

MTO Design Supplement

**For
TAC Geometric Design Guide for
Canadian Roads**

**Appendix 9A for Section 9.17.2.1 Volume
Warrants for Left-Turn Lanes**

Chapter 9 - Intersections

~~October~~ July ~~TBD~~ 2023 2026

DRAFT

MTO Design Supplement

Appendix 9A for Section 9.17.2.1 Volume Warrants for

Left-Turn Lanes

Chapter 9 Intersections

The following **additional guidance** for left-turn lanes at intersections ~~are is~~ Applicable to Section 9.17.2.1 Volume Warrants of Chapter 9 – Intersections of the TAC Geometric Design Guide for Canadian Roads - June 2017:

Signalized Intersections

At an intersection consisting of through lanes and separate left-turn lanes, traffic may require a signal control may be required when the volume of traffic entering the intersection is such that the traffic flow ~~allows results in~~ insufficient gaps to permit all intersecting vehicles to enter, turn, or cross the intersection with little delay or inconvenience. The decision to install a traffic signal must be based on a careful evaluation of the volume warrants and ~~approved traffic~~ guidelines (*Refer to OTM Book 12 – Traffic Signals*). The service volumes that a signalized intersection can accommodate, and the capacity are dependent on the traffic factors, intersection geometrics and signal operations. For signalized intersections the geometrical configuration of the entire intersection design should be coordinated with the appropriate signal design and traffic signal phasing consistent with the operational requirements of both present and future traffic demands. The Project Delivery office should ~~have early liaison work~~ with the Regional Traffic ~~office~~ section early in the design process.

As a general guideline, left-turn lanes must be considered and installed on all highway approaches at all signalized intersections whether the left-turn warrants are met or not, unless the left turn is prohibited by geometrics (T-intersection) or traffic regulations (one-way traffic).

Separate left-turn lanes at signalized intersections have the advantages of increased safety, improved intersection capacity, flexibility for possible phasing schemes and clarity of purpose.

The left-turn storage-lane length is a function of the signal cycle length and left-turning traffic volume. A left-turn storage lane can function with or without separate left-turn traffic signal phasing. The length of left-turn storage lane should be determined by using the methodology

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Unsignalized Intersections

When the number of left-turning vehicles at intersections is less than 5 percent of through traffic however it creates a hazard and reduces capacity, consideration should be given to the provision of a left-turn lane. The collision history and Level of Service (LOS) of the intersection should be reviewed to assess the operational performance with and without provision of a left-turn lane. Capacity and LOS should be reviewed using HCM 2000 for existing scenario and for horizon year. Adjacent intersections should also be reviewed in the context of driver expectation and consistency throughout a corridor.

Left-Turn Lane Requirement - General Criteria For two-lane, four-lane divided and undivided highways, unsignalized intersections.

A separate left-turn lane shall be considered at an un-signalized intersection when either of the following conditions exist:

- Where left-turn lane warrants are met as per warrant graphs in Exhibit-9A-3 to Exhibit-9A-30.
- The volume of left-turning vehicles is such that it continuously reduces the level of service for through traffic
- Where four or more left-turn-related collisions occur per year
- Where six or more left-turn-related collisions occur within a two-year period

Uniform volume warrants graphs and design guidelines ~~of~~ for left-turn storage lanes at unsignalized intersections have been developed and were based on theoretical analysis and on a series of field studies of traffic behaviour at intersections.

The warrant graphs provided in this **Appendix** based on vehicles operating at the design speed indicated, show the conditions when left-turn storage lanes should be added or where traffic signals are to be considered.

~~An a~~ Additional length should be added to the graph value if the percentage of the left-turning commercial vehicles is significant. **Exhibit-9A-1** lists additional storage lengths based on commercial vehicles percentages of left-turning volumes, V_L , and storage length, 'S', obtained from warrant graphs provided in this **Appendix**.

Exhibit -9A-1
ADDITIONAL STORAGE LANE LENGTH FOR COMMERCIAL VEHICLES
Additional Storage-Lane Length for Commercial Vehicles

“S” Storage Lengths from Warrant Graphs; Appendix 9A	Percentage of Commercial Vehicles in Left-Turning Volume, V_L						
	10%	15%	20%	25%	30%	40%	50%
	Additional Storage-Lane Lengths in Meters						
15	10	10	10	10	10	15	15
25	10	10	10	10	10	15	15
30	10		10	10	15	15	15
40	10	10	10	15	15	15	25
50	10	10	15	15	15	25	25
55	10	15	15	15	25	25	30
65	10	15	15	15	25	30	30
70	10	15	15	25	25	30	40
80	10	15	15	25	25	30	40
90	15	15	25	25	30	40	50
95	15	15	25	25	30	40	50
105	15	15	25	30	30	50	50
110	15	25	25	30	40	50	50
120	15	25	25	30	40	50	50
130	15	25	30	30	40	50	50

Left-turn lane volume warrants and storage-lane lengths for unsignalized intersections are based on turning, advancing and opposing design hour volumes, which are shown on the example of the Design Hour Volume (DHV) turning volume diagram, see **Exhibit -9A-2**, and are determined from the warrant graphs in **Exhibit -9A-3 to Exhibit -9A-30**.

The design charts have been are based on passenger car dimensions and operating characteristics.

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The minimum storage length that should be provided is 15 m ~~from practical design considerations alone. This length of 15 m which will provides~~ adequate storage for two vehicles.

Use of **Warrant** Graphs

Select the appropriate ~~proper~~ graph based on the percentage of left turns in Advancing Volume, V_A , and design speed in kilometres per hour (km/h).

- The 5% graph applies whenever left-turning traffic is less than or equal to 5% and a left turn lane is warranted based on level of service or collisions as described above
- For VL/ V_A value above 5%, apply the following rounding rule:
 - 0 5.0% - 7.4% VL/ V_A : use the 5% graph
 - 0 7.5% - 12.4% VL/ V_A : use the 10% graph
 - 0 12.5% - 14.4% VL/ V_A : use the 15% graph
 - 0 Continue similarly for higher percentages.

If the intersection of lines projected from Advancing Volume, V_A , and Opposing Volume, V_O , falls to the left of the warrant line, a left-turn lane is not required.

To the rRight of the warrant line, 'S', indicates the length of the storage lane in metres. If the percentage of commercial vehicles in the left-turning traffic is more than 10% see **Exhibit -9A-1** and add the tabulated value to storage-lane length.

The charts also indicate conditions where the combination of advancing and opposing traffic may warrant traffic signals. A warrant for traffic signals may occur when no warrant for left-turn storage lanes ~~exist~~exists due to the requirements of the side road traffic.

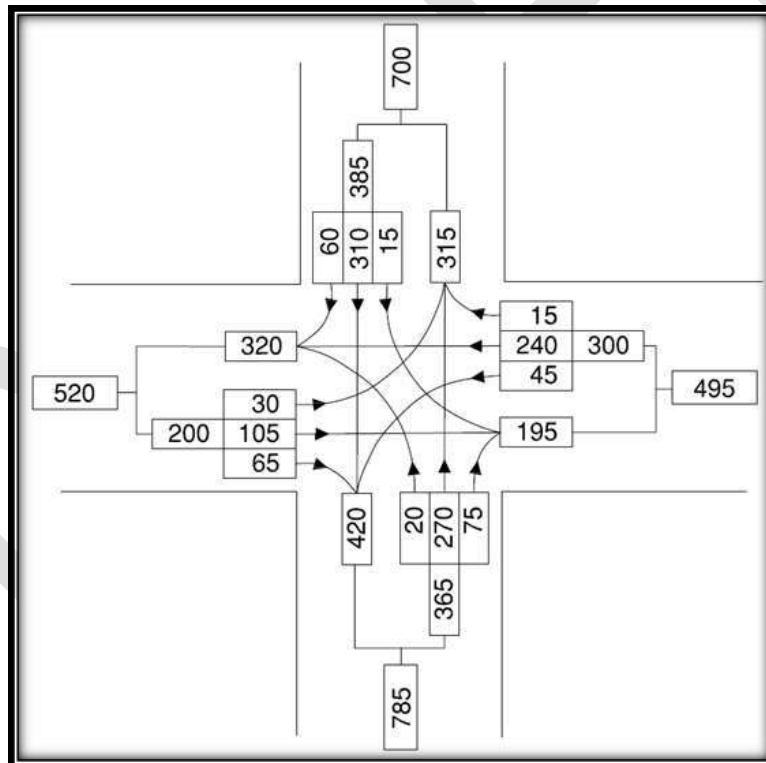
On approaches where a separate ~~turning~~ lane is provided for right-turning traffic, ~~the right turns are not included in the determination of V_A or V_O as the case may be.~~ For right-turning lanes, refer to *Section 9.14 – Tapers and Auxiliary Lanes of Chapter 9- Intersections*.

The following Eexample 1 relates to the turning volume diagram in **Exhibit -9A-2** and left-turn storage lane chart **Exhibit -9A-4**.

Example 1

Design Speed = 50 km/h

Advancing Traffic Volume, V_A = 300 vph

~~TBD~~ July ~~October~~ 20263Opposing Traffic Volume, $V_O = 200$ vphLeft-Turn Traffic Volume, $V_L = 45$ vph**Exhibit -9A-2****~~DESIGN HOUR VOLUME (DHV)~~ Design Hour Volume (DHV)****~~TURNING VOLUME DIAGRAM~~ Turning Volume Diagram**

$$\text{Percentage of Left-Turning Traffic} = \frac{45 \times 100}{300} = 15 \%$$

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The projected lines intersect to the left of the warrant line; ~~and hence therefore~~ no left-turn lane is ~~needed~~ required. Also, the lines intersect to the left of the traffic signal warrant line indicating that traffic signals are not required.

Example 2

Design Speed = 100 km/h

Advancing Traffic Volume, $V_A = 400$ vph

Opposing Traffic Volume, $V_O = 300$ vph

Left-Turn Traffic Volume, $V_L = 120$ vph

$$\text{Percentage of Left-Turning Traffic} = \frac{120 \times 100}{400} = 30 (\%)$$

The traffic volumes and derived left-turning traffic percentage of 30% are applied to **Exhibit-9A-25**.

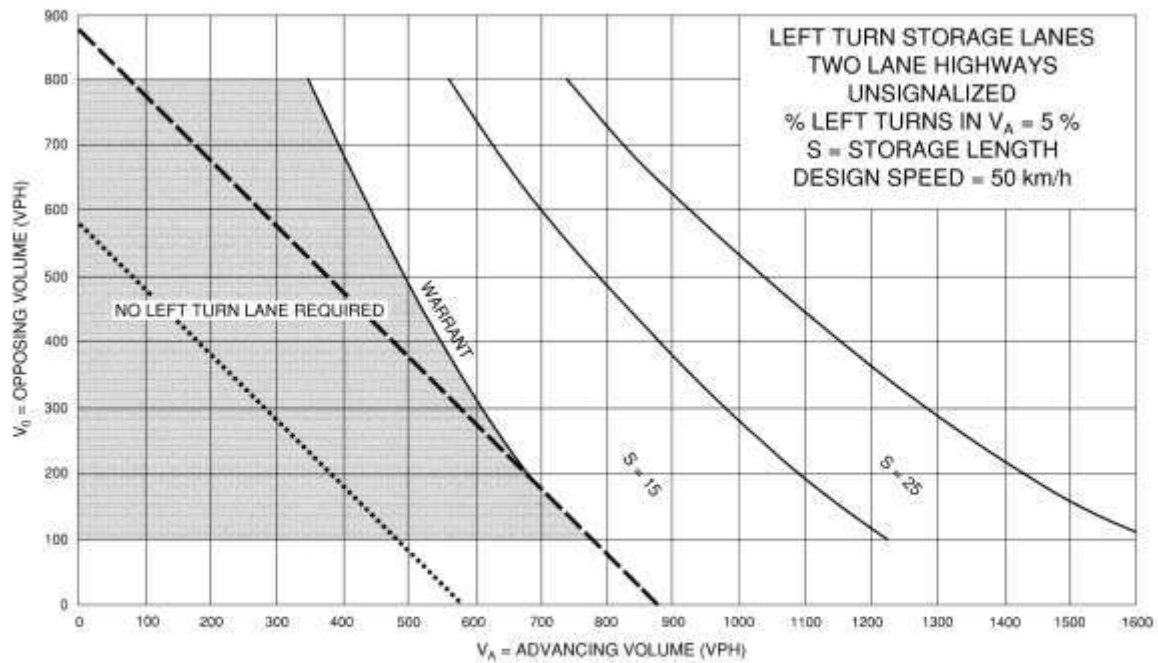
The ~~value in the~~ graph indicates that the required length of the left-turn storage-lane length, 'S' should be 25 m.

If the percentage of commercial vehicles in the left-turn lane is 20%, see **Exhibit-9A-1** for additional storage length and add the value to the left-turn lane; $25 \text{ m} + 10 \text{ m} = 35 \text{ m}$.

Since the lines intersect to the right of the short-dashed line and to the left of the long-dashed line, ~~therefore~~ traffic signals may be warranted only in "free-flow" urban areas ~~only~~. These graphs are not ~~the to be used as~~ substitutes for determining signal warrants.

~~If the value of left turning volume is in between the two charts, e.g., 16% then the designer should be using the chart of 15% and 20% and select the conservative storage length of the two charts. Similarly, for a 28% left turning volume, charts of 25% and 30% should be looked at and the conservative storage length should be selected.~~

Exhibit -9A-3



--- TRAFFIC SIGNALS MAY BE WARRANTED IN RURAL AREAS OR URBAN AREAS WITH RESTRICTED FLOW
 TRAFFIC SIGNALS MAY BE WARRANTED IN "FREE FLOW" URBAN AREAS

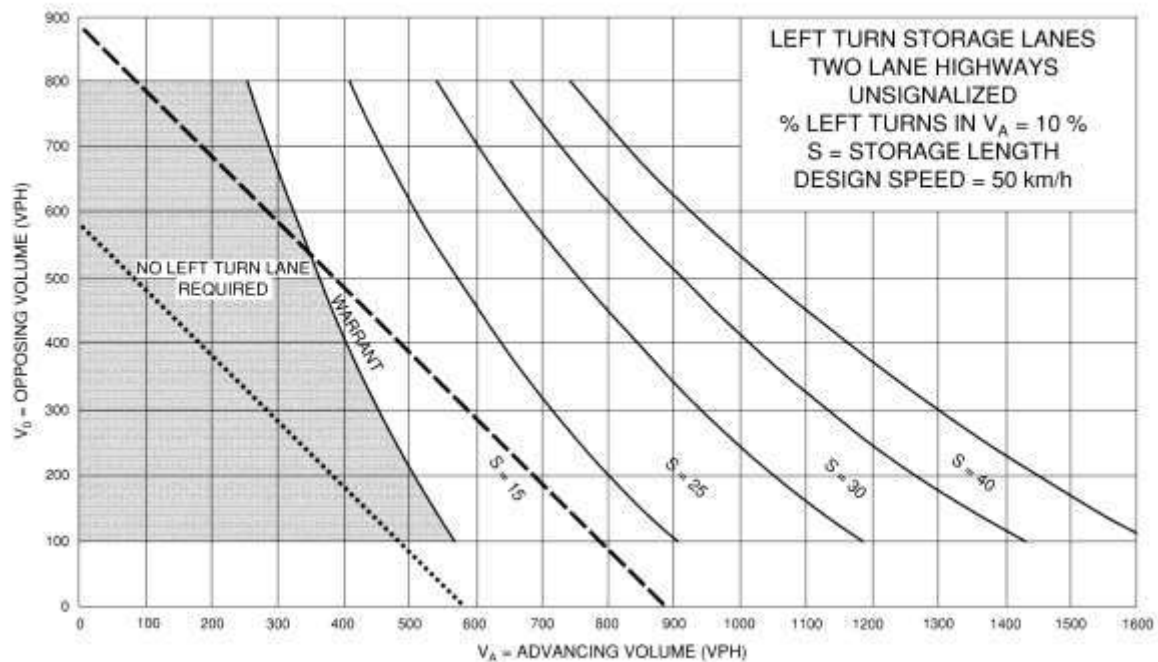
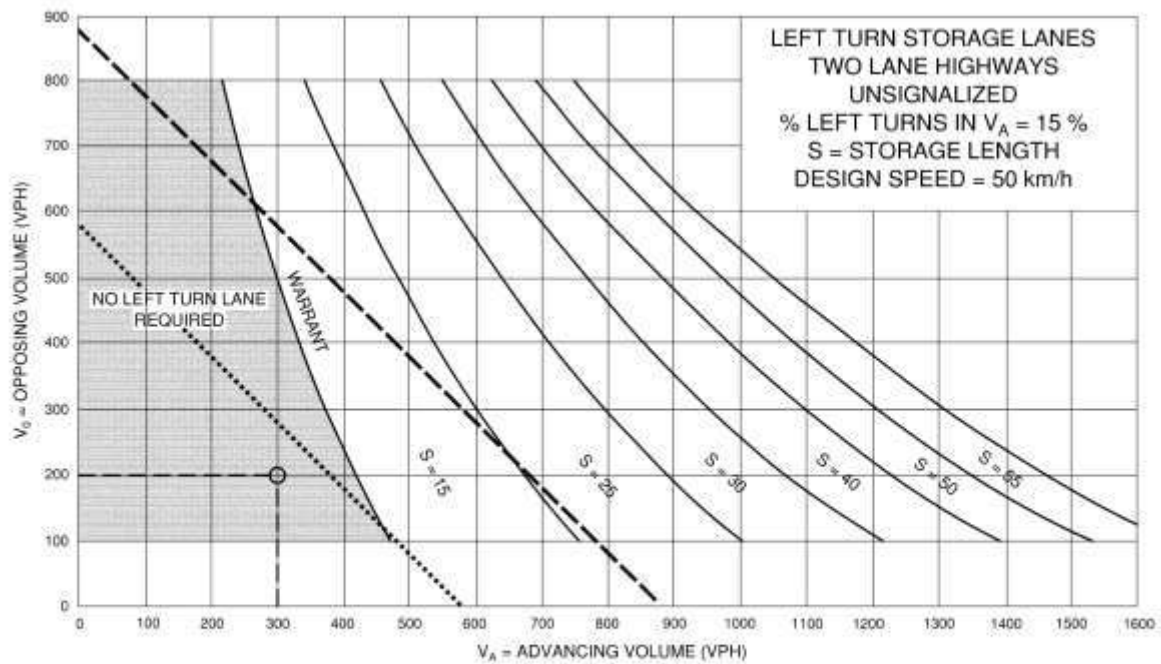


Exhibit -9A-4



--- TRAFFIC SIGNALS MAY BE WARRANTED IN RURAL AREAS OR URBAN AREAS WITH RESTRICTED FLOW

..... TRAFFIC SIGNALS MAY BE WARRANTED IN "FREE FLOW" URBAN AREAS

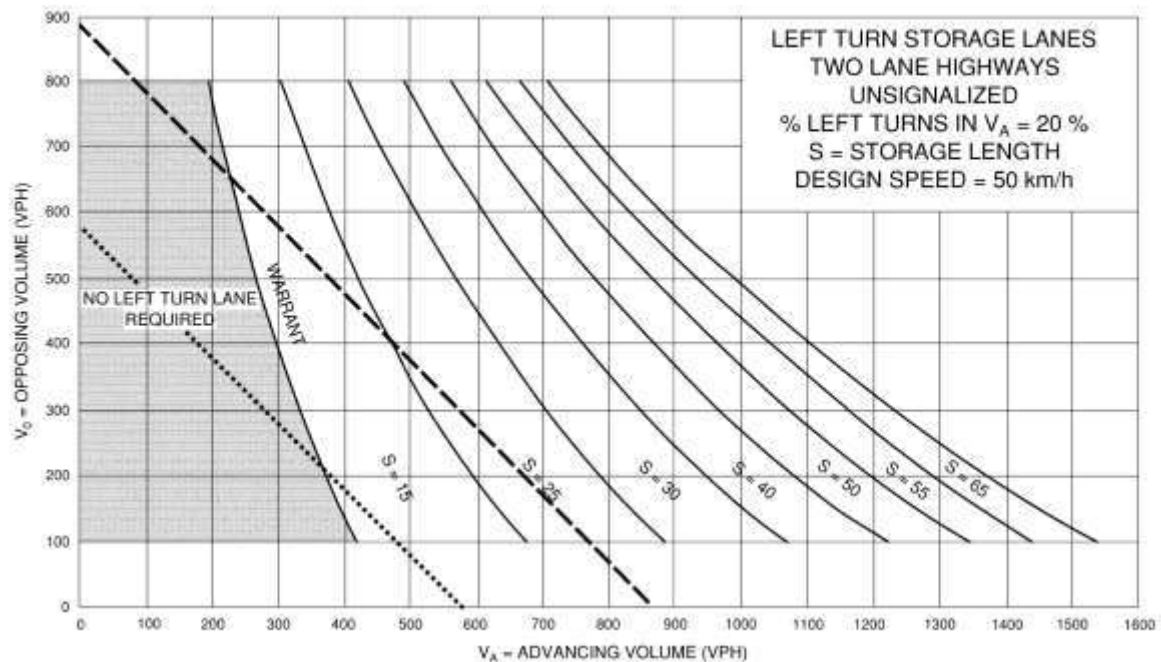
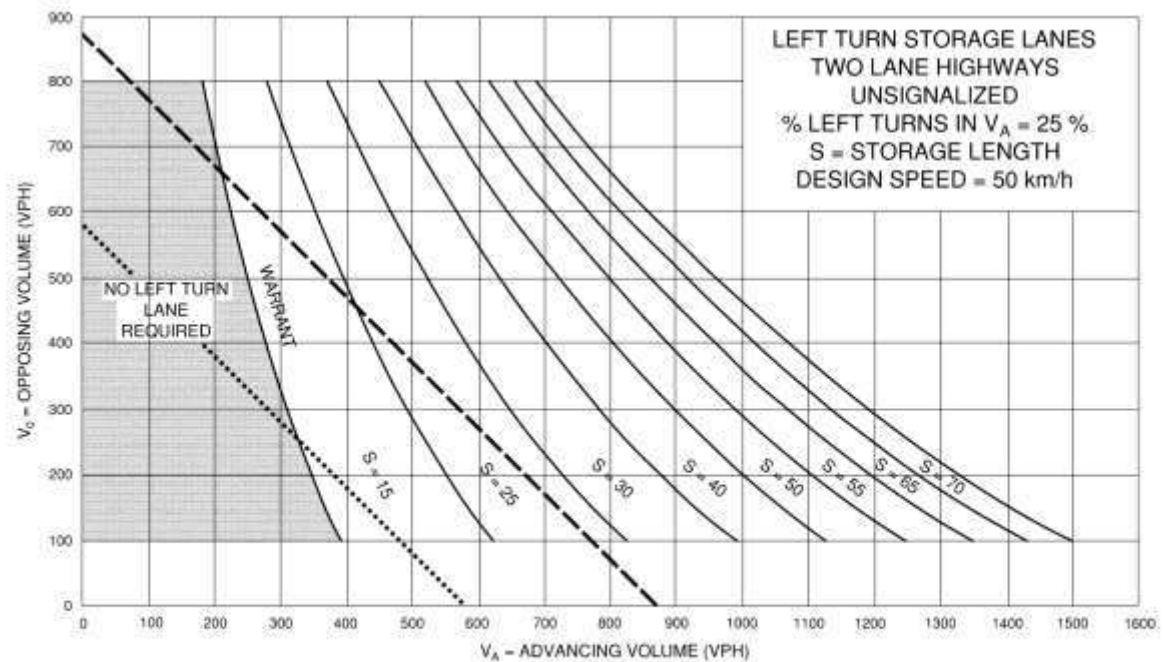


Exhibit -9A-5



- TRAFFIC SIGNALS MAY BE WARRANTED IN RURAL AREAS OR URBAN AREAS WITH RESTRICTED FLOW
- TRAFFIC SIGNALS MAY BE WARRANTED IN "FREE FLOW" URBAN AREAS

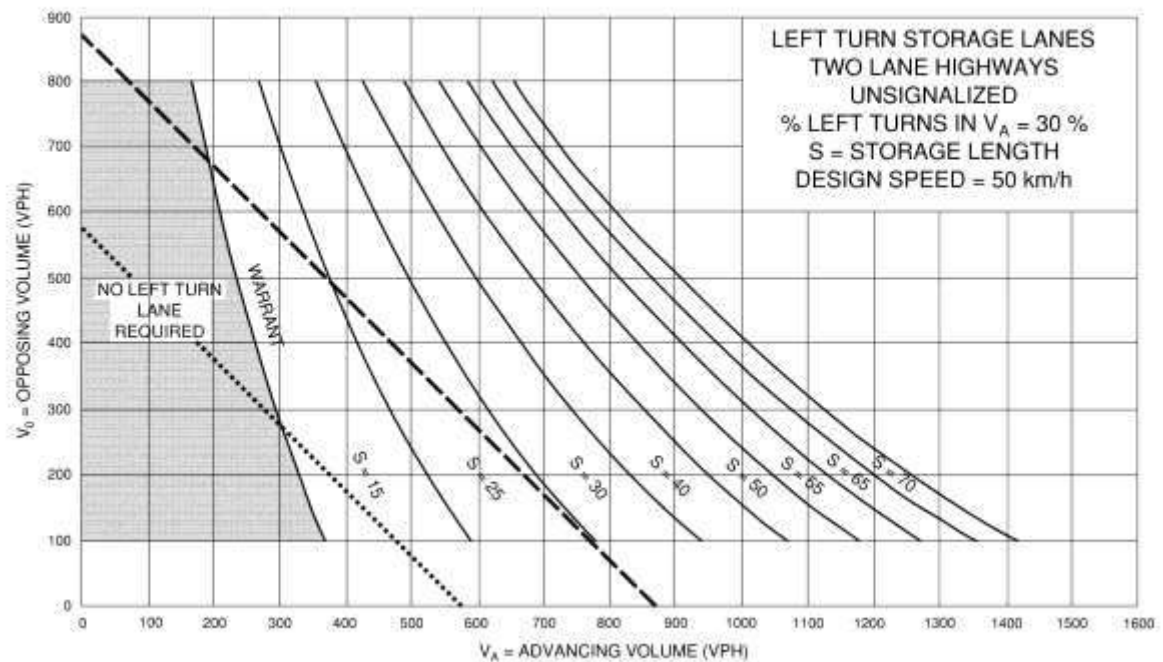


Exhibit -9A-6

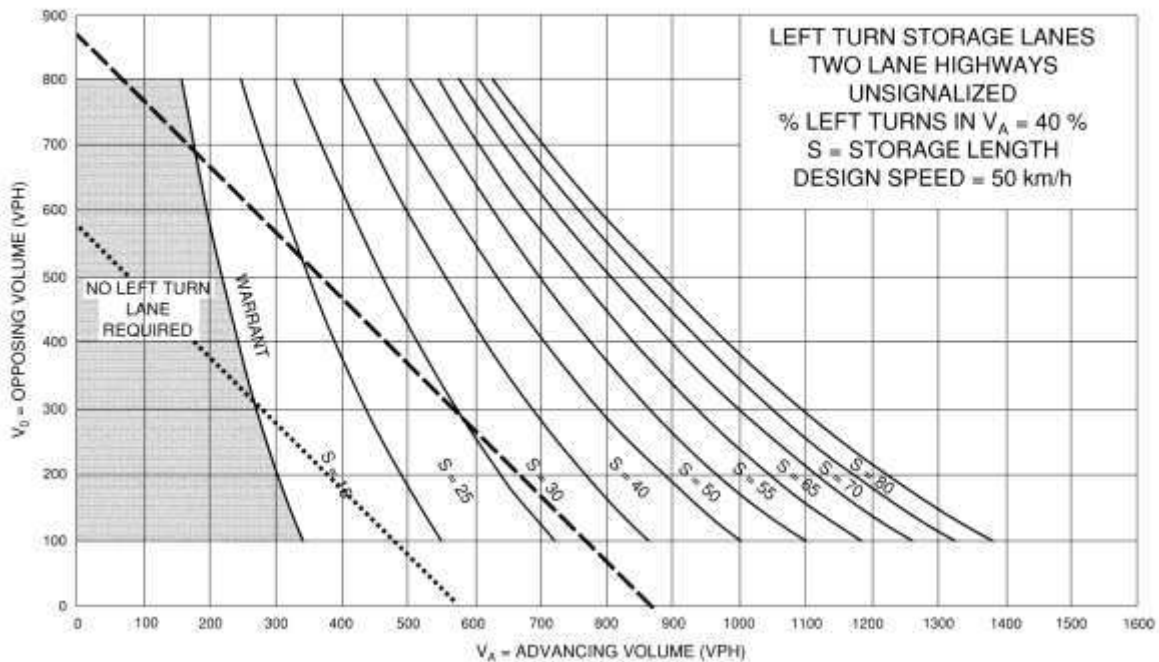
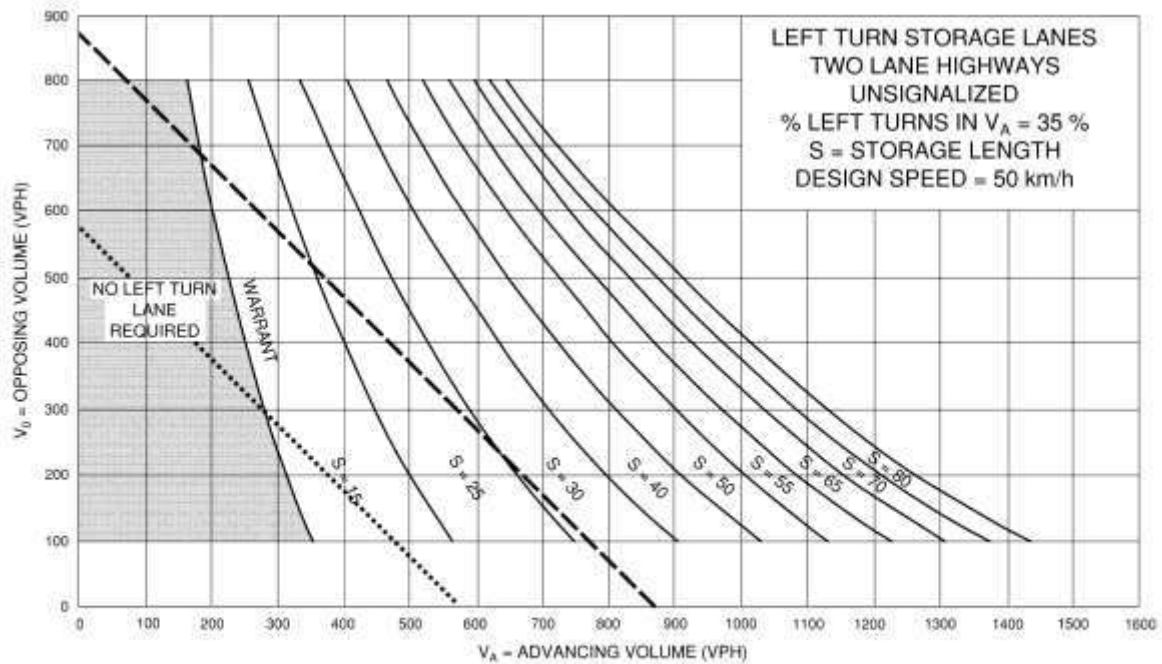


Exhibit -9A-7

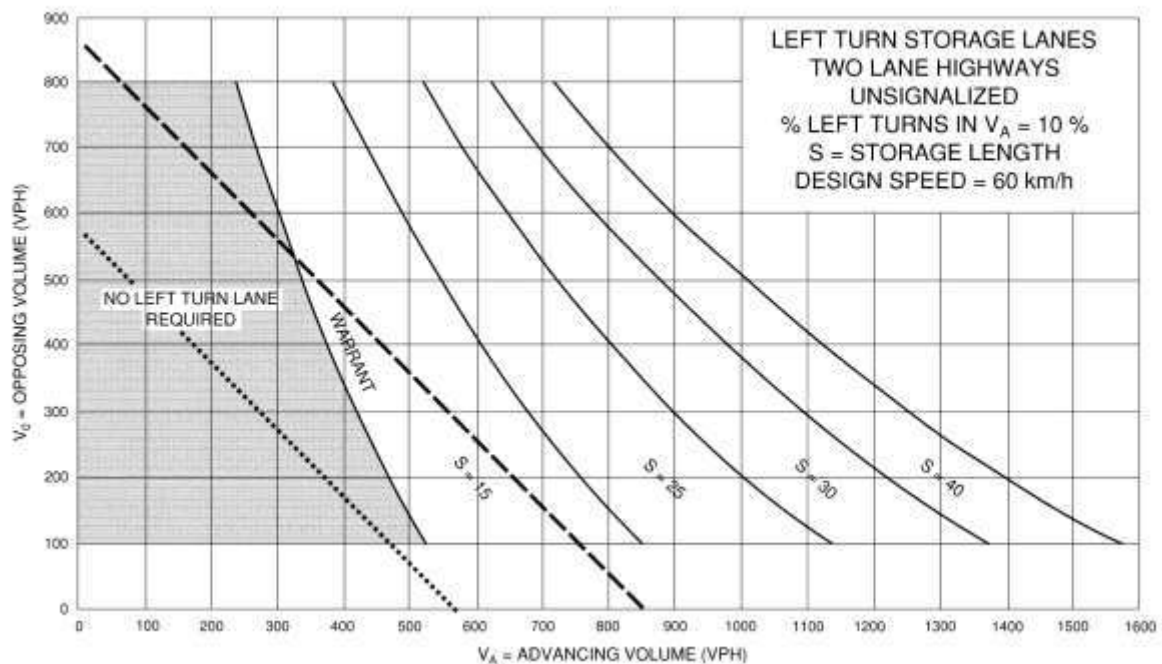
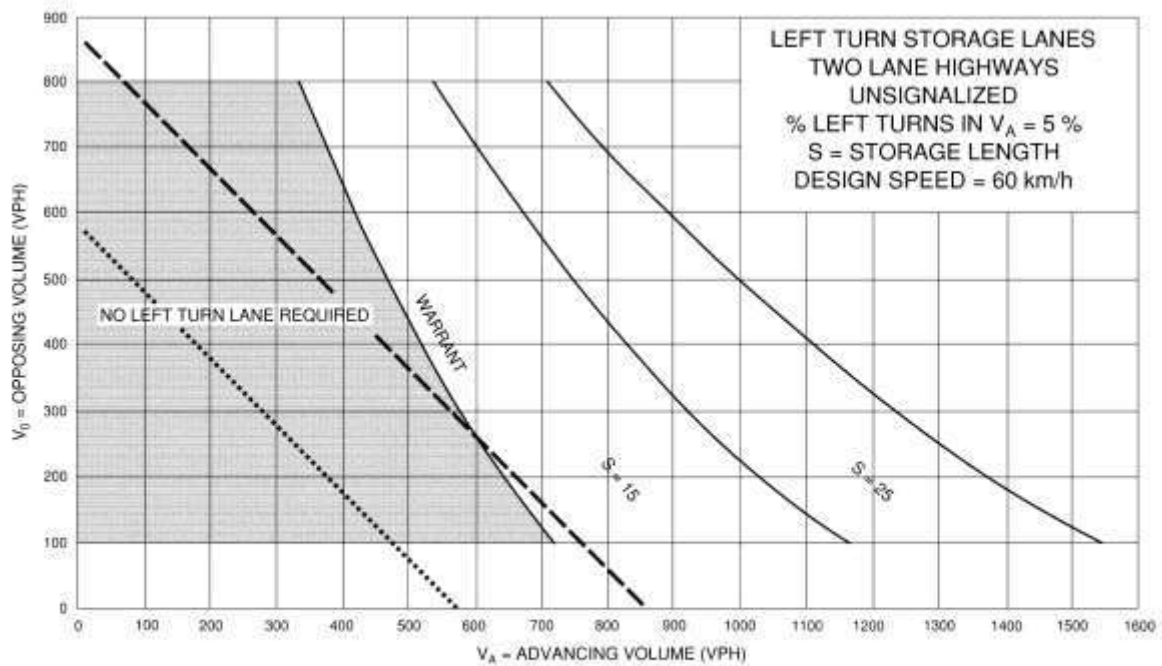
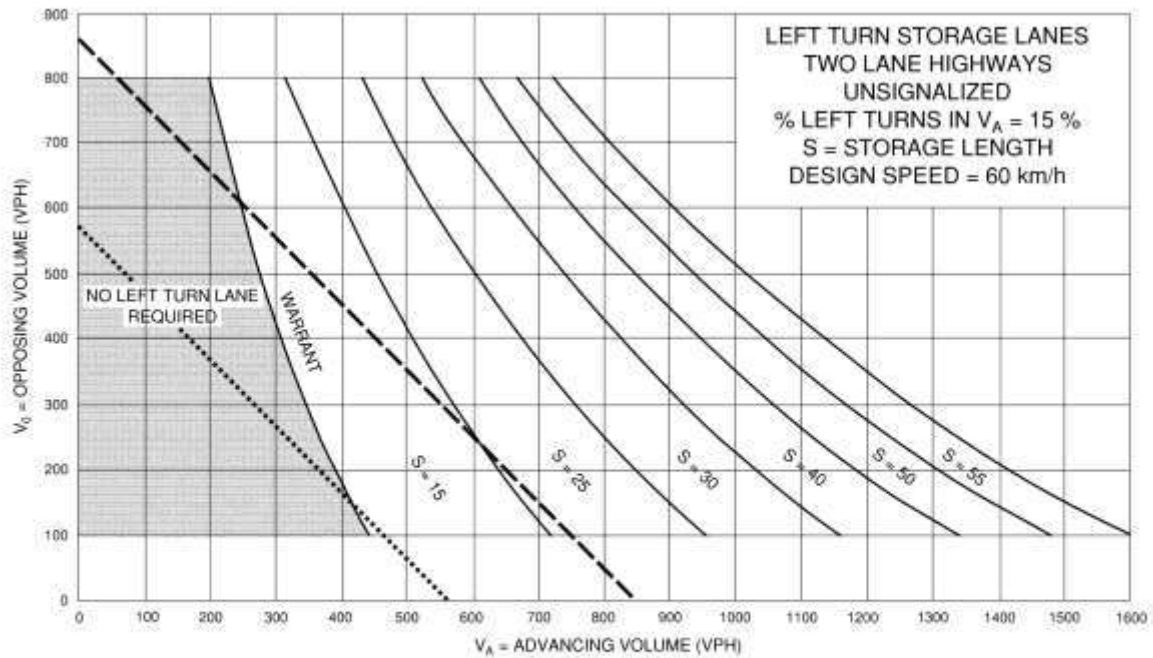


Exhibit -9A-8



--- TRAFFIC SIGNALS MAY BE WARRANTED IN RURAL AREAS OR URBAN AREAS WITH RESTRICTED FLOW
..... TRAFFIC SIGNALS MAY BE WARRANTED IN "FREE FLOW" URBAN AREAS

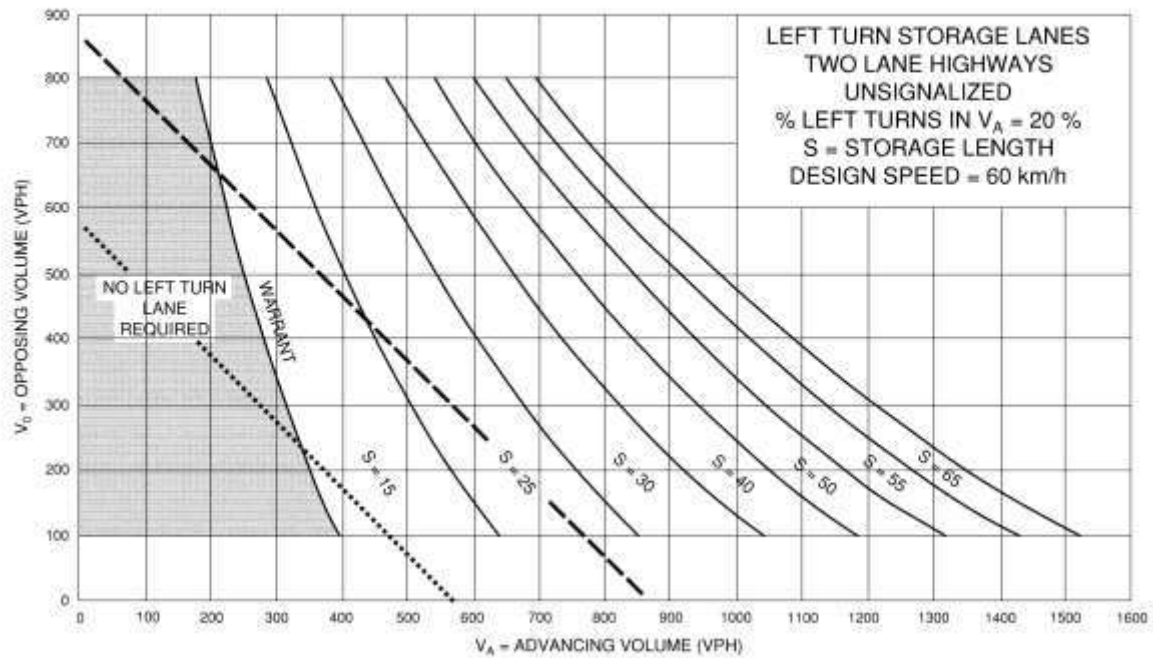


Exhibit -9A-9

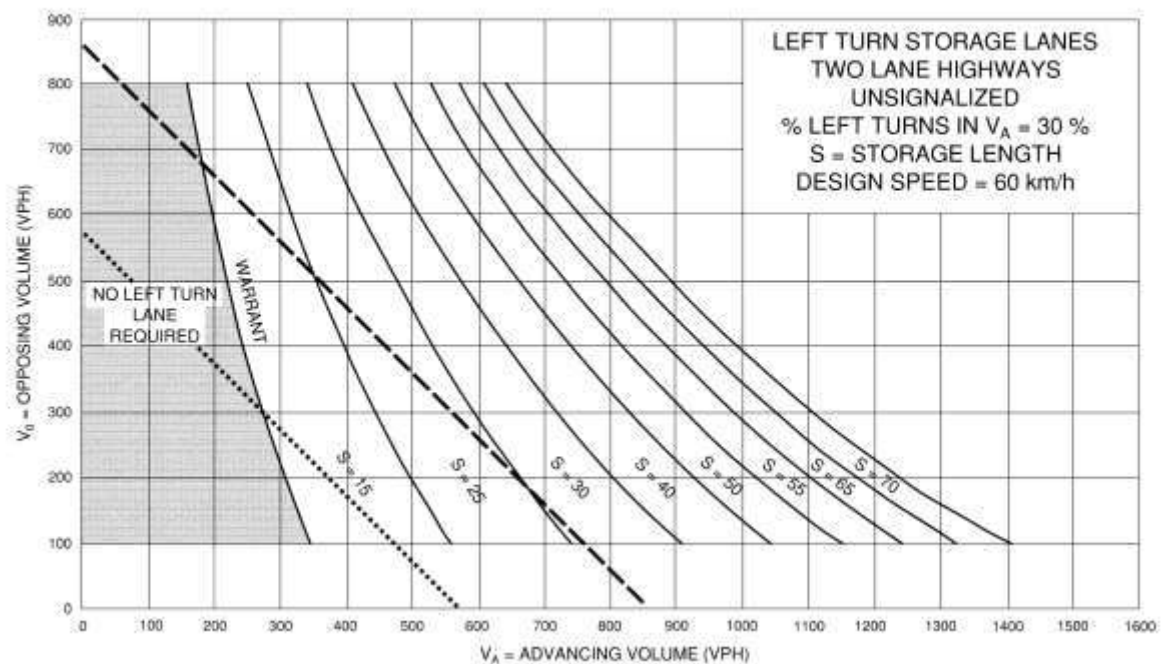
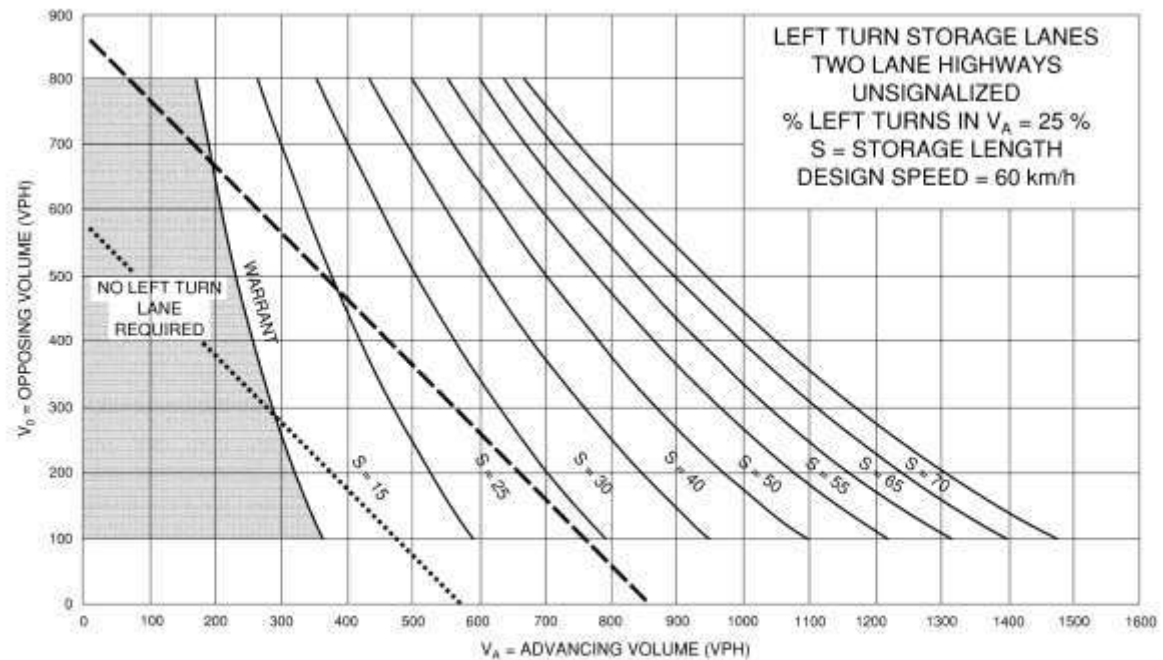


Exhibit -9A-10

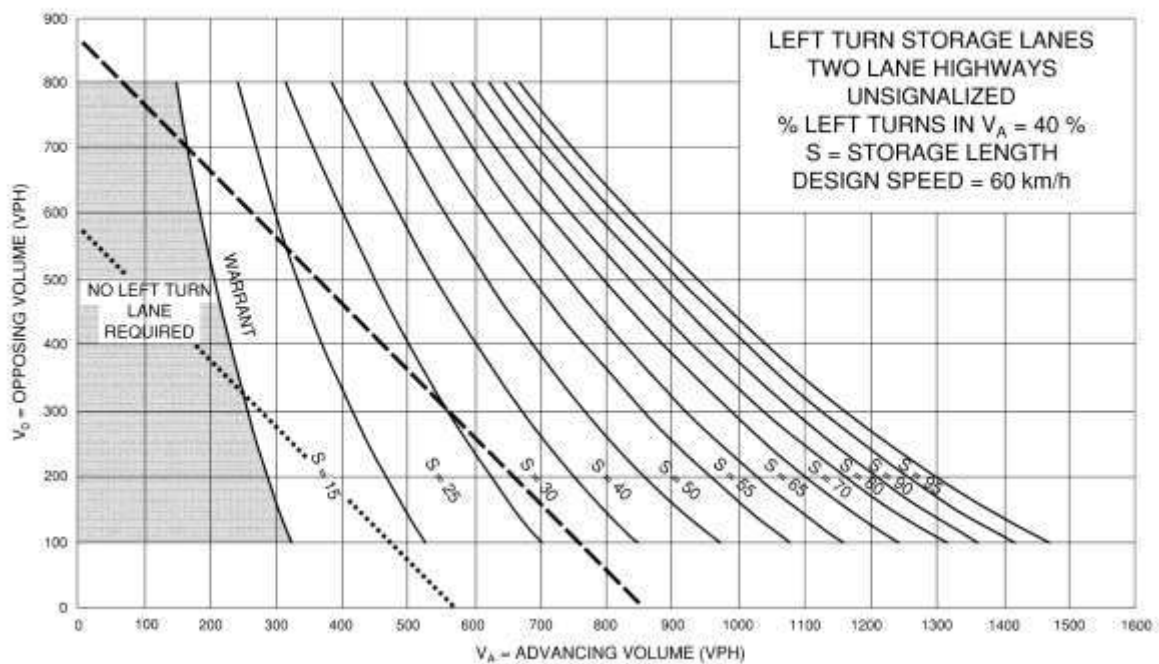
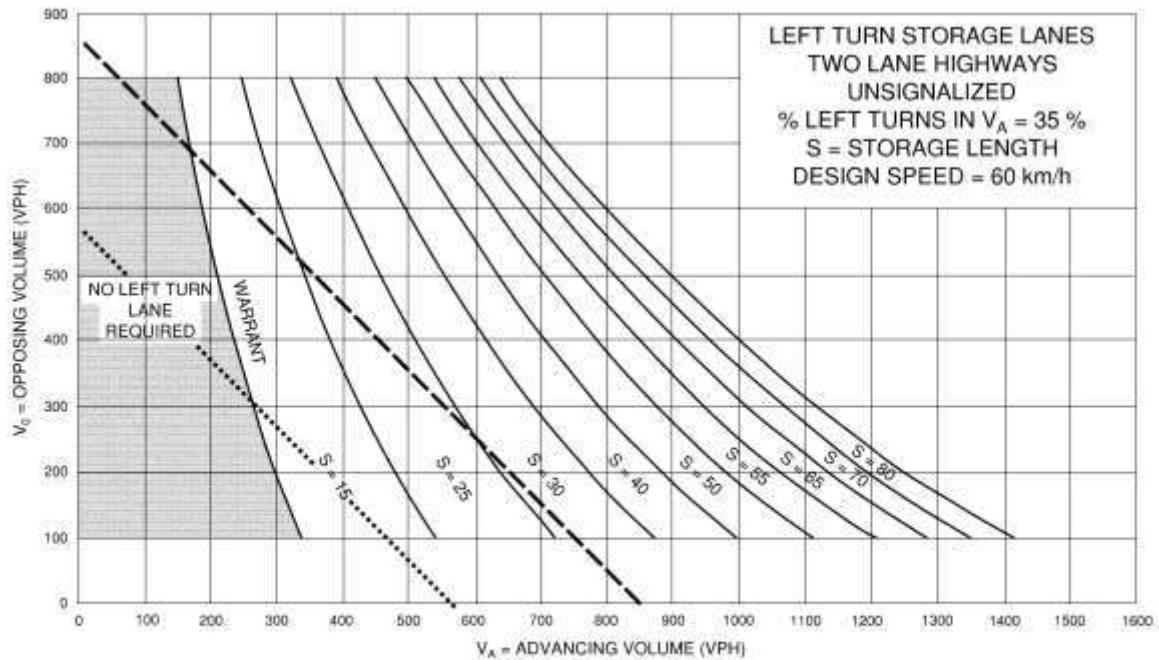
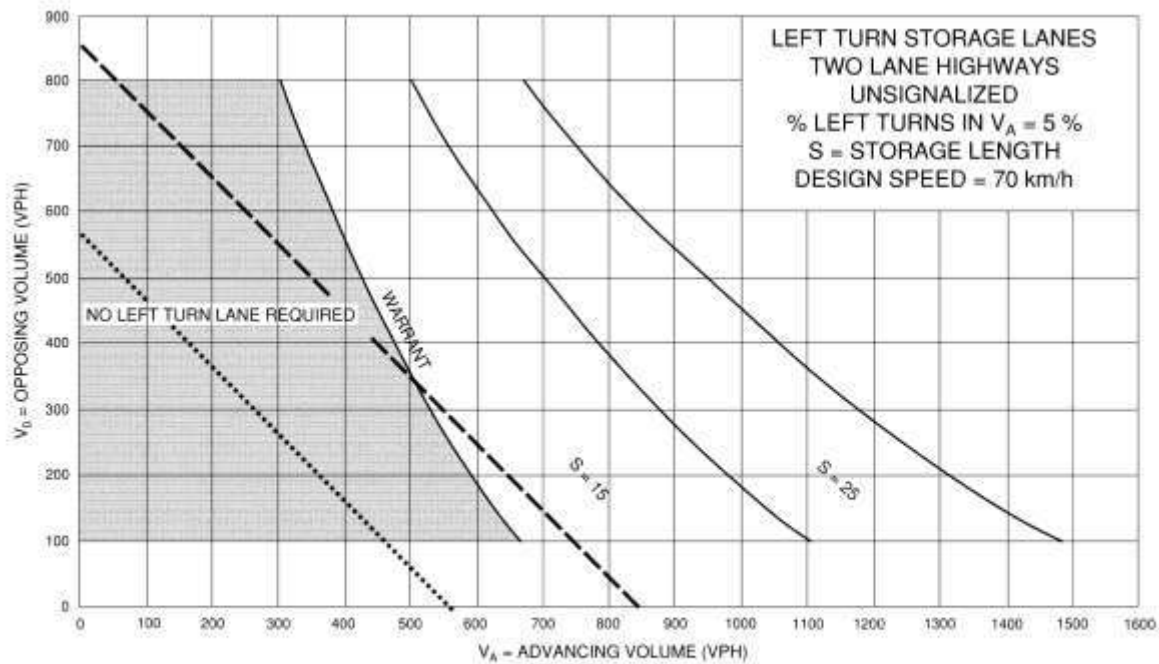


Exhibit -9A-11



- TRAFFIC SIGNALS MAY BE WARRANTED IN RURAL AREAS OR URBAN AREAS WITH RESTRICTED FLOW
- TRAFFIC SIGNALS MAY BE WARRANTED IN 'FREE FLOW' URBAN AREAS

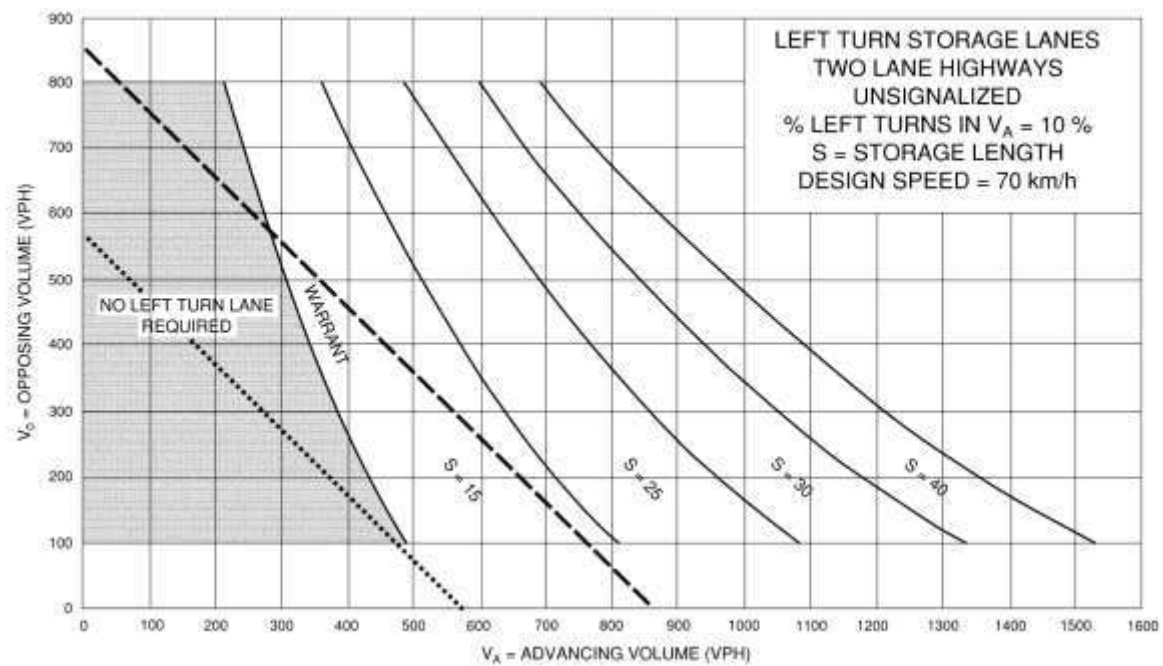
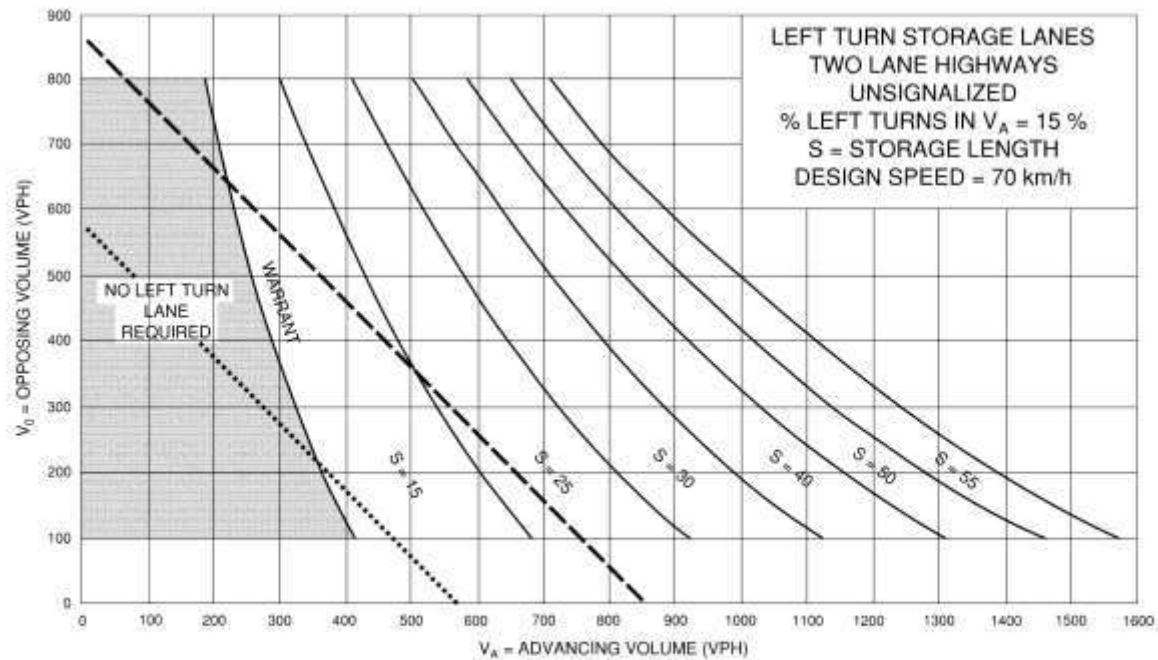


Exhibit -9A-12



- TRAFFIC SIGNALS MAY BE WARRANTED IN RURAL AREAS OR URBAN AREAS WITH RESTRICTED FLOW
- TRAFFIC SIGNALS MAY BE WARRANTED IN "FREE FLOW" URBAN AREAS

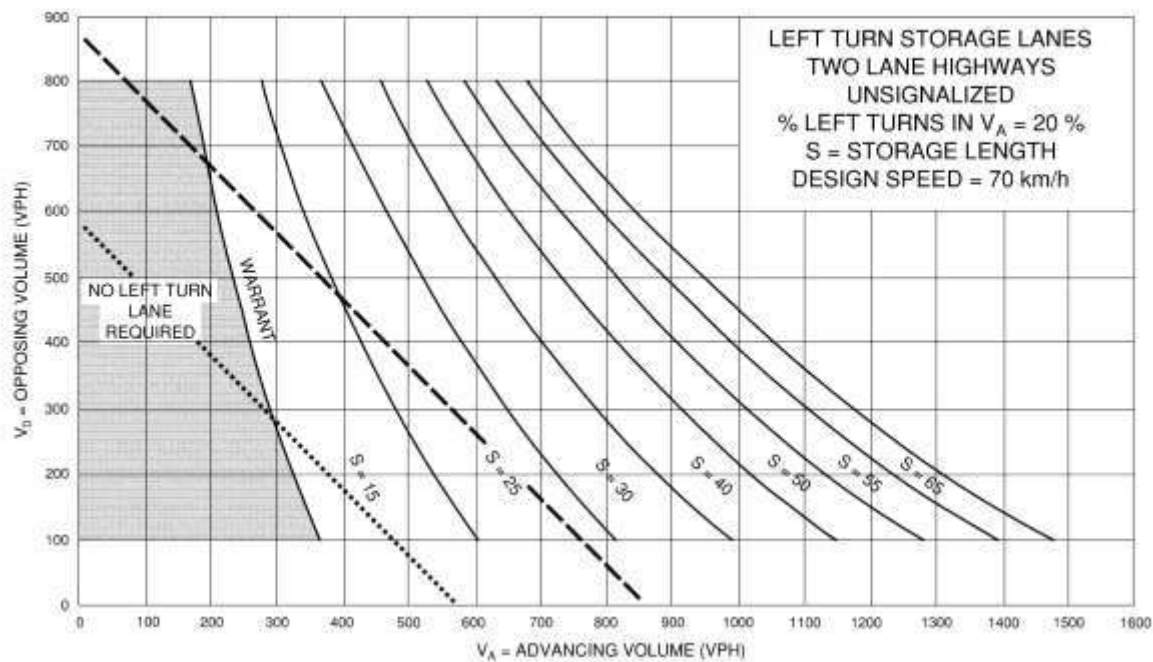


Exhibit -9A-13

