Auxiliary Turn Lanes

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INTRODUCTION

- SPR Project: Criteria for the Design and Justification of Auxiliary Turn lanes

- Purpose
  - Provide consistent and clear left and right turn-lane warrants
  - Develop standards for their design
  - Alternative turn lane designs (“blister” or “bump-out”)
  - Positive offset of left-turn lanes
  - Warrants and standards for two-way left-turn lanes (TWLTL)

Background
Left Turn Lane Warrants

- KYTC Design Policy
  - Median openings on divided roadways
  - All non-stopping approaches of rural arterials and collectors
  - All other approaches where required on the basis of capacity,safety, and operational analysis

Background
Left Turn Lane Warrants

- KYTC Permit Policy
  - Median openings on divided roadways
  - All other approaches based on highway Research Record 211

Background
Turn Lane Length

- KYTC Design Policy
  - Storage Length: 1.5 to 2 times average number of arrivals per cycle
  - Deceleration Length: Common practice is to accept a moderate amount of deceleration within the through lanes...

Agenda

- Turn Lane Design
  - Approach Taper
  - Turn Lane Length
- Alternative Designs
- Positive Offset of Left-Turn Lanes
- Two-Way Left-Turn Lanes

LEFT-TURN LANE WARRANTS

- Signalized Intersections
  - All arterials and collectors must have left-turn lanes
  - All other roadways; left-turn lanes only when required by capacity analysis

LEFT-TURN LANE WARRANTS

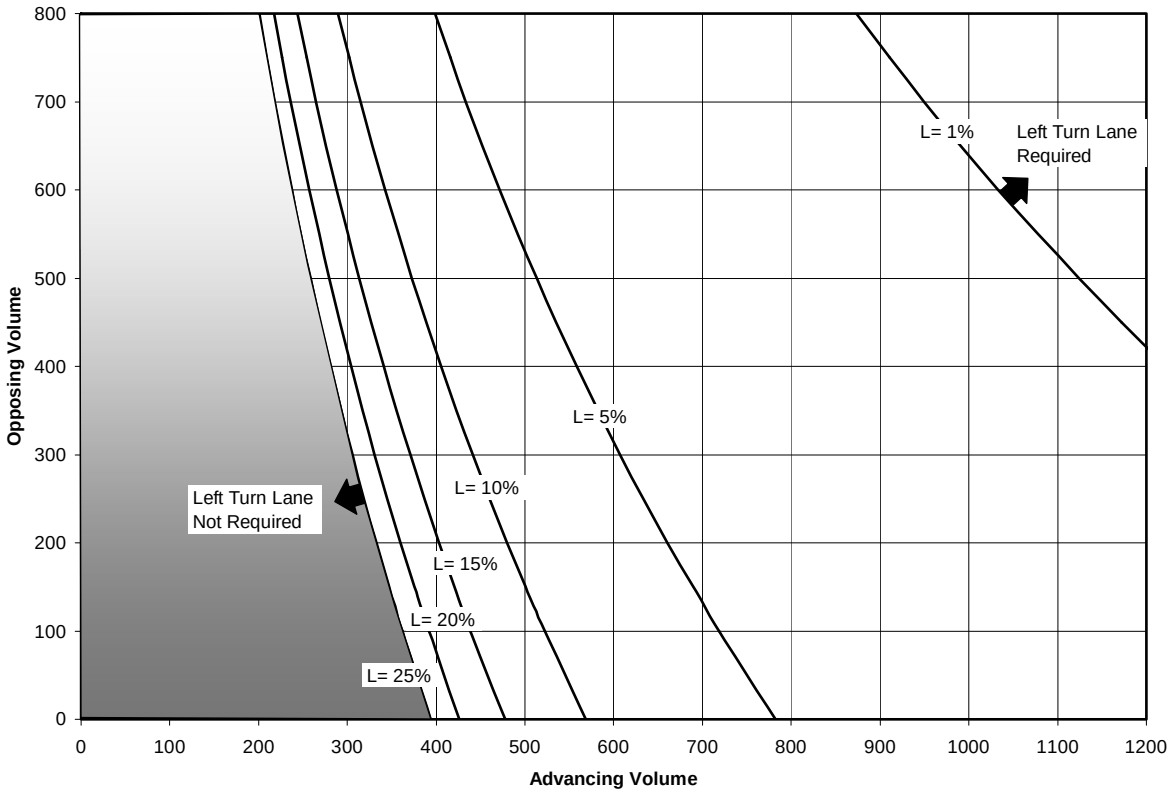
- Stop Controlled Approaches
  - Left-turn lanes shall be provided at median openings on divided roadways
  - Left-turn lanes only when required by capacity analysis
  - Left-turn lanes should be considered as a safety countermeasure, e.g. where sight distance of approaching traffic is limited.

LEFT-TURN LANE WARRANTS

- Uncontrolled Approaches
  - Left-turn lanes shall be provided at median openings on divided roadways
  - Left-turn lanes shall be provided if traffic volumes at the intersection meet the thresholds identified in Figures 1 and 2.
  - Left-turn lanes should be considered as a safety countermeasure, e.g. where sight distance of approaching traffic is limited.

LEFT-TURN LANE WARRANTS

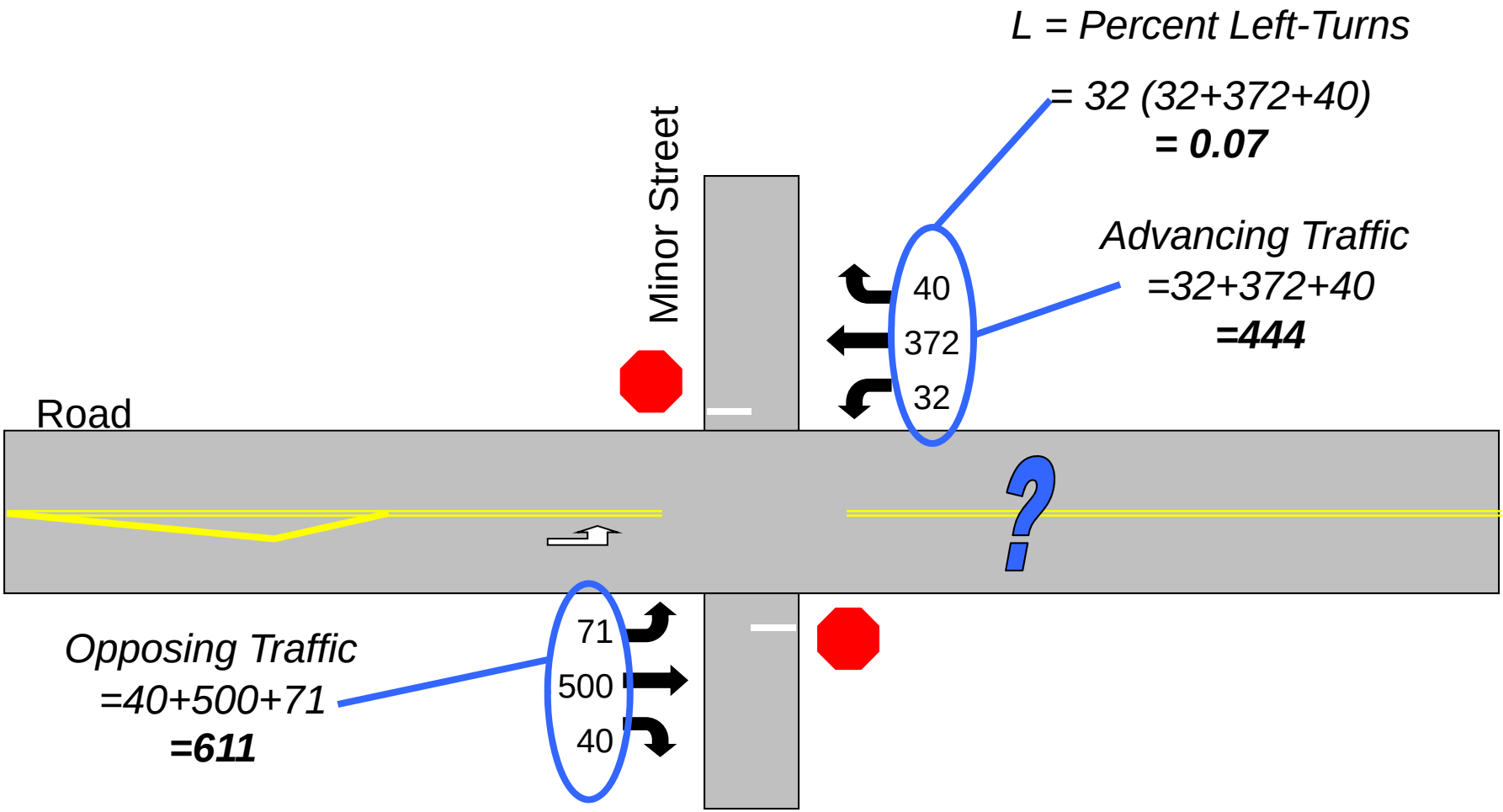
- 2 Graphs measure probability of stopped vehicle blocking lane
  - ≤ 45 MPH (P = 0.02)
  - >45 MPH (P = 0.01)



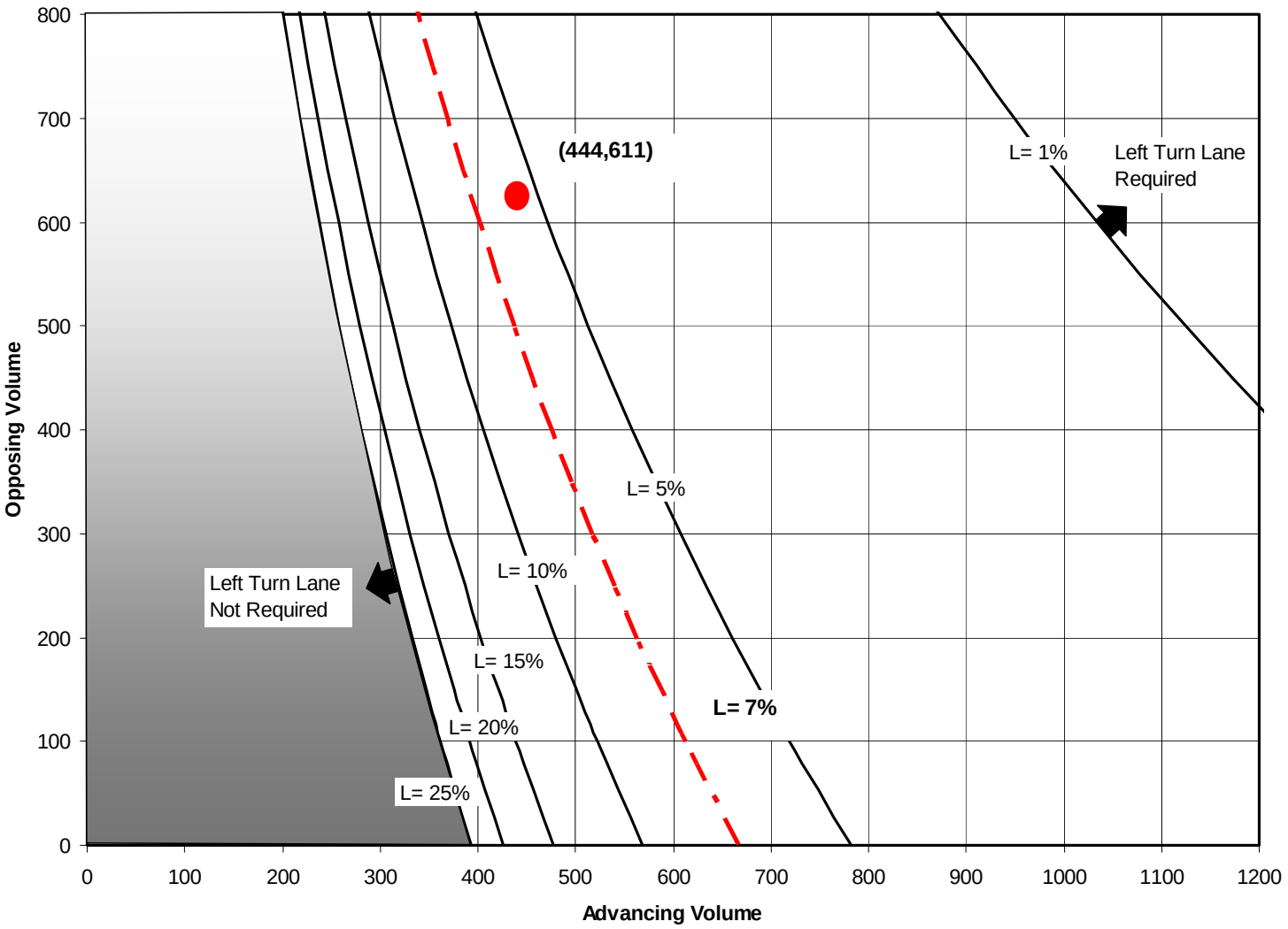
LEFT-TURN LANE WARRANTS

- Inputs
  - *L = Percent Left-Turns*
  - *Advancing Volume = Through + Left + Right-Turn Traffic*
  - *Opposing Volume = Through + Left + Right-Turn Opposing Traffic*

LEFT-TURN LANE WARRANTS



LEFT-TURN LANE WARRANTS



LEFT-TURN LANE WARRANTS

Heavy Vehicles = 6%

L = Percent Left-Turns

= 32 (32+372+40)

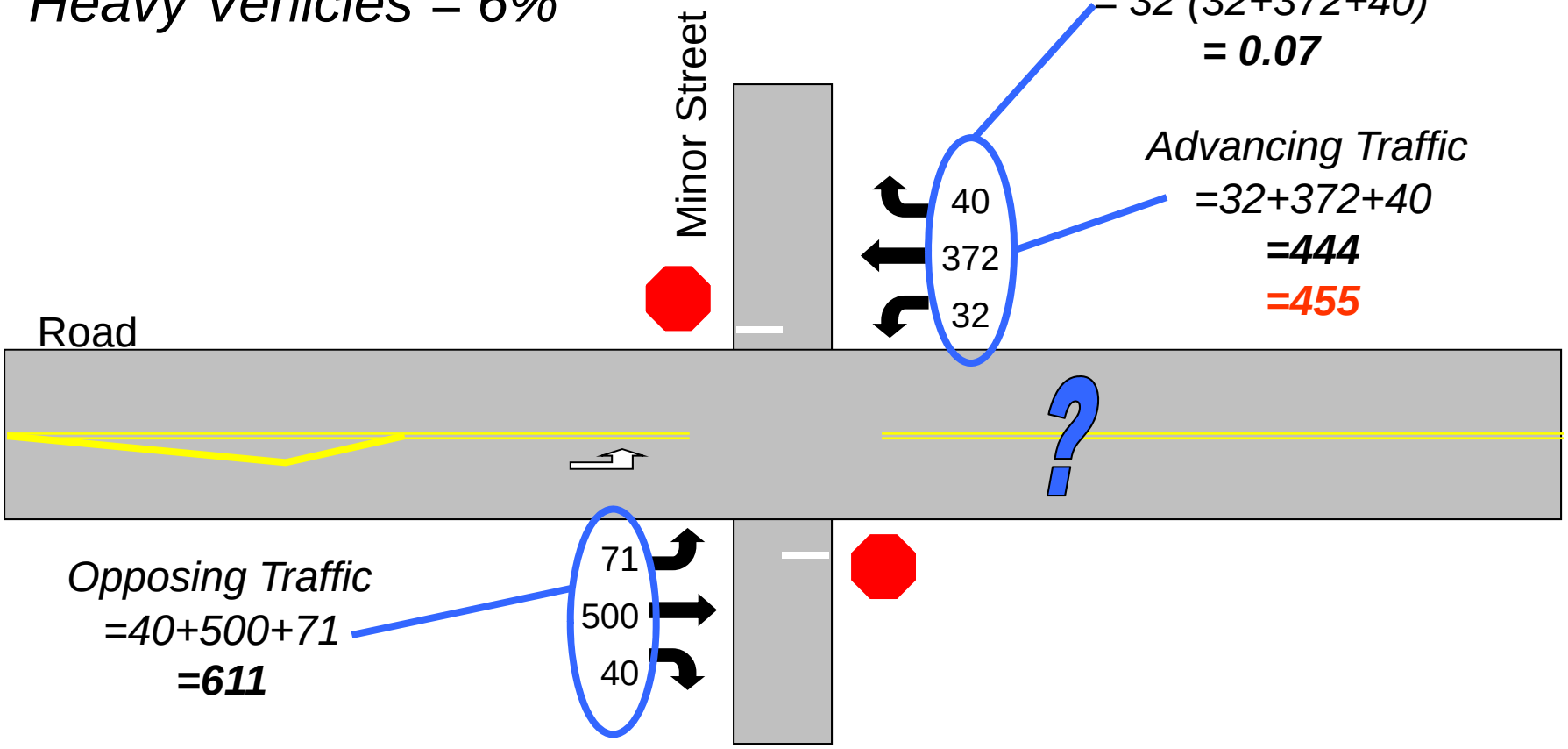
= 0.07

Advancing Traffic

=32+372+40

=444

=455



Opposing Traffic

=40+500+71

=611

LEFT-TURN LANE WARRANTS

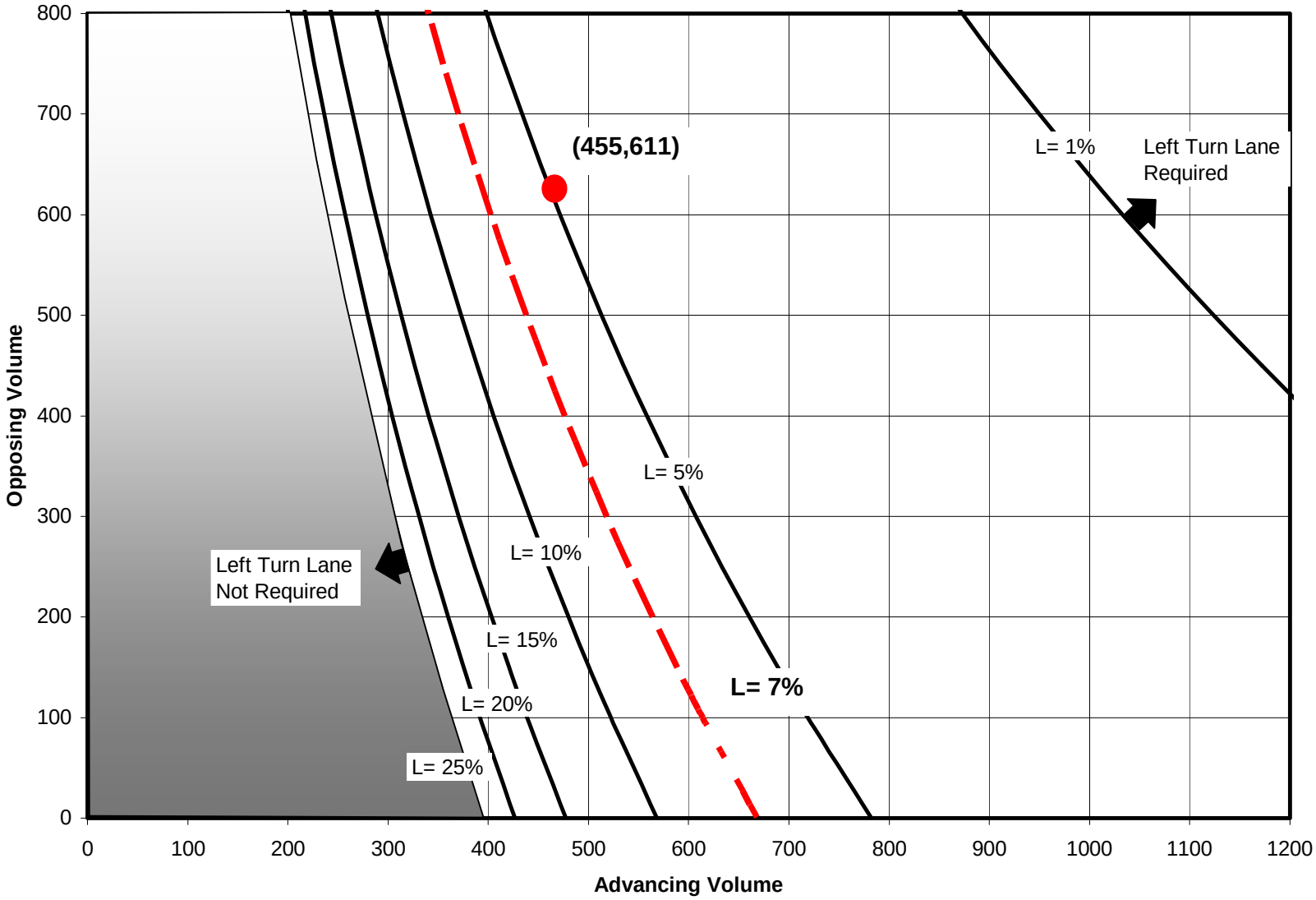
- Heavy Vehicle Adjustment Factor
- $v_A' = v_A [1+P_{HV}(E_{HV})]$
  - v_A' = Adjusted advancing traffic volume
  - v_A = Unadjusted advancing traffic volume
  - P_{HV} = Percent heavy vehicles
  - E_{HV} = Passenger car equivalency factor
    = 0.00035 (v_O) (two-lane facilities)
    = 0.0007 (v_O) (four and six-lane facilities)
  - v_O = Opposing traffic volume

LEFT-TURN LANE WARRANTS

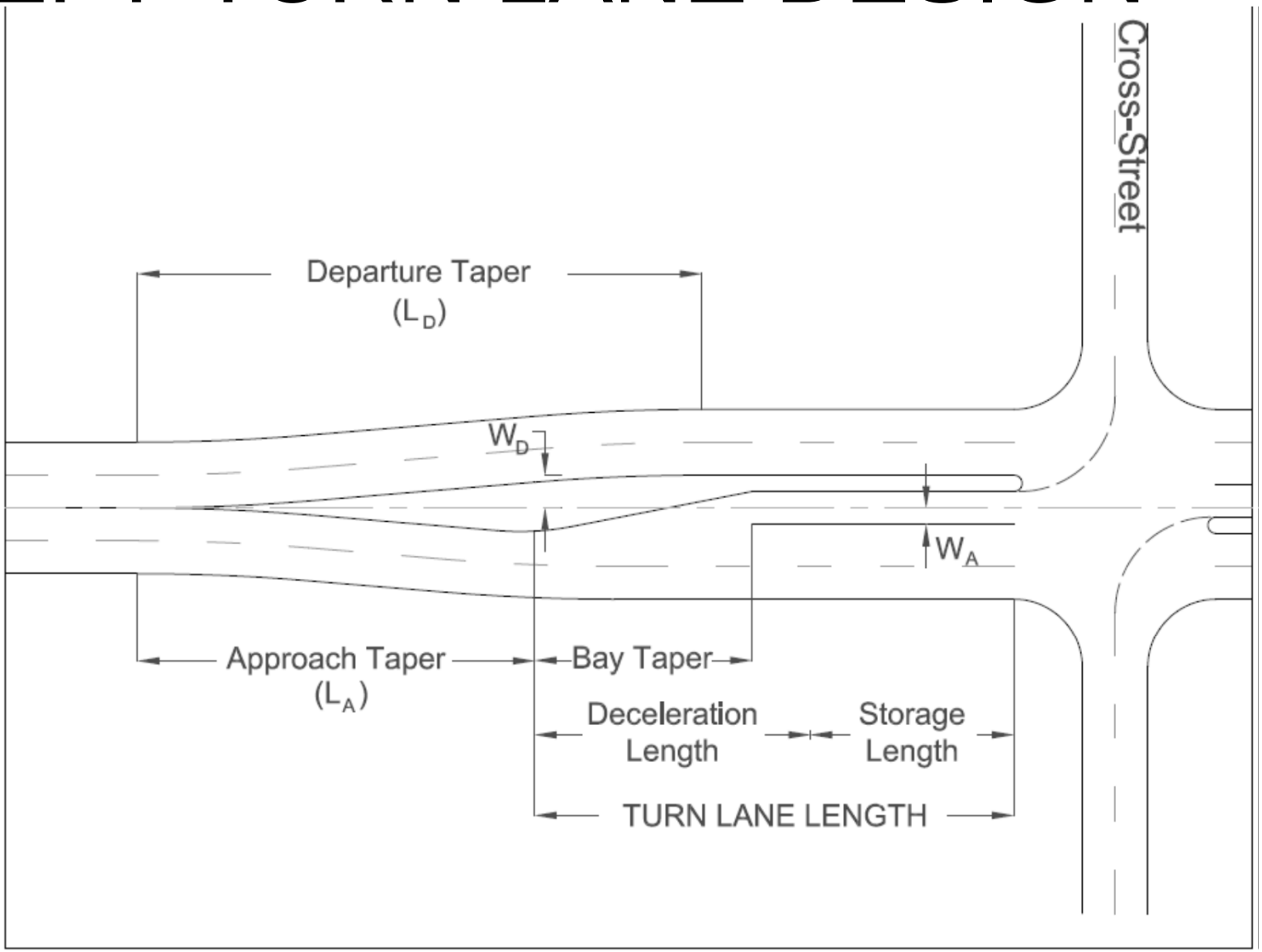
- Heavy Vehicle Adjustment Factor
  - v_A = Unadjusted advancing traffic volume = 444 vph
  - P_{HV} = Percent Heavy Vehicles = 0.06
  - v_O = opposing traffic volume = 611 vph
  - E_{HV}= Passenger Car Equivalency Factor
    = 0.0007 (v_O) (four and six-lane facilities)
    = 0.0007 (611) = 0.428

- Solving for v_A:
  - $v_A' = v_A [1+P_{HV}(E_{HV})]$
  - $v_A' = 444 [1+0.06(0.428)]$
  - $v_A' = 455$ vph

LEFT-TURN LANE WARRANTS



LEFT-TURN LANE DESIGN

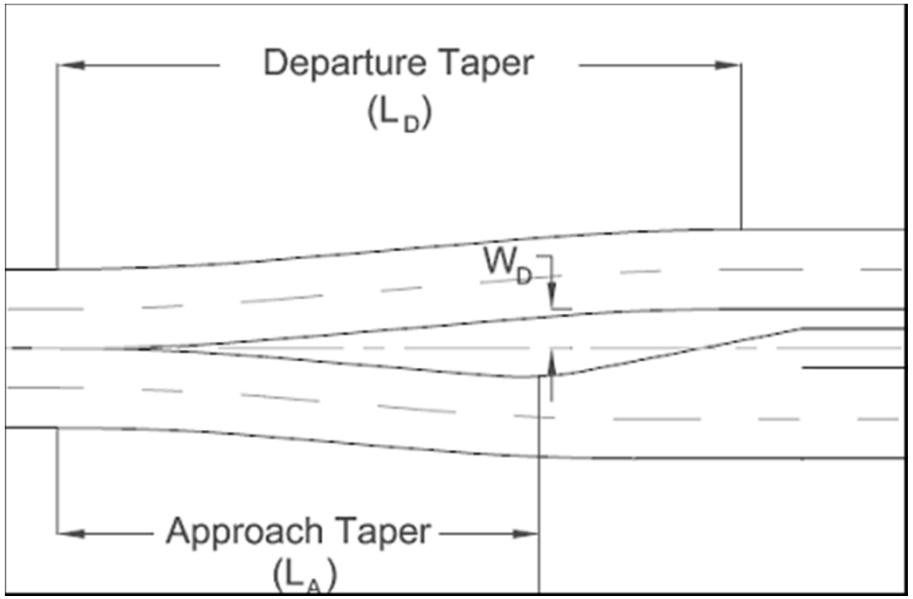


LEFT-TURN LANE DESIGN

- 3 primary components
  - Approach Taper
  - Bay Taper
  - Turn Lane Length
    - Deceleration Length
    - Storage Length

LEFT-TURN LANE DESIGN

- Approach Taper
  - ≥ 45 MPH L = W x S
  - < 45 MPH, L = $\frac{WS^2}{60}$



    - Where:

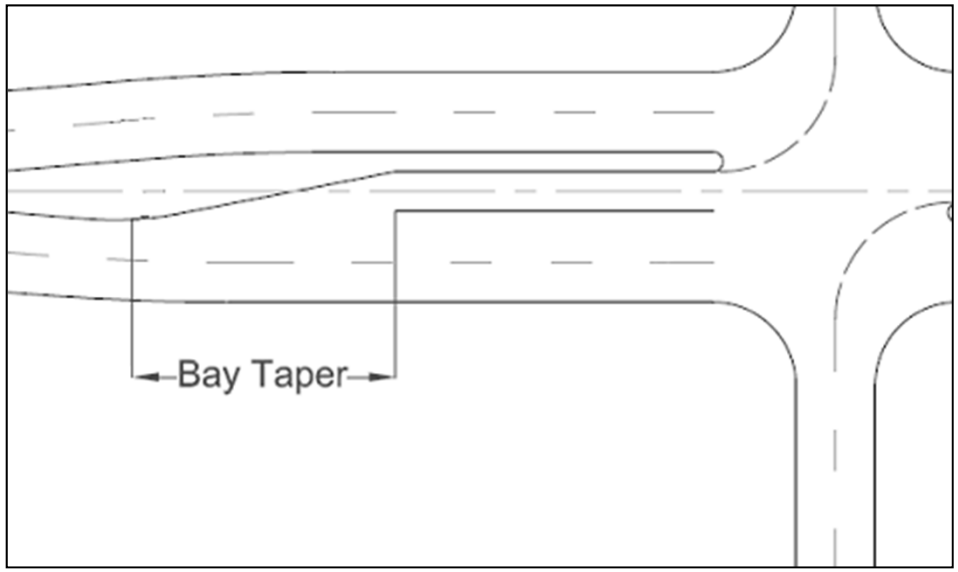
L = Taper length in feet

W = Width of roadway offset for taper in feet

S = Speed in miles per hour (MPH)

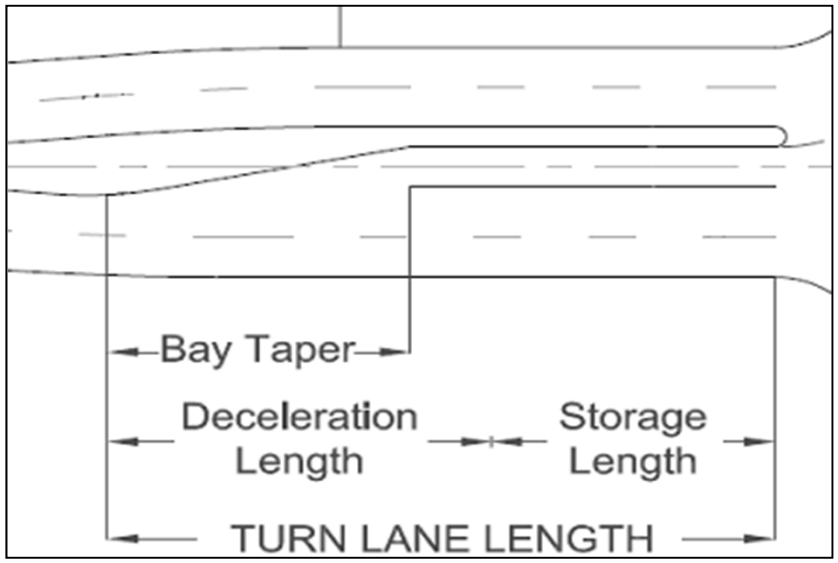
LEFT-TURN LANE DESIGN

- Bay Taper
  - ≥ 45 MPH L = 100 ft
  - < 45 MPH, L = 50 ft



LEFT-TURN LANE DESIGN

- Turn Lane Length
  - Deceleration Length
  - Storage Length



LEFT-TURN LANE DESIGN

- Turn Lane Length

Table 1: Auxiliary Turn Lane Length by Turn Type and Intersection Control

Approach Control	Turn Type	Turn Lane length
Uncontrolled	Left-Turn	Greater of Method 1[A] or Method 2[A]
Stop Controlled	Left-Turn	Storage + Bay Taper
Signal Control[B]	Left-Turn	Greater of Method 1 or Method 2

Notes: A: See Table 2 below.
B: At signalized intersections the length of turn lanes should be extended so that it is not blocked by the queue of adjacent through traffic.

LEFT-TURN LANE DESIGN

- Turn Lane Length

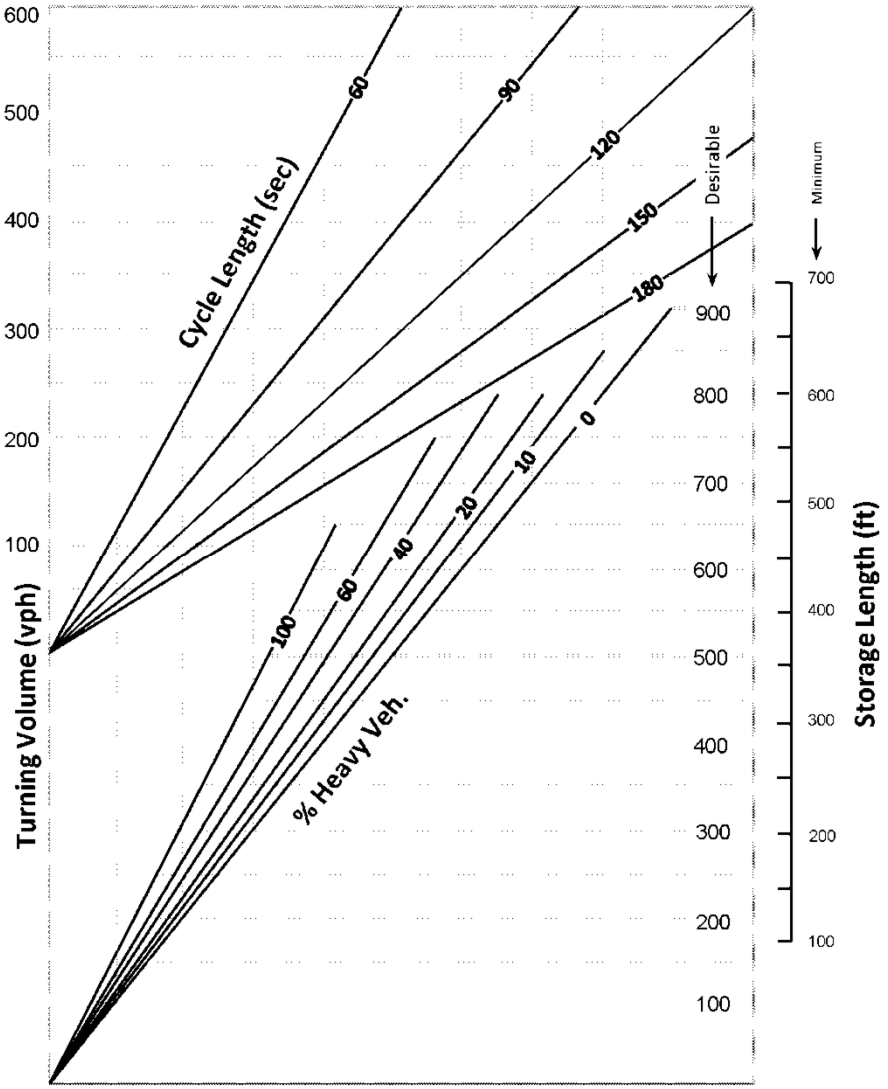
Table 2: Turn Lane Length by Speed

Speed (MPH)	Method 1: Deceleration Only[B]	Method 2: Moderate Deceleration + Storage[B]	Method 3: Full Deceleration + Storage (Rural Arterial ≥45 mph)[B]
20	125 ft	Storage + Bay Taper	N/A
25	125 ft	Storage + Bay Taper	
30	125 ft	Storage + Bay Taper	
35	125 ft	Storage + Bay Taper	
40	170 ft	70 ft + Storage	
45	220 ft	115 ft + Storage	340 ft + Storage
50	275 ft	170 ft + Storage	410 ft + Storage
55	340 ft	220 ft + Storage	485 ft + Storage
60	410 ft	275 ft + Storage	565 ft + Storage
65	485 ft	340 ft + Storage	645 ft + Storage

B: At signalized intersections the length of turn lanes should be extended so that it is not blocked by the queue of adjacent through traffic.

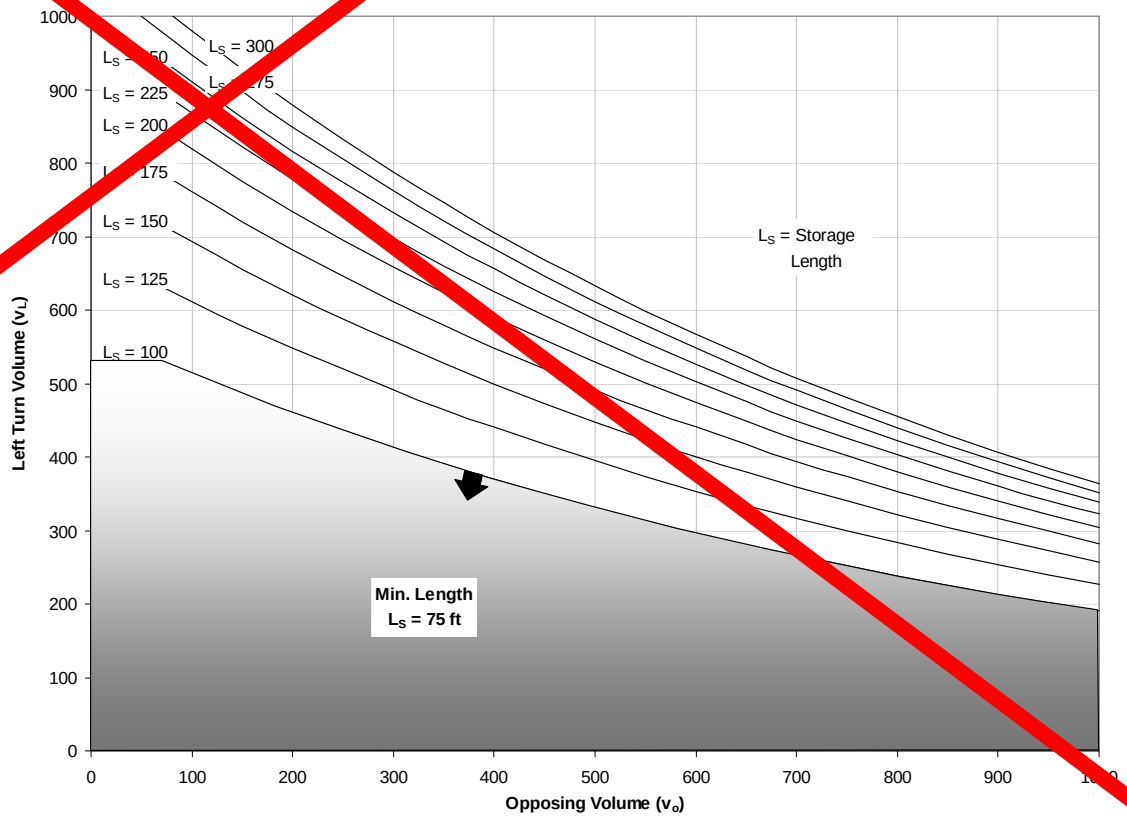
LEFT-TURN LANE DESIGN

- Storage Length (Signal and Stop Control)
  - Stop Control Cycle Length = 60 (sec)
  - 2 x Average Arrival per Cycle



LEFT-TURN LANE DESIGN

- Storage Length (Uncontrolled Approach)
  - 2 Graphs (≤ 45 mph; > 45mph)



LEFT-TURN LANE DESIGN

- Storage Length (Uncontrolled Approach)
  - 75 ft

RIGHT-TURN LANE WARRANTS

- Signalized Intersection:
  - Right-turn lanes shall be provided on if traffic volumes at the intersection meet the thresholds identified in Figure 3.
  - May also be considered to reduce the frequency of rear end crashes at intersections with a high volume of right-turns.

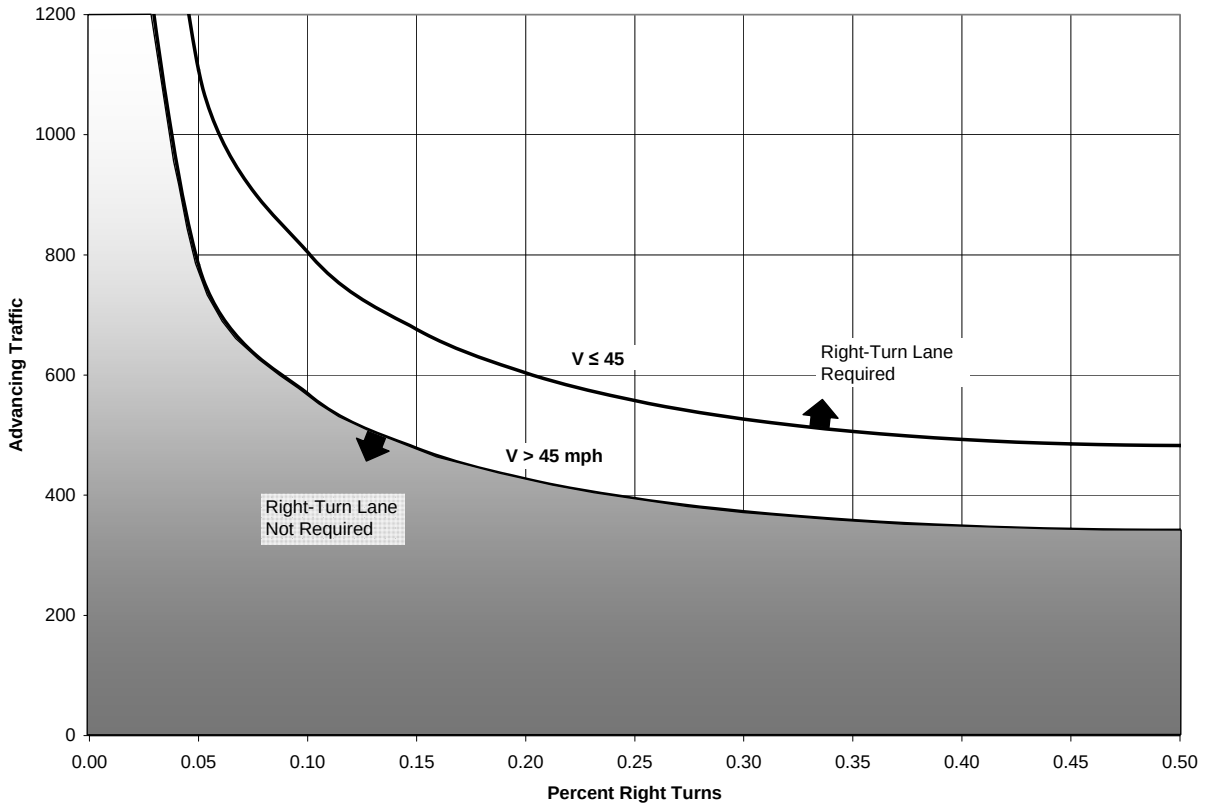
- Stop Controlled Approaches:
  - Right-turn lanes only when required by capacity analysis

RIGHT-TURN LANE WARRANTS

- Uncontrolled Approaches
  - Right-turn lanes shall be provided on if traffic volumes at the intersection meet the thresholds identified in Figure 3.
  - Right-turn lanes should be considered as a safety countermeasure, e.g. where sight distance of approaching traffic is limited.

RIGHT-TURN LANE WARRANTS

- 1 Graph measures probability of turning vehicle blocking lane
  - ≤ 45 MPH (P = 0.02)
  - >45 MPH (P = 0.01)

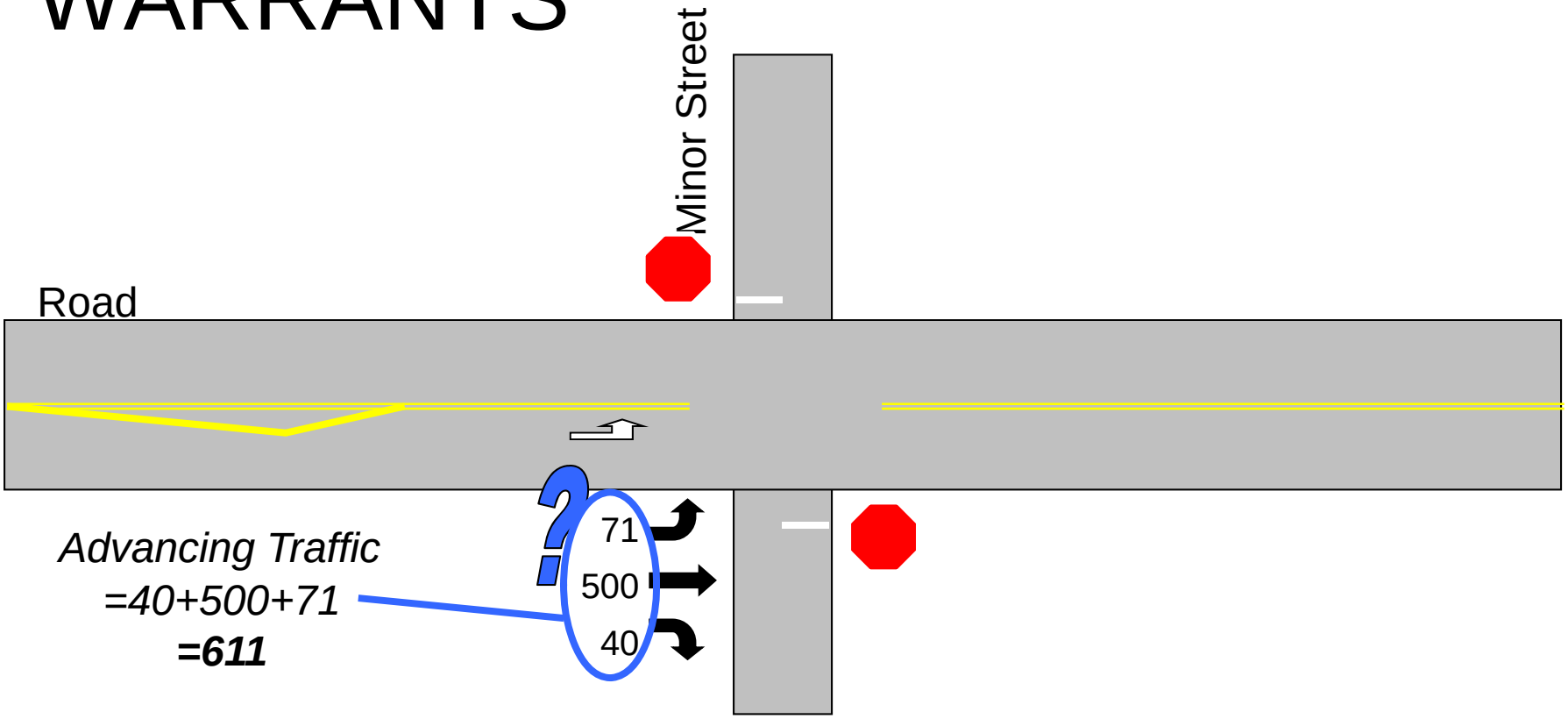


RIGHT-TURN LANE WARRANTS

- Inputs
  - *Percent Right-Turns*
  - *Advancing Volume = Through + Left + Right-Turn Traffic*

NO HEAVY VEHICLE ADJUSTMENT FACTOR

RIGHT-TURN LANE WARRANTS



Advancing Traffic

=40+500+71

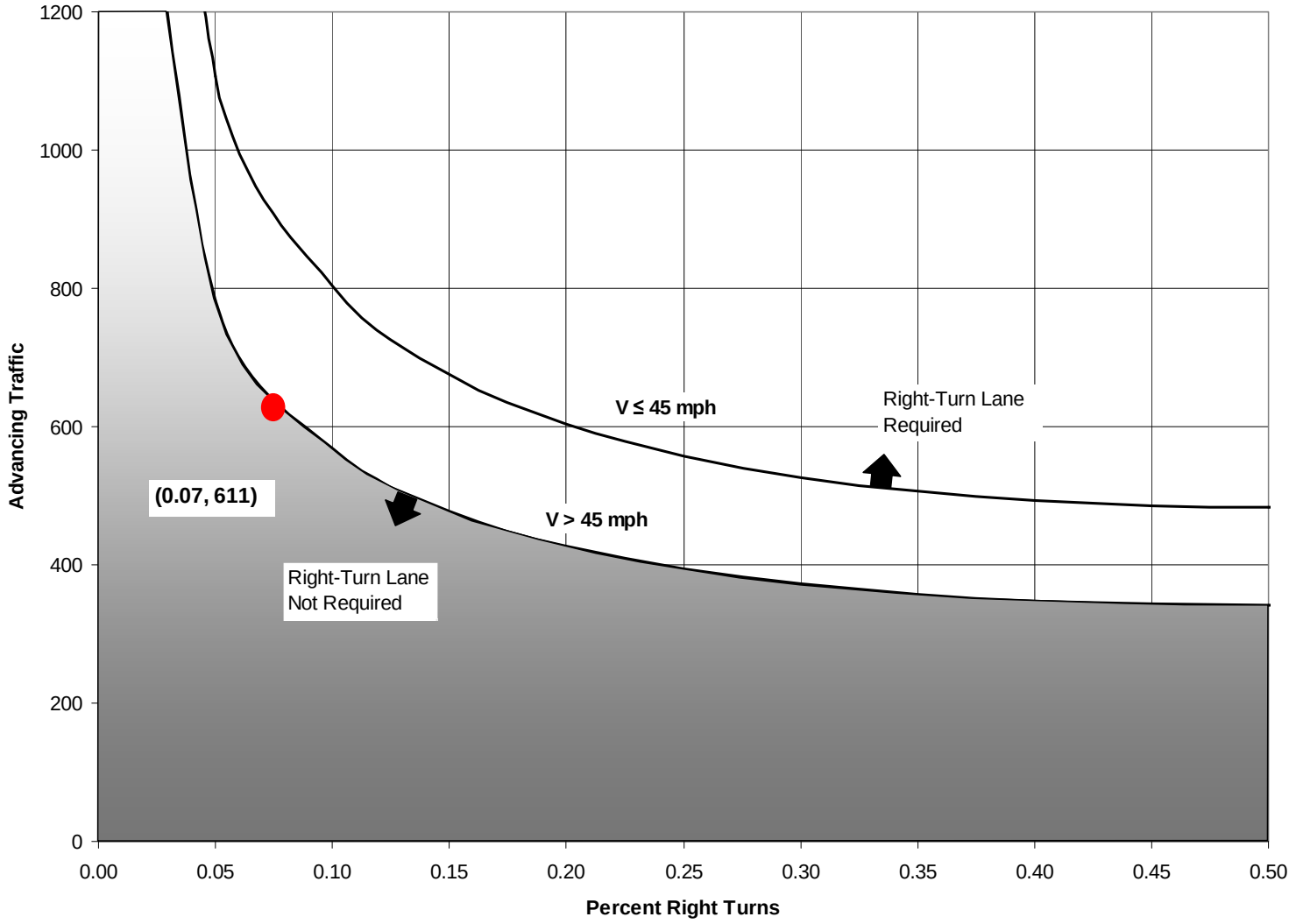
=611

Percent Right Turns

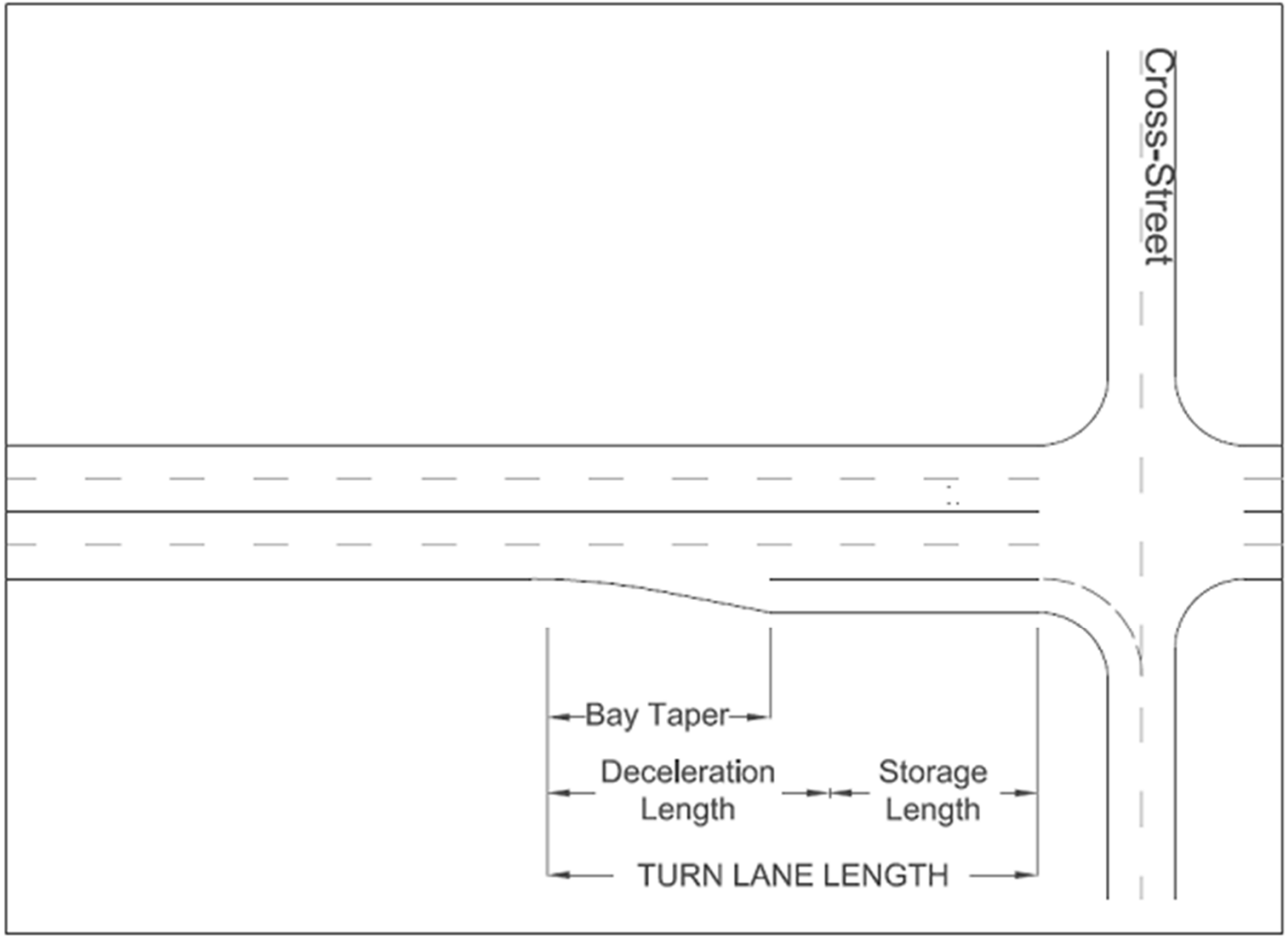
=40 / 611

=0.07

RIGHT-TURN LANE WARRANTS



RIGHT-TURN LANE DESIGN

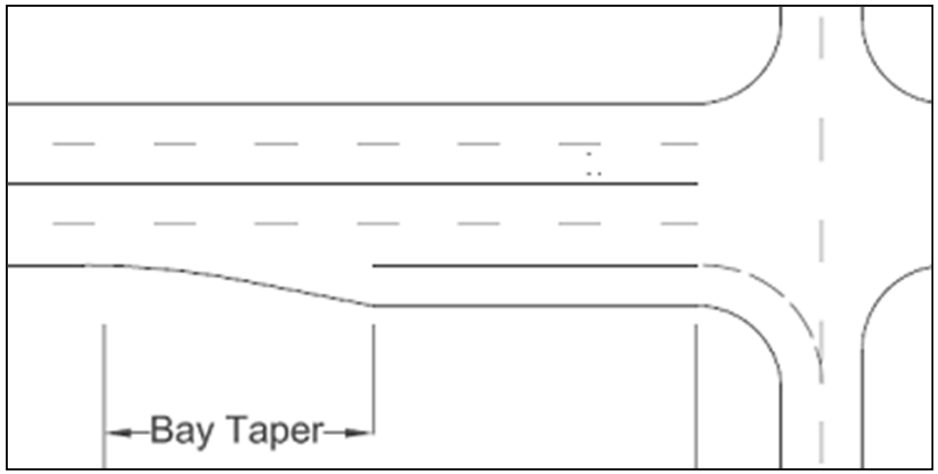


RIGHT-TURN LANE DESIGN

- 2 primary components
  - Bay Taper
  - Turn Lane Length
    - Deceleration Length
    - Storage Length

RIGHT-TURN LANE DESIGN

- Bay Taper
  - ≥ 45 MPH L = 100 ft
  - < 45 MPH, L = 50 ft



RIGHT-TURN LANE DESIGN

- Turn Lane Length
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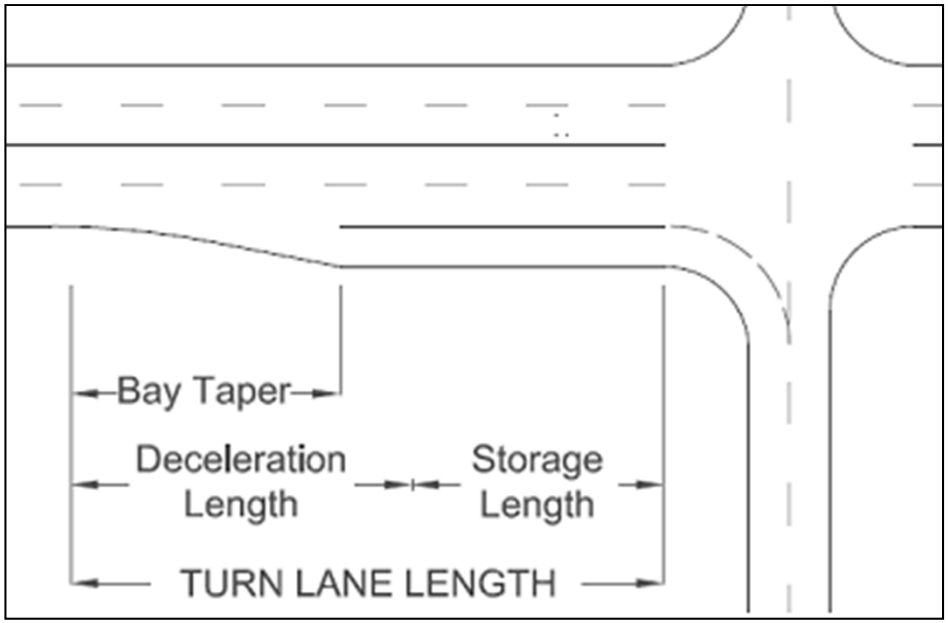


RIGHT-TURN LANE DESIGN

- Turn Lane Length

Table 1: Auxiliary Turn Lane Length by Turn Type and Intersection Control

Approach Control	Turn Type	Turn Lane length
Uncontrolled		
	Right-Turn	Method 1[A]
Stop Controlled		
	Right-Turn	Storage + Bay taper
Signal Control[B]		
	Right-Turn	Greater of Method 1[A] or Method 2[A]

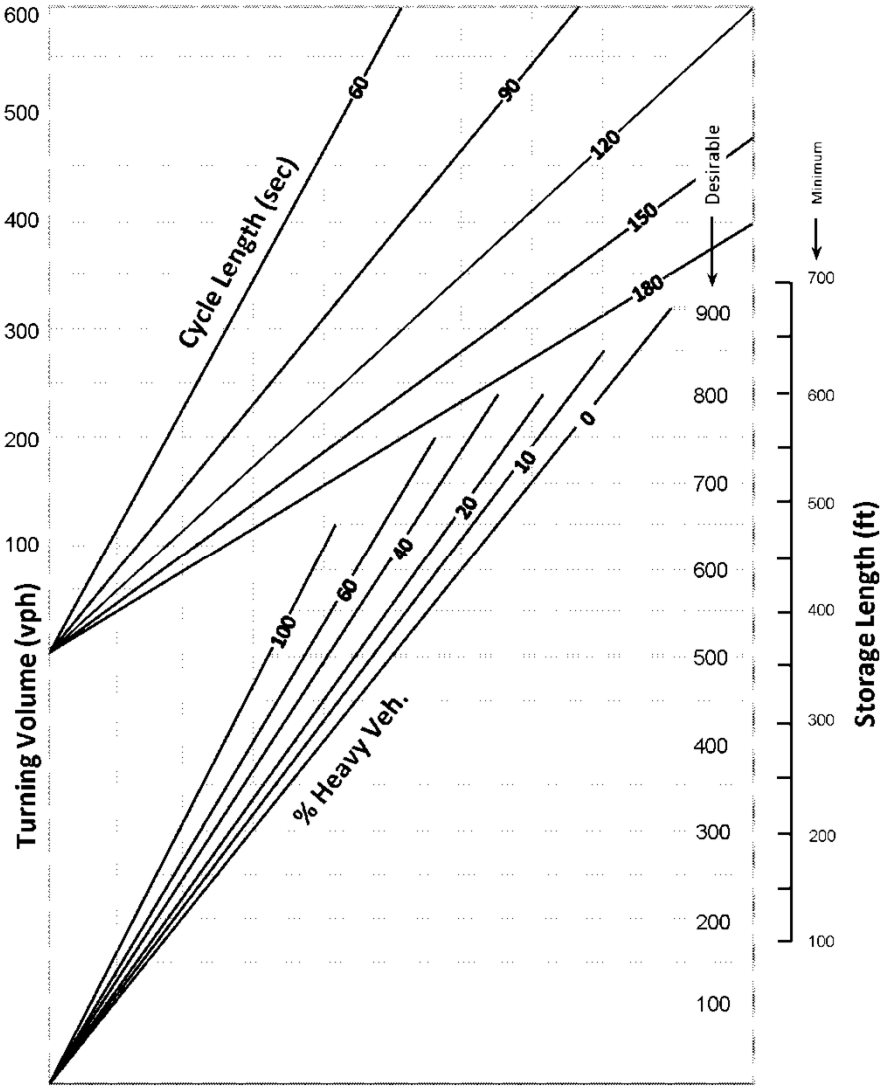
Notes: A: See Table 2 below.
B: At signalized intersections the length of turn lanes should be extended so that it is not blocked by the queue of adjacent through traffic.

Table 2: Turn Lane Length by Speed

Speed (MPH)	Method 1: Deceleration Only	Method 2: Moderate Deceleration + Storage
20	100 ft	Storage + Bay Taper
25	100 ft	Storage + Bay Taper
30	100 ft	Storage +Bay Taper
35	100 ft	Storage +Bay Taper
40	170 ft	70 ft + Storage
45	220 ft	115 ft + Storage
50	275 ft	170 ft + Storage
55	340 ft	220 ft + Storage
60	410 ft	275 ft + Storage
65	485 ft	340 ft + Storage

RIGHT-TURN LANE DESIGN

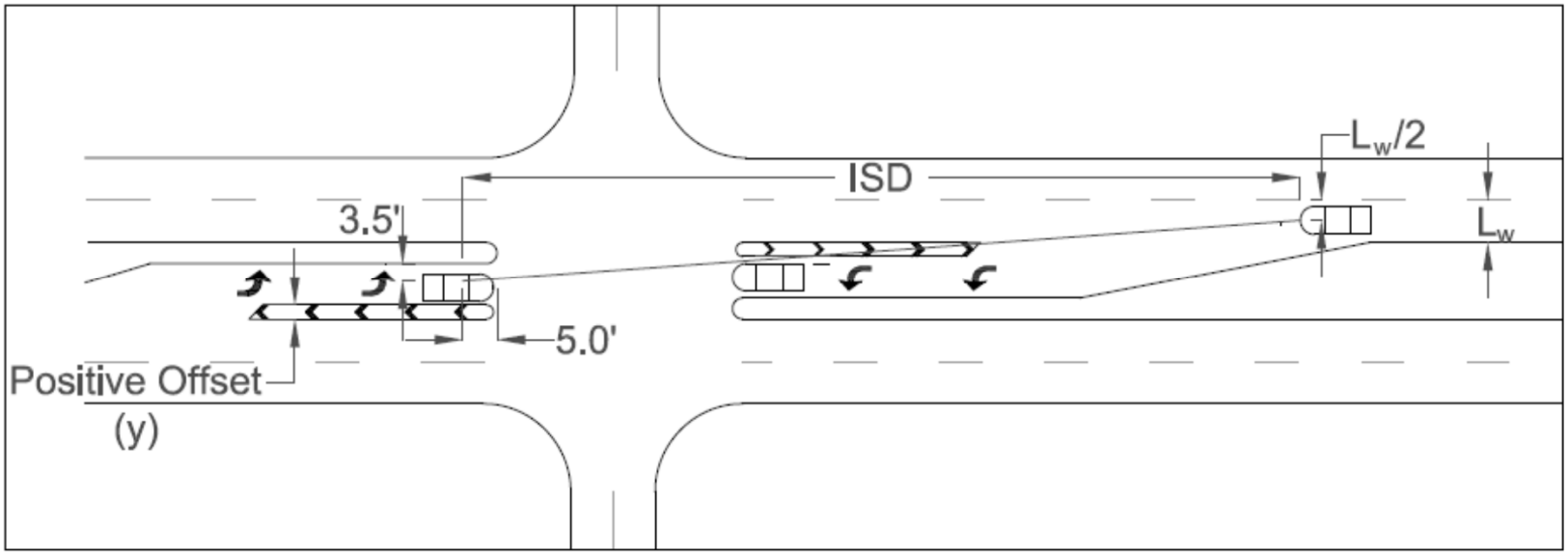
- Storage Length (Signal and Stop Control)
  - Stop Control Cycle Length = 60 (sec)
  - 2 x Average Arrival per Cycle



ALTERNATIVE DESIGNS

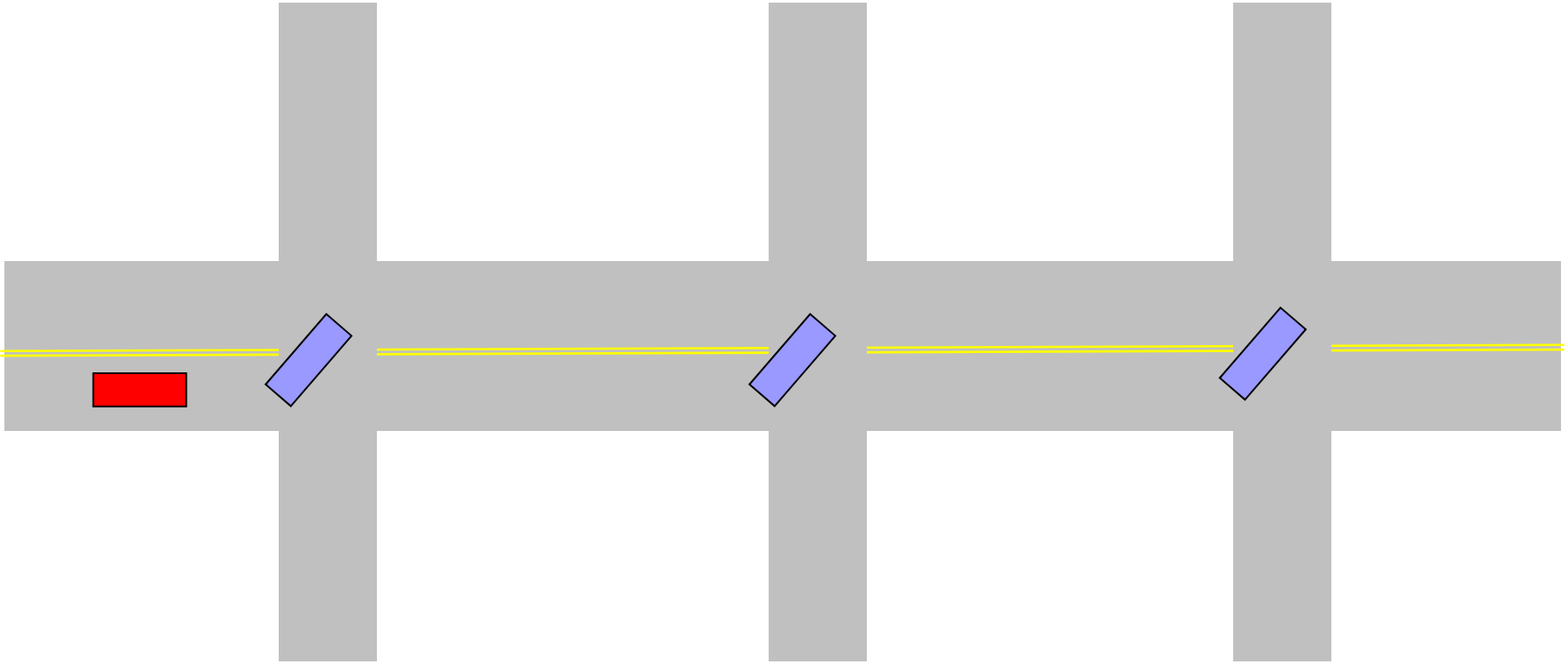
- Guidance for Reduction of the turn lane length is recommended only when site constraints make it impractical to provide a full length turn lane. Reduced turn lane length should not be used for the sole purpose of reducing construction costs.

POSITIVE OFFSET



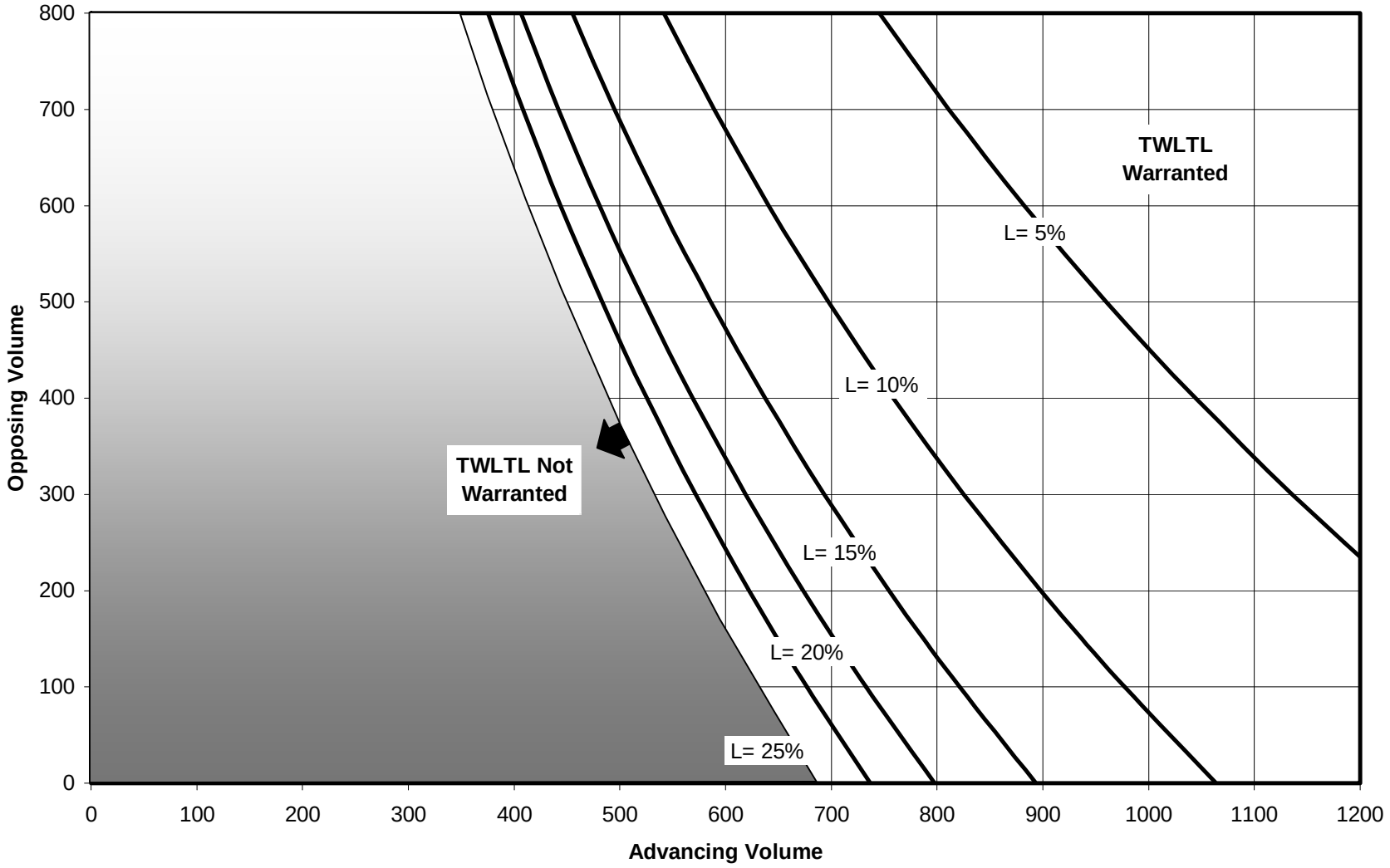
Design Speed (MPH)	Intersection Sight Distance		
	Passenger Car (t_g = 5.5)	Single Unit Truck (t_g = 6.5)	Combination Truck (t_g = 7.5)
25	205	240	275
35	285	335	385
45	365	430	495
55	445	525	605
65	525	620	715
75	605	715	825

TWO-WAY LEFT-TURN LANE



- Used to mitigate delay to through traffic resulting from the cumulative impact of consecutive access points

TWO-WAY LEFT-TURN LANE



TWO-WAY LEFT-TURN LANE

- Operating speeds ≤ 45 MPH
- ADT ≤ 17,000 (Two-Lane)
  ADT ≤ 24,000 (Multi-Lane)
- Access ≥ 10 access points per mile.
- Minimum TWLTL Length 425 foot typical section
- Maximum Access Density ≤ 85 access points per mile.

QUESTIONS

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