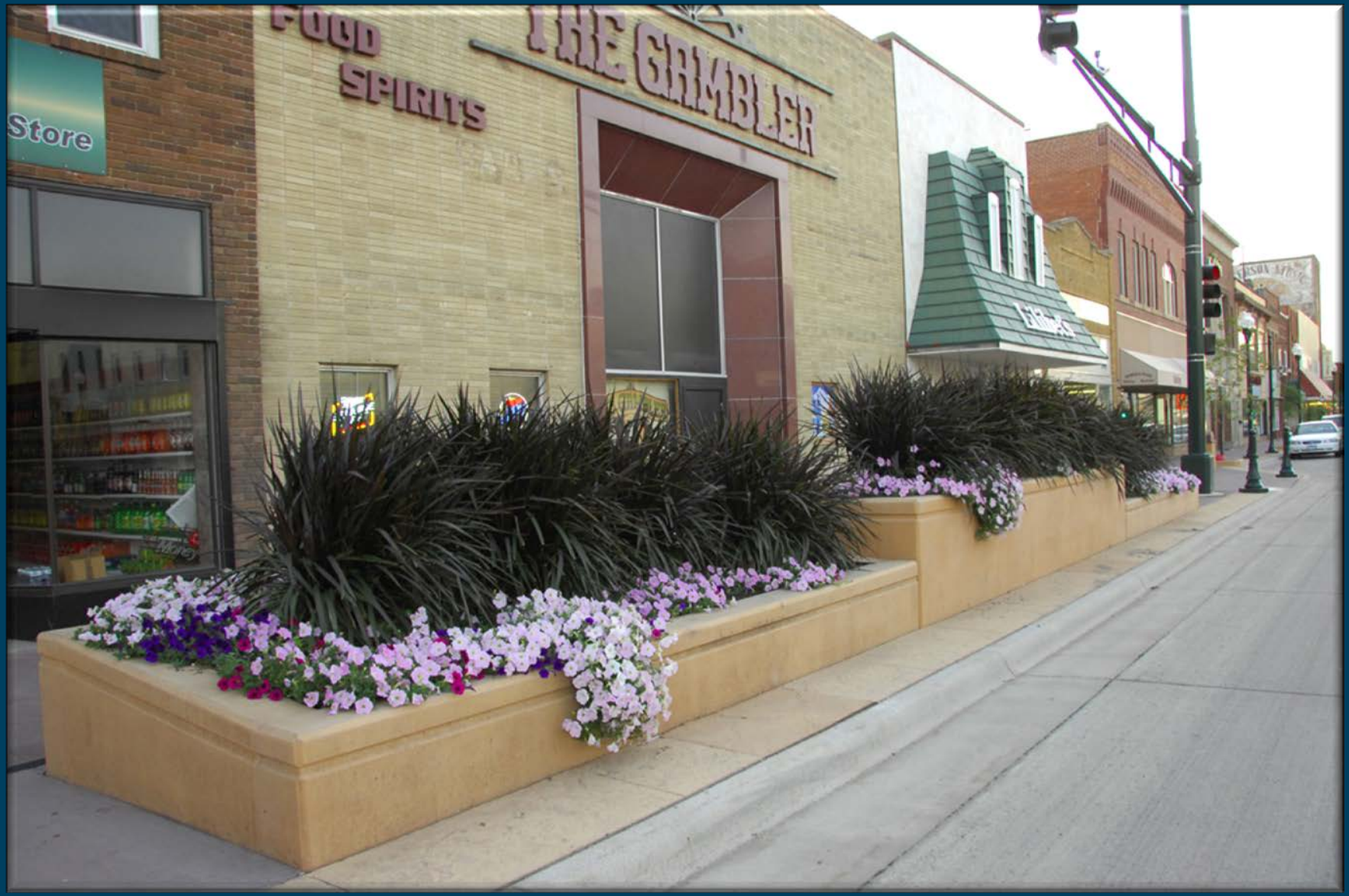

# 10-foot parking lane

Residential collector

# Let's Design a Cross Section!

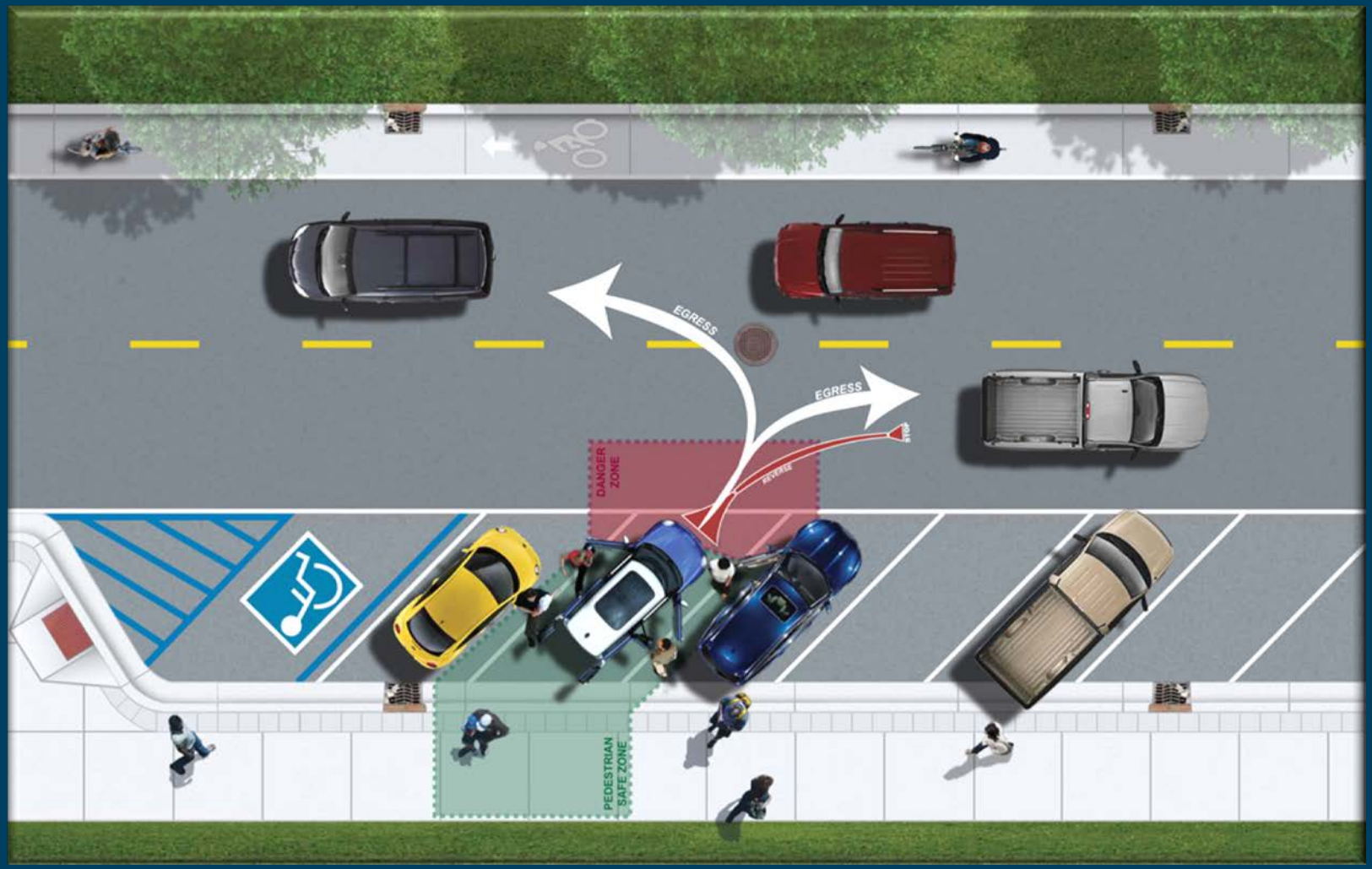

- Using the "STREETMIX" software!

# New TH4 Driving Surface


FOOD
SPIRITS
THE GRIMBLER
Store

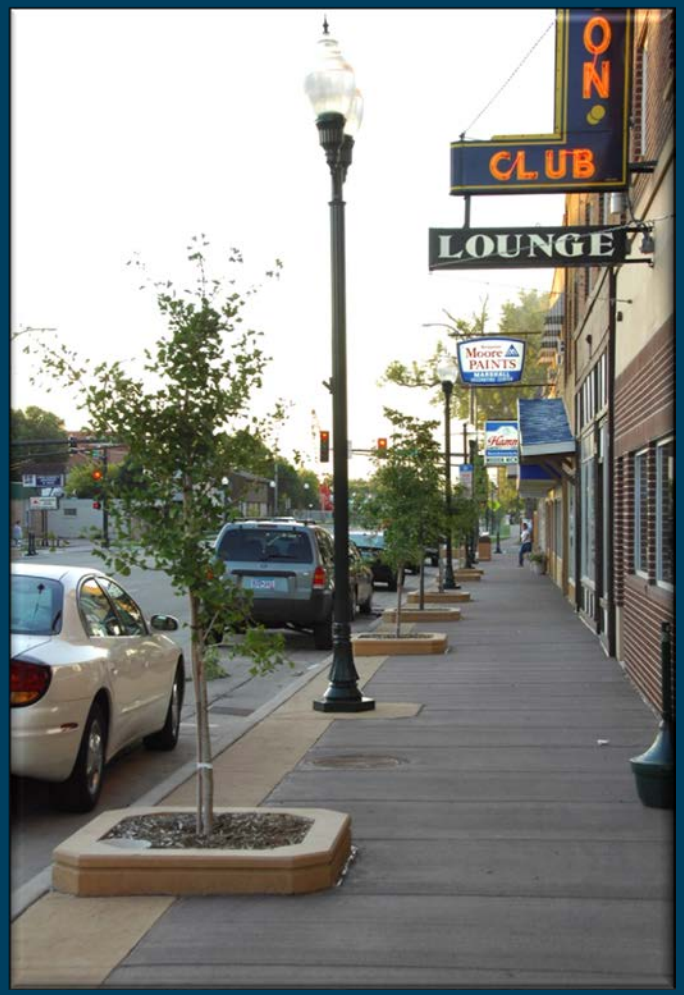

BROMEN

# Back In Angled Parking



# Other Tools: Bump-Outs

# Other Tools:  Streetscaping



# Constrained Urban Streets

- Major Challenges
  - Community Desires
  - Traffic Analysis – often high traffic volumes but high use by all modes
  - Target Operating Speed – needs to be slow
  - Allocation of Space – who gets the limited space available
  - Intersections – pedestrian crossing distances and times

# Where is the Most Design Flexibility?

- Vehicle Design Considerations
  - Lower Speeds are appropriate
  - Smaller Design Vehicle is appropriate

- Allocation of space
  - Number of Lanes
  - Lane width
  - Parking (depends on adjacent land use)
  - Pedestrian and bicycle demand
  - *No two blocks are the same*

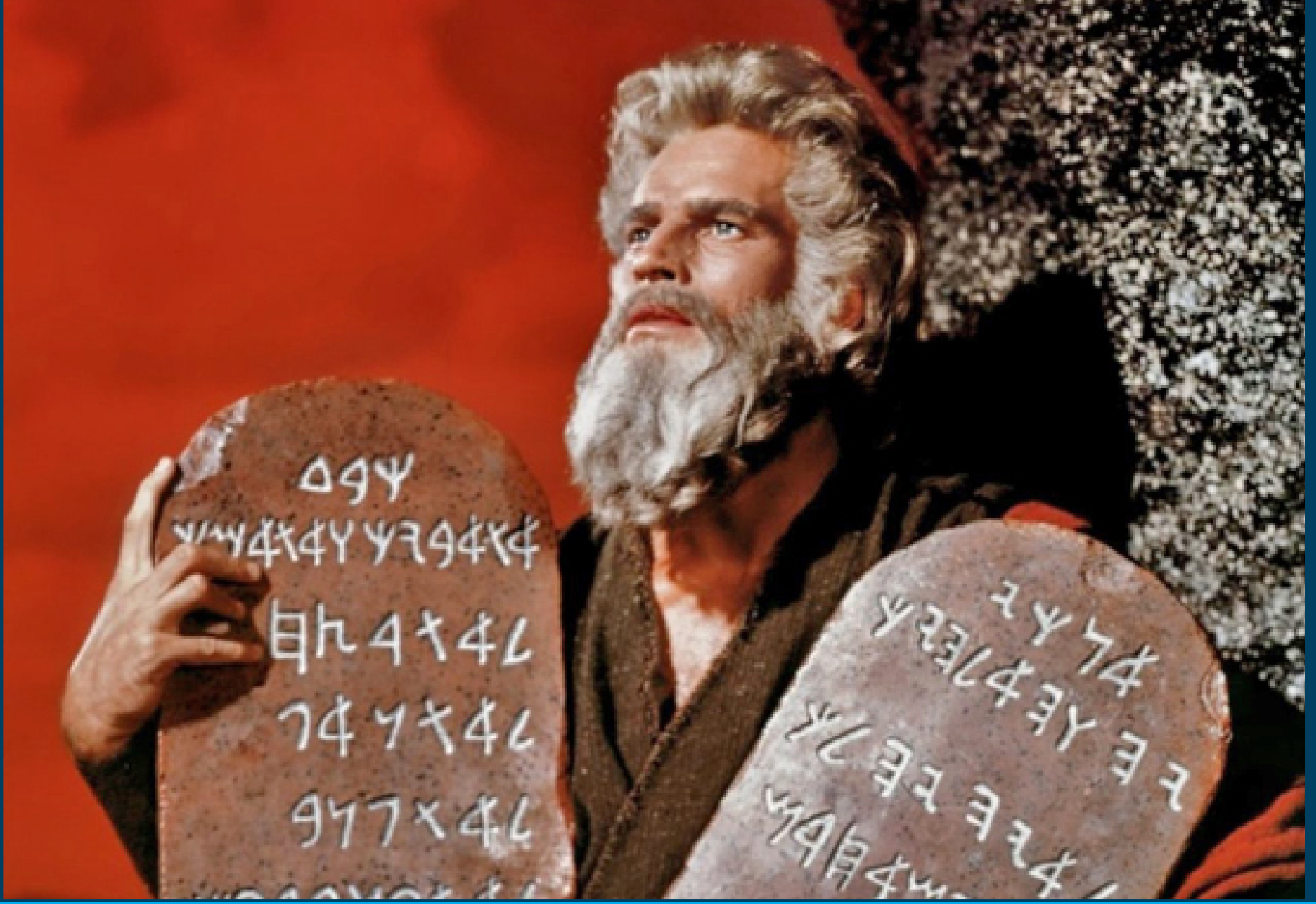
# 80’ Building Front to Building Front

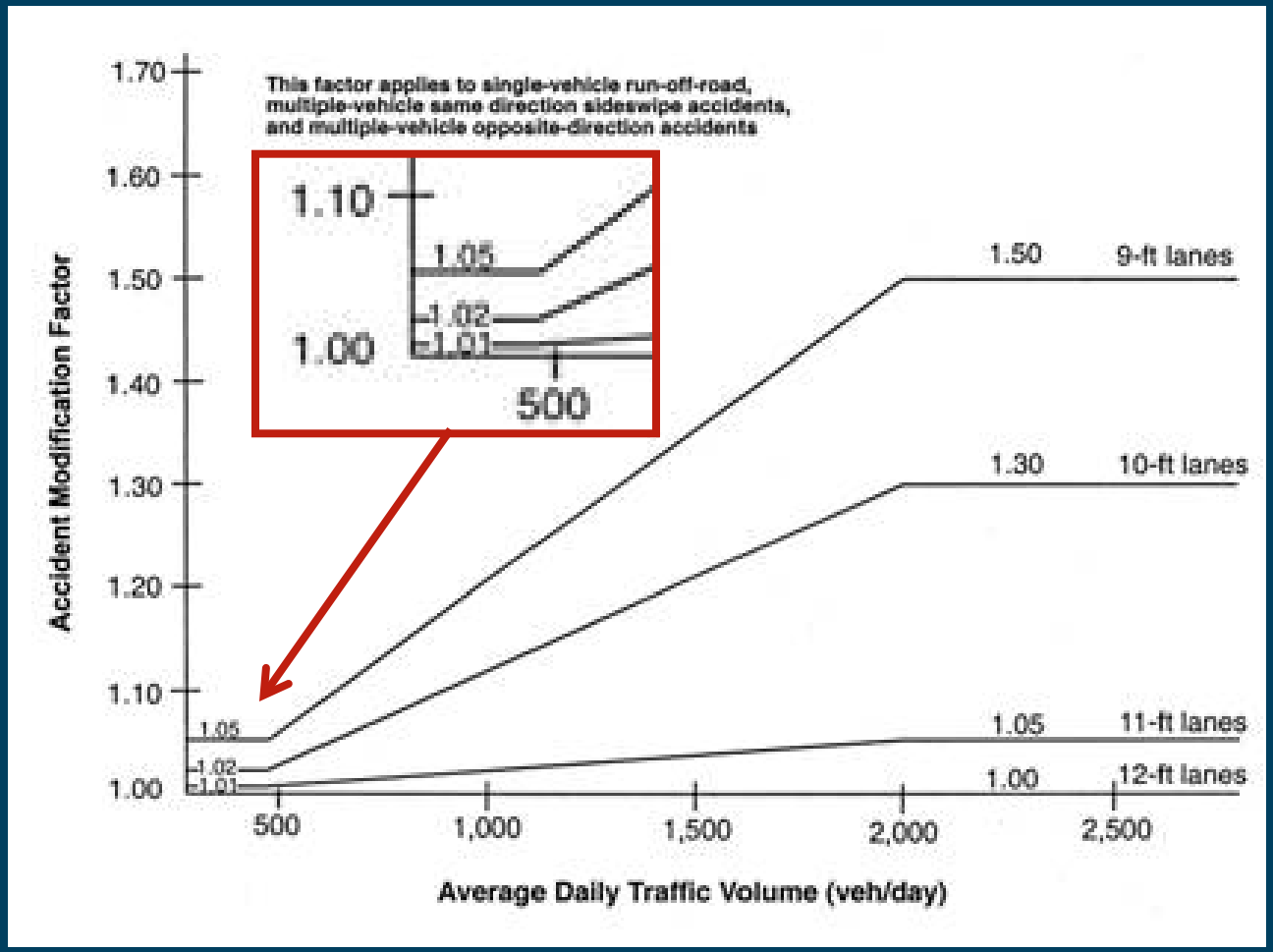
- Transit Route
- Retail Stores
- Sidewalk Cafes
- Many Walkers
- Many Bicyclists
- On-Street Parking
- Near School for Seeing/Hearing Impaired

# Design Element Spotlight

## Lane Width


12’






# Rural two-lane: lane width effects on safety

From AASHTO Highway Safety Manual

**Table 4-3.XX**
**TRAVEL LANE WIDTHS – RURAL HIGHWAY SETTINGS**

| FUNCTIONAL CLASSIFICATION | DESIGN SPEEDS (mph) | LANE WIDTHS FOR SPECIFIED DESIGN ADT, feet | | | |
|---|---|---|---|---|---|
| | | under 400 | 400 to 1500 | 1500 to 2000 | over 2000 |
| COLLECTOR | 20-30 | 10 - 12 (1) | | 11 - 12 | 12 (2) |
| | 35-50 | 10 - 12 (1) | 11 - 12 | | 12 (2) |
| | 55+ | 11 - 12 | | 12 (2) | |
| ARTERIAL | 40-45 | 11 - 12 | | | 12 (2) |
| | 50-55 | 11 - 12 | | 12 (2) | |
| | 60+ | 12 (2) | | | |
| FREEWAY | 50+ | 12 | | | |

(1) 9 feet minimum for roads with a design speed of 40 mph or lower and with a design ADT less than 250

(2) On reconstruction projects, existing 11-foot lanes may be retained where the horizontal alignment is satisfactory and there is no crash pattern suggesting the need for widening

# MnDOT standard lane widths – rural highways

Technical Memo No. 12-07-TS-02

# 1973 AASHTO "Red Book"

"Traffic lanes on all freeways should be 12 feet wide. This is considered to be the ideal width for capacity and proper operations."

"Desirably the through lanes on arterial streets should also be 12 feet wide. However, the stringent controls of right-of-way and existing development may make use of 11-foot lanes necessary."

# 1973 AASHTO "Red Book"

"Any width less than 11 feet is considered unsatisfactory for arterial highways."

# 1984 AASHTO "Green Book"

"[Urban arterial] Lane widths may vary from 10 ft to 12 ft. The 10-ft widths are used in highly restricted areas having little or no truck traffic. The 11-ft lanes are used quite extensively for urban arterial street designs. The 12-ft lane widths are most desirable and are generally used on all higher speed, free-flowing, principal arterials."

# 1984 AASHTO "Green Book"

"Under interrupted-flow operating conditions at low speeds up through 40 mph narrower lane widths are normally adequate and have some advantages."

"Reduced lane widths allow greater numbers of lanes in restricted right-of-way and allow better pedestrian cross movements because of reduced distance."

# Relationship of Lane Width to Safety for Urban and Suburban Arterials

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Paper revised from original submittal.

# Potts, Harwood & Richard – 2007

"…no general indication that the use of lanes narrower than 12 ft on urban and suburban arterials increases crash frequencies."

"The lane width effects in the analysis conducted were generally either not statistically significant or indicated that narrow lanes were associated with lower rather than higher crash frequencies."

# 2011 AASHTO "Green Book"

"Lane widths may vary from 10 to 12 ft. Lane widths of 10 ft may be used in more constrained areas where truck and bus volumes are relatively low and speeds are less than 35 mph. Lane widths of 11 ft are used quite extensively for urban arterial street designs. The 12-ft lane widths are desirable, where practical, on high speed, free-flowing, principal arterials."

**Table 4-3.YY**
**TRAVEL LANE WIDTHS – URBAN AND SUBURBAN HIGHWAY AND STREET SETTINGS**

| FUNCTIONAL CLASSIFICATION | LANE WIDTHS FOR SPECIFIED DESIGN SPEED RANGES, feet | |
|---|---|---|
| | LOW SPEED (< 50 mph) | HIGH SPEED (≥ 50 mph) |
| COLLECTOR | 10 - 11 (1) (2) | 11 - 12 |
| MINOR ARTERIAL | 10 - 12 (2) | 11 - 12 |
| PRINCIPAL ARTERIAL | 11 - 12 | 12 |
| FREEWAY | N/A | 12 |

(1) 12 feet may be considered in industrial areas

(2) 11 feet minimum on four-lane undivided facilities

# MnDOT standard lane widths – urban streets

Technical Memo No. 12-07-TS-02

# MnDOT / LRRB – 2013

"…changes including lane width reduction…did not have any adverse safety impacts."

"No adverse safety impacts were observed in the use of 11 foot lane widths. No operational impacts were reported."

# MnDOT / LRRB – 2013

"Literature suggests that 10-foot lanes provide no significant operational or safety impacts in suburban or urban arterials. No findings or observations in this research dispute these claims."

# U.S. 10 – Staples

# Let's Design a Cross Section!


- Using the "STREETMIX" software!

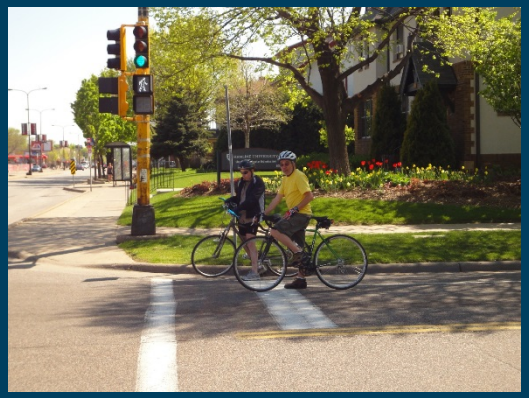
# Other Tools: Medians

- Planted median
- Right-in/ right-outs
- Parking lanes
- Pedestrian crossings

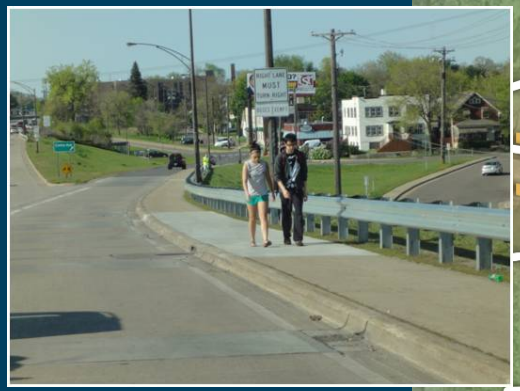
# Other Tools:

- Bump-outs
- Bicycle parking
- Pedestrian lighting
- Landscaping
- Streetscaping

# Other Tools:

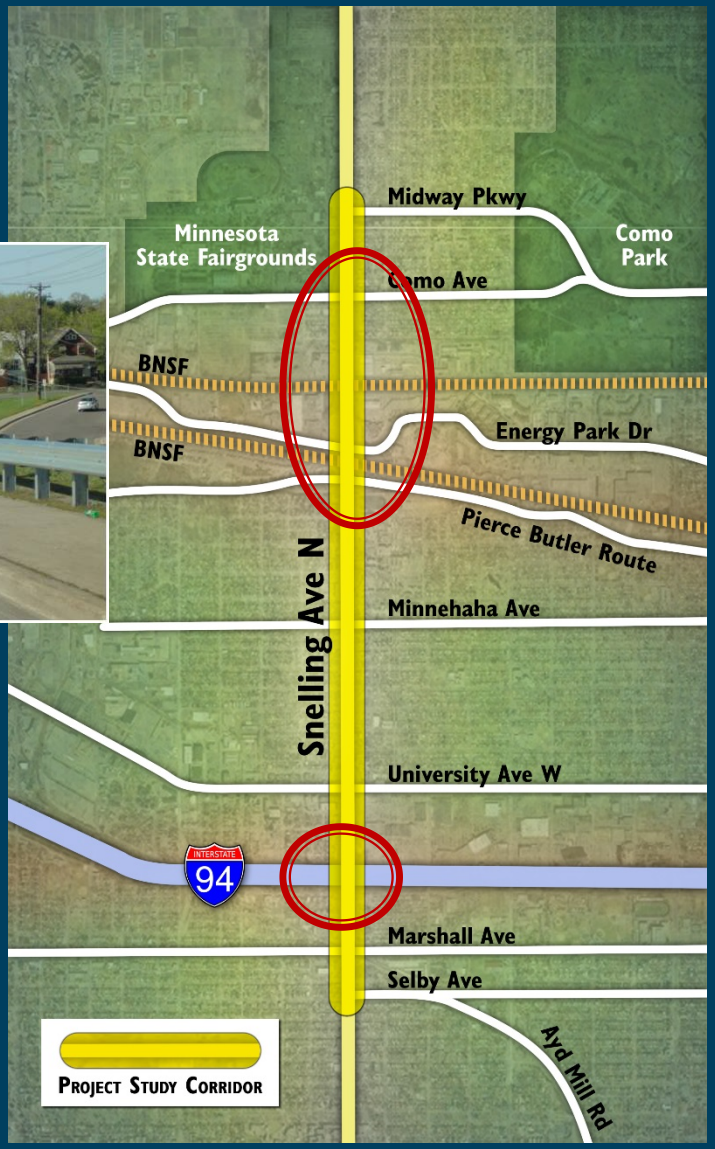


Parallel Bike Boulevards



Sidewalks/Bike Lanes Across Major Barriers

Pedestrian Crossings



# Re-Cap of Key Principles

- Design for Type of Community
- Design Outside-In
- Address Vulnerable Users First
  - Pedestrians, Transit Users, Bicyclists, Disabled
  - Pedestrian Crossing Times
  - Conflict Points
- Consider All Day/Corridor Traffic (not just peak period, single intersection LOS)
- Use Slower Speeds
- Use Fewer/Narrower Lanes

# Final chat page check-in

# Thank you

**Upcoming Training Opportunities**:

Advanced Flexibility in Design Workshop
April 22 – April 24, 2014

Complete Streets Workshop
May 14 – May 15, 2014

For more information visit:
www.cts.umn.edu/contextsensitive/workshops/