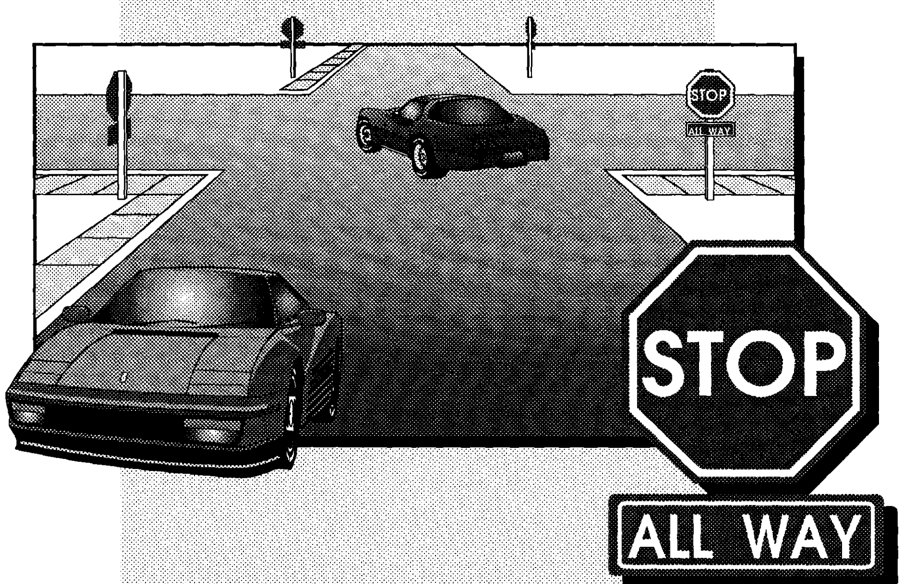
FINAL REPORT

# USING ALL-WAY STOP CONTROL FOR RESIDENTIAL TRAFFIC MANAGEMENT





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16. Abstract

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The objective of this study was to evaluate the effectiveness of AWSC for residential traffic management. The study was limited to the use of AWSC on local residential streets. A comprehensive review of the literature and a questionnaire survey of selected traffic engineering agencies were conducted to identify current use of AWSC. Three case studies using a series of AWSC intersections to reduce cut-through traffic on local residential streets were analyzed.

The majority of traffic engineering agencies use AWSC warrants from the Manual on Uniform Traffic Control Devices (MUTCD). Several agencies use modified MUTCD warrants or a rating system because the MUTCD warrants appear inappropriate for residential streets with lower traffic volumes. When installed at a series of intersections, AWSC was effective in reducing cut-through volumes at the three locations. VDOT should continue to use a series of AWSC intersections as one tool to decrease cut-through traffic on local residential streets.


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Virginia Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the
Virginia Department of Transportation and
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## ABSTRACT

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## INTRODUCTION

All-way, or multiway, stop signs are perhaps the most controversial form of residential traffic control. Residents are likely to request all-way stop signs more frequently than any other form of control. Stop signs are thought of as a panacea for many traffic problems. The Virginia Department of Transportation (VDOT) receives requests for all-way stop control (AWSC) on residential streets primarily to slow traffic, but also to reduce cut-through traffic. Because the primary purpose of a stop sign is to assign right of way, VDOT, like many transportation agencies, is usually reluctant to use stop signs for other purposes. On the other hand, politicians frequently view the installation of stop signs as an easy, low cost way to satisfy their constituents' requests. The political factor further complicates the controversy because traffic engineers may be overruled on their decision not to install stop signs.

Generally, traffic engineers disapprove of using AWSC for residential traffic management. Frequently cited disadvantages of AWSC are: (1) such installations are not warranted in the Manual on Uniform Traffic Control Devices (MUTCD)[1]; (2) noncompliance with stop signs increases because motorists tend to disregard traffic control devices they perceive as unnecessary, creating a safety problem by increasing the potential for accidents; and (3) there are increases in vehicle delay, operating costs, and air and noise pollution. An argument can be made to discount each disadvantage. It appears that the volume warrants for AWSC in the MUTCD are too high to be applicable for residential areas. Some localities have developed their own warrants for residential streets. The fact that such use of AWSC does not meet MUTCD warrants may not be a justifiable disadvantage. No evidence supports the notion that an accident-related safety problem is created; in fact, accident reductions have been experienced.[2] Noncompliance following the installation of AWSC has not been found to create a safety problem. Given the low volumes involved, increases in vehicle delay, operating costs, and pollution may be minimal, and do not appear to justify not using AWSC.

In "Policy and Procedures for Control of Residential Cut-Through Traffic," adopted in 1989, VDOT states its policy to recognize the problems associated with cut-through traffic on local residential streets and to implement appropriate remedial measures whenever possible.[3] The procedures define the steps to follow and the responsibilities of VDOT and the county/town who are partners in this process. The procedures are briefly described below. The neighborhood association prepares a petition outlining the cut-through traffic problem and obtains the signatures of at least 75 percent of the households. The petition is given to the county's transportation office. This office provides some support data and a resolution by the county board of supervisors for VDOT to study the problem. The VDOT district traffic engineer studies the problem with the assistance of an operating guide.[3] A series of AWSC intersections was considered as one remedial measure. This is a new use for AWSC.

As VDOT and local governments become more involved in residential traffic management, the use of AWSC needs to be examined. VDOT's Northern Virginia District, which receives the most requests for cut-through traffic studies, requested this study.

## OBJECTIVE AND SCOPE

The objective of this study was to evaluate the effectiveness of AWSC for residential traffic management. If such use was found to be effective, guidelines would be developed. For this study, the use of AWSC is limited to local residential streets where the streets' primary purpose is to serve the abutting residences.

## METHODS

The study's objective was accomplished in four tasks: (1) literature review, (2) survey of selected local and state departments of transportation, Virginia local traffic engineers, and VDOT district traffic engineers, (3) review of cut-through traffic studies conducted by VDOT where AWSC was used, and (4) development of guidelines.

## RESULTS AND DISCUSSION

### Literature Review

The AWSC and stop sign literature is substantial. Pertinent aspects are highlighted below in five areas: 1) speed and volume control, 2) delay, 3) stop sign compliance, 4) safety impacts of AWSC, and 5) guidelines or warrants for AWSC.

#### *Speed and Volume Control*

A before-and-after study of four intersections on residential collector streets in Troy, Michigan, concluded that stop signs are not effective in reducing speeds and that there was a tendency for speeds to increase slightly.[4] Studies conducted in seven cities in the western United States before 1980 similarly concluded that speeds were not significantly changed but tended to increase slightly.[5] A study of 12 intersections in North Carolina found that there was no significant difference in the vehicle speed after AWSC was installed, and that the change in speed ranged from +4.8 to -6.4 kph (+3 to -4 mph).[6] A study of three stop sign locations in San Francisco revealed that the speed reduction is limited to within 61 m (200 ft) of the intersection.[7]

A study of four AWSC intersections on a collector street in the cities of Cupertino and San Jose showed that there was no change or a slight increase in speeds as a result of the AWSC installation.[8] It was observed that most of the sites in the above studies did not have a speeding problem; that is, the 85th percentile speed was less than 16 kph (10 mph) over the posted speed limit before the AWSC was installed. Of the 19 sites studied in references 3, 5, and 6, only 2 sites had a speeding problem. At these 2 sites, both in North Carolina, there was a slight but statistically insignificant reduction in speed. If there was no speeding problem, as was the case in most of these studies, one can argue that there was no need to attempt or expect a reduction in speed.

Little literature was found on the effectiveness of AWSC in reducing traffic volume in general, and cut-through traffic volume in particular. A collector street study in the cities of Cupertino and San Jose revealed that, overall, AWSC did not divert commuter traffic.[8] However, in one part of the 4.8 km (3 mi) street section, traffic volumes decreased from 9,000 to 7,100 vehicles per day (vpd). The traffic was diverted to a parallel residential street and not to an arterial.

Changes in volume were documented in a study of three low-volume intersections (major road volume less than about 400 vpd) in West Virginia.[9] Volumes on the major streets changed by +2, -23, and -1.7 percent. The 23 percent reduction may have been attributed to drivers selecting an alternative route. AWSC was only used during summer months when children play in or near the streets. The volume reduction may also be caused by a change in traffic patterns because of school vacation.[9]

### *Delay*

When an intersection with stop sign control only on the minor street is converted to AWSC, an inherent additional delay will be induced. AWSC (four-way) produced an annual average of 3,300 hr of additional delay and $37,080 (1982 dollars) per intersection in additional road user costs, based on the analysis of eight intersections in three cities in northwestern South Carolina.[10] The average volumes on the major and minor streets were 1,780 and 930 vpd, respectively. For a major collector street in Raleigh, North Carolina, with 5,200 vpd, the estimated average additional delay cost per year for AWSC was $ 88,560 (1990 dollars).[6] In both studies, delay was determined using *A Manual on User Benefits Analysis of Highway and Bus-Transit Improvements* (1977).[11] Because of changes in automotive technology and the value that users place on their time, this 1977 manual is probably not appropriate for use today. National Cooperative Highway Research Program (NCHRP) Project 2-18, Research Strategies for Improving User Cost-Estimating Methodologies, is assessing the 1977 manual to identify improvements in the highway user cost-estimating procedures.[12]

Procedures for capacity and level of service (based on delay) analysis for AWSC intersections are presented in the *Highway Capacity Manual*.[13]

### *Stop Sign Compliance*

Table 1 shows the results of five studies on stop sign compliance. The Cupertino and San Jose, and Boulder studies indicated that AWSC intersections were analyzed. The other three studies probably examined intersections with stop signs only on the minor streets. The Cupertino and San Jose study found that of the three intersections studied, the percent of vehicles not stopping was influenced by traffic volumes. The intersection with the highest percentage of side street traffic had the lowest percentage of vehicles not stopping (12 percent); the intersection with a low side street volume was in the middle with 25 percent not stopping; and the low volume intersection, where there were three right-angle accidents in a 12-month period, had the highest percent of vehicles not stopping, 43 percent.[8]

In a study of nine four-way and four three-way stop-controlled intersections in Boulder, Colorado, the majority of vehicles, 73 and 82 percent respectively, made a rolling stop while 23 and 7 percent respectively, came to a full stop.[14] The ranges of values are presented in Table 1. Like the Cupertino and San Jose study, the higher compliance levels were at the sites with the highest volumes, especially side street volumes.

Table 1
Findings of Stop Sign Compliance Studies

| Study Identification | Full Stop (Percent) | Rolling Stop (Percent) | No Stop (Percent) |
|---|---|---|---|
| Cupertino/San Jose | 11 - 31 | 46 - 59 | 12 - 43 |
| n=3 *(8)* | 19 | | |
| Boulder, Colorado | | | |
| four-way stop | 6 - 40 | 59 - 88 | 1 - 15 |
| n=9 mean | 23 | 73 | 4 |
| three-way stop | 2 - 11 | 76 - 89 | 9 - 15 |
| n=4 mean *(14)* | 7 | 82 | 11 |
| Troy, Michigan | 9 - 51 | 34 - 64 | 11 - 45 |
| n=4 *(4)* | | | |
| North Carolina | 10 - 38 | 30 - 68 | 10 - 32 |
| n=9 mean *(6)* | 28 | 54 | 18 |
| ITE *(17)* | 5 - 20 | 40 - 60 | 20 - 40 |

The Troy, Michigan, study implied that the collector street with the lowest volume had the highest percent of vehicles not stopping.[4]

A North Carolina study examined nine intersections in four cities. Of those intersections, the two intersections in Raleigh had the highest percentages of traffic making a full stop (30 and 37) and not stopping (33).[6]

In a study of stop sign compliance at low volume intersections, Mounce concluded that major roadway volume and minor roadway sight distance have a highly significant influence on the percent of roll stops and no stops combined.[15] The study included minor roads with up to 500 vpd that intersect major roads with between 0 (more practically 500) to 6,000 vpd. Major roadway volume was the best predictor of percent of roll stops and no stops combined. An FHWA study on compliance with traffic control devices concluded that based on observations at 142 intersections, 32 percent of vehicles came to a full stop.[16] Full stops were observed most often when cross street traffic was heavy. Of the 68 percent of vehicles not fully stopping, traffic conflicts resulted for only 1.9 percent of the vehicles.

A report on residential street traffic control stated that generally, when not required to stop by cross traffic, 5 to 20 percent of all drivers make a complete stop, 40 to 60 percent come to a rolling stop, and 20 to 40 percent will pass at speeds above 8 kph (5 mph).[17] This statement was based on numerous studies on stop sign compliance and is not specific to AWSC.

In summary, these studies reveal that the majority of motorists perform a rolling stop at stop signs. The roadway volume substantially influences the percent of traffic that makes a full stop. The definitions of a rolling stop, running stop, and no stop varied to a minor degree. Noncompliance with traffic control devices is a problem in general, not just at AWSC.

### *Safety Impacts of AWSC*

A common traffic engineering belief is that unwarranted stop signs (based on the MUTCD) tend to increase traffic accidents because motorists disregard unwarranted signs. An Institute of Transportation Engineers (ITE) report notes that it is difficult to substantiate the safety effects of unwarranted stop signs. Evidence on the safety effects of stop signs used for speed and volume control is mixed.[17] Furthermore, this report states that it is difficult to assess reasons why the common traffic engineering belief is not more convincingly supported by studies. The author believes (supported by observations of driver compliance) that although most drivers roll through the intersection, they do so with caution. Therefore, safety is not compromised despite the absence of a high percentage of full stop compliance.

A study of the San Francisco Bay area found that unwarranted stop signs have not created a measurable increase in accidents and cannot be termed hazardous.[8] However, from the viewpoint of the common traffic engineering belief, it was concluded that unwarranted stop signs do not reduce accidents and do increase the potential for accidents.

The results of a Raleigh, North Carolina, before-and-after study of four intersections where AWSC was installed were inconclusive because of the low accident history.[6] Three sites had one accident in the three years before the change; one site had no accidents. There were no accidents in the after period. It was further noted that because there was no prior safety problem, an improvement in safety would not be expected.

Two studies analyzed the effectiveness of converting 222 intersections of one-way streets from one-way stop control to AWSC in Philadelphia.[17,18] Ebbecke, using two years of before-and-after data, concluded that: 1) three of four conversions improved conditions regardless of the before accident rate, 2) overall, total accidents decreased by 55 percent, 3) right-angle and pedestrian injury accidents both decreased by 83 percent, and 4) rear-end, side-swipe, and fixed-object accidents were unaffected.[18] Persaud revealed findings on four issues: 1) the effectiveness of the conversions increases as the expected number of accidents at an intersection increases, 2) there appears to be some support for the existence of safety migration, 3) safety is not reduced during the learning period immediately after installation, and 4) there is no support for the claim that safety effectiveness decreases as AWSC proliferates in an area.[19] Regarding safety migration, the increase in accidents at one-way controlled intersections may be based on a variety of speculative factors such as increased risk taking to compensate for the reduced accident risk at AWSC intersections, confusion as to whether one-way control intersections were also AWSC, and a redistribution of traffic to avoid AWSC.[19]

The most comprehensive review on the safety effect of converting from two-way stop control to AWSC was conducted by Hauer.[20,21] Hauer performed a thorough critical analysis of studies conducted from 1949 to 1985 on the safety effect of conversion from two-way to AWSC. His summary of findings and estimates of effectiveness show that the conversion to AWSC was consistently effective in reducing accidents, based on the results of 10 studies.[21] Total accidents were reduced by 40 to 60 percent and injury accidents by 50 to 80 percent for studies where the selection-bias was cleansed. The cited studies represented a wide range of conditions. Hauer concluded that, "there is no ground to believe that four way stops do not improve safety even at volumes which are either below or above the (MUTCD) warrants or are unbalanced."[20] Also, Hauer indicated that further research is urgently needed on the indication from Ebbecke's study that two-way stop safety is adversely affected by the proximity of many AWSCs. An interesting point revealed by Hauer involved the learning process: from a review of the literature, each study stood alone; there was no plan to combine the individual results to develop conclusions.

### *Guidelines or Warrants for AWSC*

From the literature, four basic types of warrants or guidelines for AWSC were identified: 1) MUTCD, 2) modified MUTCD, 3) ranking/rating system, and 4) political warrant.

*MUTCD*

The MUTCD warrant for AWSC is presented below.[1]

> The "Multiway Stop" installation is useful as a safety measure at some locations. It should ordinarily be used only where the volume of traffic on intersecting roads is approximately equal. A traffic signal is more satisfactory for an intersection with a heavy volume of traffic. Any of the following conditions may warrant a multiway STOP sign installation (sec. 2B-4):
> 1. Where traffic signals are warranted and urgently needed, the multiway stop is an interim measure that can be installed quickly to control traffic while arrangements are being made for the signal installation.
> 2. An accident problem, as indicated by five or more reported accidents of a type susceptible to correction by a multiway stop installation in a 12-month period. Such accidents include right- and left-turn collisions as well as right-angle collisions.
> 3. Minimum traffic volumes:
> (a) The total volume entering the intersection from all approaches must average at least 500 vehicles per hour for any 8 hours of an average day, and
> (b) The combined vehicular and pedestrian volume from the minor street or highway must average at least 200 units per hour for the same 8 hours, with an average delay to minor street vehicular volume of at least 30 seconds per vehicle during the maximum hour, but
> (c) When the 85-percentile approach speed of the major street traffic exceeds 40 miles per hour, the minimum vehicular volume warrant is 70 percent of the above requirements.

The first three sentences of the warrant appeared in the 1948 MUTCD when four-way stop control was first mentioned.[22] The three conditions were added in the 1961 MUTCD except for "and pedestrian" in condition (b), which was added in the 1988 MUTCD. Because the available committee reports do not reveal how the warrants were developed, it is presumed that the warrants were based on the experience and judgment of the committee members.[22] The committee's basic tenet was to use the lesser control until it was proven inadequate based on accidents, congestion, or other criteria.[22] It appears that this tenet has been preserved through the traffic engineering profession through the years. The three arguments against the use of AWSC stated in the introduction were evident in the ITE committee work performed in the 1950s that led to the 1961 MUTCD warrants.[22]

*Modified MUTCD*

Because the minimum volume conditions warranted in the MUTCD are substantially higher than the traffic volumes experienced on many streets (especially residential streets), and because of other conditions that were deemed important, many jurisdictions have modified MUTCD warrants to reflect conditions that are reasonable for residential streets. The extent of the modification varied substantially.

The City of Anaheim, California reduced the accident warrant from five to four accidents in a 12-month period and changed the volume warrants as follows: (a) a minimum hourly average (for any <u>six</u> hours) volume of 400 vehicles entering from all approaches with at least 40 percent from the minor or secondary street; (b) a minimum hourly average (for any <u>six</u> hours) volume of 400 vehicles entering from the main approach and a pedestrian volume of at least 150 per hour crossing the main street during the same six hours.[8]

The warrants for the City of Concord, California, which represent a substantial variation from the MUTCD, are shown in Table 2. Key changes are 1) the minimum average approach volumes were lowered by 40 percent from 500 to 300 vehicles per hour (vph), 2) a visibility or sight distance criterion was added, and 3) specific conditions for residential streets including volume warrants that were reduced to 60 percent of the general warrants (180 vph) were included.[8]

The City of Escondido, California added a fourth condition: when unusual conditions, intersection geometry, and other factors based on engineering judgement indicate that multiway stops will improve safety without impeding traffic flow.[8]

*Point System Method*

In 1962, The City of San Diego developed an AWSC policy based on a point system, and a group of several warrants each worth a few points. San Diego initiated a study in 1986 to revise it to achieve consistency (conformance with traffic engineering principles), accountability (based on AWSC, not traffic signals like the MUTCD), flexibility (warrants that include extreme conditions and a combination of factors), and selectivity (effectively identifying intersections that will benefit from AWSC).[23] Figure 1 shows an evaluation worksheet and tables that are used for the new policy. Under the new policy, consisting of five warrants totaling 50 points, AWSC may be justified at intersections that are assigned 25 or more points. The point requirement may be waived if the MUTCD's AWSC warrants number 1 (an interim measure for a traffic signal) or 2 (accident warrant) are satisfied, or an extreme combination of unusual conditions results in an engineering judgment that AWSC would best serve the intersection. Examples of unusual conditions are a school, fire station, playground, bus route, steep hill, and limited visibility. The maximum points are assigned for a high number of accidents, high volumes in the major and minor approaches that are about equal, and high pedestrian volumes. A study of the warrants revealed that this approach was effective in identifying intersections that benefit from AWSC.

The City of Naperville, Illinois, a suburb of Chicago, established a committee of representatives from homeowners associations, City Council, and the City's Transportation Advisory Board (with technical assistance from the City's traffic engineering staff) to develop new AWSC warrants that reflected the concerns of the city's residents which were not in the MUTCD AWSC warrants.[24] A systems warrant approach, similar to the MUTCD's traffic signal warrants, considering several concerns and based on engineering judgment, was developed. The AWSC warrant worksheet with 11 items based on a point system is shown in Appendix A. The 11 items are 1) classification of streets, 2) traffic speed, 3) school pedestrians, 4) non-school pedestrians, 5) accidents, 6) critical approach speed, 7) unexpected hazards, 8) nearby public facilities, 9) intersection conditions, 10) traffic volumes, and 11) adjacent traffic control.

Table 2
Warrants for Four-Way Stop Sign Installation (City of Concord, CA)[7]

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Four-way stop sign installation may be considered if any of the following conditions exist:

1. VOLUME

(a) Total vehicular volume entering the intersection from all approaches must average 300 vehicles per hour for any 8 hours of an average day. (24-hr equivalent approximately 4000 vehicles.)

(b) In addition, the vehicular volume entering the intersection from the minor street(s) for the same 8 hours must average at least 1/3 or the total volume entering the intersection (100 per hour min.)

2. ACCIDENTS

Five or more of types susceptible of correction by stop signs within a 12-month period, with satisfactory observance and enforcement of less restrictive control.

3. VISIBILITY

The straight line sight distance on one or more approaches of the major street for vehicles or pedestrians crossing the intersection is less than 49.2 m (160 ft)

4. RESIDENTIAL AREA

Volume warrants to be reduced to 60 % of the values above if ALL of the following conditions are met:

(a) Both streets have a residential frontage with existing 40.2 kph (25 mph) speed limits.

(b) Neither street is an adopted through street.

(c) Neither street exceeds 12.3 m (40 ft) of roadway width.

(d) No existing stop sign or signal is located on the more heavily traveled street within a distance of 246.2 m (800 ft).

(e) Intersection has four legs, with streets extending 246.2 m (800 ft) or more away from the intersection on at least three sides.

(f) Installation of a four-way stop is compatible with overall traffic circulation needs for the residential area.

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*Political Warrant*

The political warrant is fairly well known. Essentially, an elected official or governing body such as a city council or county board, or an appointed commission such as a transportation or traffic commission, determines whether or not AWSC is installed at an intersection.

Intersection ______________________________
(MAJOR) (MINOR)

File __________
Date __________
Investigator __________

Qualifies for All-Way Stop based on 25 or more points:
Yes ___ No ___ Points ___

Qualifies for All-Way Stop based on other criteria: Yes ___ No ___
If yes, explain:

______________________________

Sketch of intersection with visibility data
On back ___ Attached ___

| | Points | Possible |
|---|---|---|
| **1. Accident Experience**<br>From __/__/__ to __/__/__<br>Accidents/year correctable by Stops x 3 points/accident | ______ | 15 |
| **2. Unusual Conditions**<br>______________________________<br>______________________________<br>______________________________ | ______ | 5 |
| **3. Traffic Volumes (Peak 4 Hours)** | | |
| Major approaches __________ | ______ | 5 |
| Minor approaches __________ | ______ | 10 |
| **4. Traffic Volume Difference** ______ | ______ | 10 |
| **5. Pedestrian Volume**<br>Pedestrians ________<br>crossing the major street during 4 hour count | ______ | 5 |
| TOTAL | ______ | 50 |
| Points Required | 25 | |

. All-way stop evaluation worksheet.

TABLE 1 POINT ASSIGNMENT FOR TRAFFIC VOLUME

| Major Street | | Minor Street | |
|---|---|---|---|
| 4-hour Volume | Points | 4-hour Volume | Points |
| 0–1,000 | 0 | 0–400 | 0 |
| 1,001–1,300 | 1 | 401–600 | 1 |
| 1,301–1,600 | 2 | 601–800 | 2 |
| 1,601–1,900 | 3 | 801–1,000 | 3 |
| 1,901–2,200 | 4 | 1,001–1,200 | 4 |
| 2,201–2,600 | 5 | 1,201–1,400 | 5 |
| 2,601–2,900 | 4 | 1,401–1,600 | 6 |
| 2,901–3,200 | 3 | 1,601–1,800 | 7 |
| 3,201–3,500 | 2 | 1,801–2,000 | 8 |
| 3,501–3,800 | 1 | 2,001–2,200 | 9 |
| 3,801–over | 0 | 2,201–over | 10 |

TABLE 2 POINT ASSIGNMENT FOR TRAFFIC VOLUME DIFFERENCE

| Volume Difference (4-hour count) | Points |
|---|---|
| 0–150 | 10 |
| 151–300 | 9 |
| 301–450 | 8 |
| 451–600 | 7 |
| 601–750 | 6 |
| 751–900 | 5 |
| 901–1,050 | 4 |
| 1,051–1,200 | 3 |
| 1,201–1,350 | 2 |
| 1,351–1,500 | 1 |
| 1,501–over | 0 |

TABLE 3 POINT ASSIGNMENT FOR PEDESTRIAN VOLUME

| No. of Pedestrians Crossing Major Street in 4 hours | Points |
|---|---|
| 0 | 0 |
| 1–50 | 1 |
| 51–100 | 2 |
| 101–150 | 3 |
| 151–200 | 4 |
| 201–over | 5 |

Figure 1. Point system used by San Diego

Typically, requests by residents for AWSC are approved. This approval may occur against the recommendation of the local traffic engineer or without consulting the engineer.

## Questionnaire Survey of Traffic Engineers

To acquire information on the AWSC practices of traffic engineers, a questionnaire survey was developed and sent to three groups of traffic engineers: 1) traffic engineers in Virginia's localities, 2)VDOT's district traffic engineers, and 3) traffic engineers in selected cities and states throughout the United States. The questionnaire survey sent to all three groups was basically the same except that the questionnaire for the Virginia groups also included questions regarding a description of the AWSC intersections and the identification of potential study sites. Also, the out-of state surveys asked about reversing stop signs. The survey responses were received between November 1991 and February 1992, and the results for each group are summarized below.

### *Local Traffic Engineers in Virginia*

Responses were received from 15 cities, 2 counties (only two county governments in Virginia maintain their own roads), and 4 towns (Table 3). Seventeen of these 21 agencies have at least one AWSC intersection in a residential area; only 4 agencies have more than 10 AWSC in a residential area.

Five agencies (24 percent) have conducted studies on AWSC intersections and 4 (19 percent) agencies have converted AWSC to two-way (or one-way) stops. Of these 21 responses, 7 (33 percent) use the MUTCD as their AWSC policy, 5 (24 percent) use the political warrant, 4 (19 percent) don't install AWSC as a policy/practice, 2 (10 percent) use the MUTCD primarily and the political warrant secondly, and three other policy/practice descriptions each received 1 response (5 percent). These percentages represent a fairly wide range of policies within the Commonwealth.

### *VDOT District Traffic Engineers*

Seven of the nine district traffic engineers responded to the survey. In general, VDOT uses the MUTCD warrants for AWSC (Table 3). Consequently, VDOT's use of AWSC is quite limited. As expected, AWSC intersections in residential areas were more likely in districts with larger urban areas and none of the seven AWSC intersections were warranted by the MUTCD. Three of the five AWSC intersections in the NOVA District were requested and installed to reduce speed; the two AWSC intersections in the Richmond District were installed to deter cut-through traffic. Limited sight distance, a condition not listed in the MUTCD warrant, was cited as a reason for use of AWSC.

TABLE 3

ALL WAY STOP CONTROL SURVEY RESULTS FOR VIRGINIA AGENCIES

| LOCATION | # AWSC INTERSECTIONS STUDIED? RESI. | BUS. | OTHER | YES | NO | CONVERTED? YES | NO | AWSC POLICY/PRACTICE | INTERSECTIONS TOTAL | SIGNAL |
|---|---|---|---|---|---|---|---|---|---|---|
| CITY | 1a | 1b | 1c | 2a | 2b | 3a | 3b | 4 | 7a | 7b |
| ROANOKE | 50 | 5 | 0 | | X | X | | MUTCD | 2900 | 130 |
| ALEXANDRIA | 50 | 5 | 0 | X | | | X | POLITICAL WARRANT | | 220 |
| PETERSBURG | 31 | 1 | 0 | | X | | X | POLITICAL WARRANT | | 53 |
| FAIRFAX | 30 | 0 | 0 | X | | | X | DEVELOPING POLICY/ WAS POLITICAL WARRANT | 468 | 49 |
| SALEM | 14 | 1 | 0 | X | | | X | MUTCD | 1286 | 32 |
| NORFOLK | 12 | 0 | 0 | | X | | X | MUTCD | | 267 |
| NEWPORT NEWS | 6 | 1 | 0 | | X | | X | MUTCD & POL. WARRANT | >1200 | 190 |
| DANVILLE | 4 | 0 | 0 | | X | X | | POLITICAL WARRANT | 1694 | 65 |
| RADFORD | 4 | 0 | 3 | | X | | X | CASE BY CASE/ONLY WHEN VOL ARE SIMILAR | 388 | 12 |
| STAUNTON | 4 | 0 | 0 | | X | | X | POLITICAL WARRANT | 1400 | 50 |
| CHESAPEAKE | 4 | 0 | 0 | X | | | X | MUTCD & POL. WARRANT | >2000 | 75 |
| HAMPTON | 3 | 1 | 0 | | X | X | | TRAFFIC SIGNAL UNDER DESIGN--TEMPORARY | | 120 |
| LYNCHBURG | 3 | 0 | 0 | | X | | X | MUTCD | 1450 | 90 |
| WINCHESTER | 3 | 0 | 0 | | X | | X | POLITICAL WARRANT | | |
| FREDERICKSBURG | 1 | 0 | 0 | | X | | X | NOT TO INSTALL AWSCs | > 400 | 40 |
| HARRISONBURG | 0 | 0 | 0 | | X | | X | NOT TO INSTALL AWSCs | | 56 |
| HOPEWELL | 0 | 0 | 0 | | X | | X | TRANS COMMISSION USUALLY REJECT AWSC | >1000 | 35 |



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TABLE 3 (continued)

ALL WAY STOP CONTROL SURVEY RESULTS FOR VIRGINIA AGENCIES

| LOCATION | # AWSC INTERSECTIONS RESID. | BUS. | OTHER | STUDIED? YES | NO | CONVERTED? YES | NO | AWSC POLICY/PRACTICE | INTERSECTIONS TOTAL | SIGNAL |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1a | 1b | 1c | 2a | 2b | 3A | 3B | 4 | 7A | 7B |
| COUNTIES/TOWNS | | | | | | | | | | |
| CO ARLINGTON | 7 | 0 | 0 | | X | | X | MUTCD WITH EXCEPTIONS/ ONLY 2 IN LAST 10 YEARS | 2400 | 218 |
| CO HENRICO | 0 | 0 | 0 | | X | | X | NOT TO INSTALL AWSCs | >5000 | 85 |
| BLACKSBURG | 8 | 0 | 1 | X | X | | | MUTCD | | 19 |
| HERNDON | 4 | 0 | 1 | X | | | X | MUTCD/FINAL DECISION NO. OF SUBJECTIVE FACTORS | 340 | 23 |
| LEESBURG | 2 | 0 | 0 | | X | | X | MUTCD | 322 | 13 |
| PULASKI | 0 | 0 | 0 | | X | | X | NOT TO INSTALL AWSCs | | 11 |
| DTEs | | | | | | | | | | |
| NOVA | 5 | 0 | 20 | X | | | X | | | |
| RICHMOND | 2 | 0 | 4 | X | | X | | | | |
| STAUNTON | 0 | 0 | 11 | | X | | | | | |
| LYNCHBURG | 0 | 0 | 0 | | X | X | | | | |
| FREDERICKSBURG | 0 | 0 | 1 | | X | X | | | | |
| BRISTOL | 0 | 0 | 0 | | X | | X | | | |
| CULPEPER | 0 | 0 | 0 | X | | | X | | | |



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*Selected Traffic Engineers Throughout the United States*

Twelve (60 percent) of the 20 selected traffic engineering agencies either used the MUTCD or implied its use (Table 4). Three (15 percent) of the agencies employed a modified MUTCD policy. Montgomery County, Maryland, has two conditions for AWSC on local streets: if a sight distance of 38.5 m (125 ft) cannot be obtained for any approach when stop signs are placed, and if there is verifiable evidence that three or more accidents susceptible to correction by AWSC have occurred within a 12-month period. Portland' s warrants are the same as the MUTCD except for the accident warrant. For local intersections, the accident history indicates five or more reported accidents in a two-year period that might be corrected by use of AWSC. For collector or arterial/local intersections, the accident rate is greater than or equal to 1.5 accidents per million entering vehicles for a two-year period that might be corrected by use of AWSC.

Washington, D.C., uses the following volume warrant: where streets are of similar character and total peak hour volumes on all approaches are 250 vph for local streets (500 vph for collectors) during the peak periods of 7:00 a.m. - 9:00 a.m. and 4:00 p.m.- 6:00 p.m., and where the balance of the traffic flow during the same peak hour is in the ratio of 60/40 for a four-way intersection and 75/25 for a three-way intersection. The accident warrant is similar that of Montgomery County, MD-- three or more accidents of the type normally correctable by the assignment of right-of-way have occurred in a 12-month period following a trial of less restrictive measures. Two other warrants are for the use of AWSC as an interim measure where a traffic signal is warranted and where regulatory controls are being reversed. These warrants are followed by lists of situations where AWSC should and should not be considered (Table 5).

Greensboro, North Carolina uses three criteria: the MUTCD accident warrant, inadequate sight distance at any approach, and a 50/50 volume split between the two streets. The AWSC practices of San Francisco are listed in Table 6. This was the only respondent that acknowledged using AWSC to break up commuter traffic flow on residential streets, that is, to discourage cut-through traffic.

Dallas uses a rating system with six criteria. To be eligible for study for AWSC under the rating system, one of two requirements must be met: one or more reported accidents (that can be corrected with stop signs) within an 18-month period over the last 3 years prior to the request, or an off-peak traffic split of at least 75/25. The six criteria and maximum number of points for each are: 1) accident history (40), 2) sight distance (20), 3) traffic volumes (20), 4) major street speeds (10), 5) neighborhood characteristics (27), and 6) cross-street delays (4). If an intersection receives 75 points out of a possible 121 points, then it is eligible for AWSC. The Dallas rating system is presented in Appendix B.

Sacramento uses the warrants for stop signs at uncontrolled approaches in residential areas (Table 7). If each approach of an intersection meets the warrants which include volumes, sight distance, and speed, then AWSC is warranted.

TABLE 4

ALL WAY STOP CONTROL - OUT-OF-STATE SURVEYS

| CITY/STATE | AWSC POLICY | STUDIES? | NO. AWSC | % MUTCD | POLICY ON AWSC REMOVAL | NO. REMOVED | USE REVERSE STOP? | POLICY ON RES. TRAFFIC MANAGEMENT? |
|---|---|---|---|---|---|---|---|---|
| BOISE CITY | MUTCD | YES | 50 | | NONE/NOT LIKELY TO/MUTCD | 0 | NO | YES/ITE |
| PR. GEORGE 'S CO, MD | MUTCD | NO | MANY | 20 | NONE/ENGR. JUDGE. | 0 | NO | NO |
| OVERLAND PARK, KS | MUTCD | NO | 27 | 67 | UPGRADE TO SIGNALS | ? | WHAT IS? | NO |
| KANSAS DOT | MUTCD | YES | NOT SURE | HOPE ALL | NO FORMAL | 2 | WHAT IS? | NO |
| NC DOT | MUTCD | NO | 6 | ASSUME ALL | NONE | 0 | NO | NO |
| SANTA FE | MUTCD | NO | 15 | 15 | NONE/DOUBT IF WOULD | 0 | NO | NO |
| MEMPHIS | MUTCD | NO | 70 | 50 | NONE/POLITICS INVOLVED | NO RECORD | WHAT IS? | NO |
| HOWARD CO, MD | MUTCD | YES | 8 | 20 | REMOVE UNWARRANTED | 4 | NO | YES/ STUDY ON REQUEST |
| DECATUR, GA | MUTCD | NO | 75 | 67 | NONE/UPGRADE TO SIGNALS | NONE | NO | NO |
| WV DIV. OF HWYS | MUTCD IMPLIED | NO | 10 | 100 | MUTCD | 0 | NO | NO |
| PHOENIX | MUTCD IMPLIED | NO | 55 | 5 | UPGRADE TO SIGNALS | MOOT POINT | YES | YES |
| BALTIMORE CO | MUTCD IMPLIED | YES | 200 | 25 | NO POLICY/DON'T REMOVE? | 1 | YES | YES |
| WASHINGTON, D.C. | MOD. MUTCD | YES | 650 | 10 | ONLY TO REPLACE WITH SIGNALS | VERY FEW | WHAT IS? | YES/RUSH HR |
| MONTGOMERY CO, MD | MOD. MUTCD | NO | 50 | 0 | STUDIED BY REQUEST | 1 | YES | YES |
| PORTLAND | MOD. MUTCD | YES | 150 | 75 | CASE BY CASE/VOL., ACC. | 2 | NO | YES |
| ST. LOUIS | POL. PREVAIL | NO | 1400 | 1 | POLITICAL | 1 | WHAT IS? | NO |
| SAN FRANCISCO | PRAM.--OTHER | NO | 750 | 50 | CASE BY CASE | 2 | WHAT IS? | NO |
| GREENSBORO | PRAM.--OTHER | | 10 | 50 | NONE | 0 | NO | NO |
| SACRAMENTO | PRAM.--OTHER | NO | 220 | NO DATA | CITY CODE | 0 | NO | NO |
| DALLAS | RATING SYSTEM | YES | 200 | 100 | SIGNALS/ACCIDENTS/MONITORED | 10 | YES | YES |

Table 5
Situations to Consider AWSC -- Washington, D.C.

All-way STOP control should be considered for use in the following situations:

- Where volumes of traffic on intersecting roads are approximately equal.
- Primarily in residential areas at the intersections of two local streets, or two collector streets or combination thereof.
- Where streets are of more or less similar character (for example, residential, commercial, etc.).
- As an interim measure where traffic control signals are warranted and planned for future installation.
- As an interim measure where regulatory controls are being reversed.
- Where multi-way STOP controls are compatible with overall traffic circulation needs for local streets.
- Where the restricting of parking to increase motorists visibility is detrimental to the community.
- Where an accident problem exists, as indicated by three (3) or more reported accidents of a type susceptible of correction by a multi-way STOP installation in a 12-month period on local or collector streets. Such accidents include right and left turn collisions as well as right angle collisions.
- All-way STOP sign controls can be considered on arterial streets where five or more accidents have occurred in a 12-month period.

DO NOT USE ALL-WAY STOP CONTROL

All-way STOP should not be used for the following situations:

- When pedestrian protection is a prime concern, particularly young school children. Such a short term need (1 hour a day) should be met by using an adult crossing guard.
- As a speed control device (where speeding is the primary concern).
- On roadways where progressive signal timing exists.
- On roadways within urban areas having a posted speed limit in excess of 35 MPH.
- At intersections having less than three or more than four approaches.
- At offset or poorly defined intersections, where assignment of right-of-way to traffic becomes a problem.
- On truck or bus routes unless in an industrial area or where two such routes cross.
- Where requiring traffic to stop or start on a grade will create a hazard
- As a means of deterring the movement of through traffic in a residential area.
- Where any other traffic device controlling the right-of-way is permanently in place within 500 ft.
- If both roads are arterials.
- On any freeway or parkway, except under ordinary conditions such as construction work or detours (temporary situations).

SUMMARY

The use of all-way STOP signs should be made very judiciously. The suggested warrants/criteria should serve as a guide in assessing the need for such controls at residential intersections. There should not be an indiscriminate use of the STOP sign to remedy community traffic problems.

Table 6
San Francisco's Practice for AWSC

All-way Stops are normally used to:

- define intersection right-of-way where it's unclear
- protect certain turning movements
- prevent pedestrian right-of-way preemption by vehicles
- adjacent to schools
- serve as interim treatment prior to signals
- at streets of equal importance
- break up commuter traffic flow in residential neighborhoods (effective only where alternate, more efficient routes are made available).

Table 7
Sacramento's Warrants for Stop Signs, Yield Signs, and Undulations for Speed Control

Stop Signs and Yield Signs for Speed Control

1. Minimum uncontrolled approach distances: 1000' for stops, 750' for yields.

   Approaches WB_____ EB_____ NB_____ SB_____ Met? Y N

2. Minimum traffic volumes: 750 VPD for stops, 500 VPD for yields

   Volume________________________ Date Taken________________ Met? Y N

3. Minimum of 50% of traffic exceeding speed limit

   Percentage exceeding speed limit _____ 85% Speed _____ Date of Survey________ Met? Y N

4. Other considerations

   a. Does intersection appear on Accident Rate Update (ZO9R3370-A)?
      Y-rate __________ N
   b. No stop or yield signs for speed control at "T" intersections or on major streets.
   c. When placing yield signs for speed control, check for adequate visibility at the intersection.

The percent of AWSC intersections that meet the MUTCD warrants was widely scattered and ranged from 0 to 100. Nine (45 percent) of the 20 agencies do not have a policy on removing AWSC. Four agencies remove them to install signals and three mentioned case studies as needed. Only Dallas with 10 AWSC removals and Howard County with 4 removed more than two AWSC.

Reverse stop signs are not used by half of the respondents, whereas four agencies (20 percent) do use AWSC. Six respondents were unfamiliar with reverse stops--two-way stops are installed to stop traffic on the major street, thus assigning the right-of-way to the minor or side street. The major reason for using this is to break up the continuous, non-stop traffic flow along the major street. The agencies were divided by those who have a residential traffic management policy, 8 (40 percent), and those who do not have a policy, 12 (60 percent). Five of the 8 agencies have a comprehensive policy that considers a wide range of passive and physical controls. Five agencies use speed humps, also called road humps, or undulations, to manage residential traffic. One agency focuses on passive devices, such as signs.

### *VDOT Cut-Through Traffic Case Studies*

Three studies conducted by VDOT to control cut-through traffic are described below.

#### *Old Warson Drive, Salem Woods Subdivision, Chesterfield County* [24]

Old Warson Drive was a cut-through route for motorists choosing to avoid Centralia Road, a minor urban arterial parallel to Old Warson Drive (Figure 2). VDOT installed AWSC (three-way control) at two adjacent intersections in September 1989 to reduce cut-through traffic and speed. Also, shoulder lane pavement markings were installed to provide an area about 1.8 m (6 ft) wide to accommodate pedestrians and bicyclists (there are no sidewalks), the majority of which are children. The 9.2 m (30 ft) wide roadway had 3.7 m (12 ft) wide travel lanes and one shoulder lane. Before these AWSC signs and markings were installed, VDOT installed: 1) a centerline on Old Warson Drive, 2) additional and upgrades of existing 25 mph speed limit signs, 3) pedestrian crosswalks at both intersections where AWSC was installed, and 4) stop signs on both side streets at their intersection with Centralia. The 24-hr traffic volumes were reduced 32 percent after the first month, 39 percent after 4 months, 23 percent after 8 months, and 29 percent (about 220 vpd) after 20 months. After 20 months, the volume was reduced 49 percent for the eastbound p.m. peak hour (from 92 to 47) and the westbound a.m. peak hour (from 81 to 41). In the first month after the AWSC installation, the average speed was reduced by 34 percent or 14.4 kph (9 mph). However, the average speed changes measured 4, 8, and 20 months after installation showed essentially no reductions-- ranging from 3 to 5 percent (0- 1.6 kph [0-1 mph]).

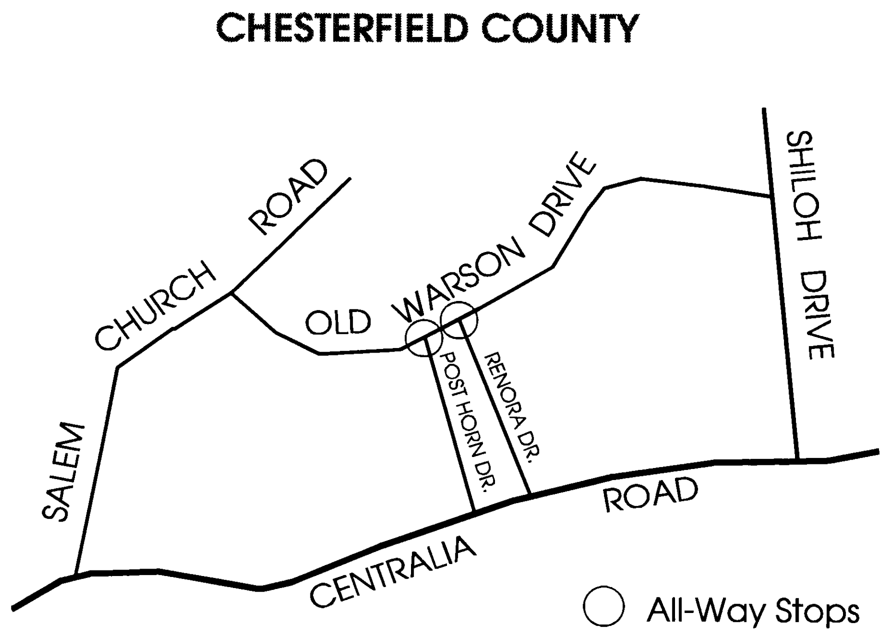


Figure 2. Old Warson Drive.

A postcard survey of the subdivision's 326 households yielded a response of 50 percent. Speeding and pedestrians in the roadway were cited most frequently as safety problems. High traffic volumes were also mentioned. Seventy-four percent of the respondents stated that the AWSC made Old Warson safer. More than 80 percent responded that the new pavement markings had a positive impact on safety. Several letters and phone calls from residents that live close to the AWSC intersections complained of the increased noise levels.

A study of stop sign compliance at the two AWSC intersections revealed that 53-59 percent of the drivers on Old Warson came to a complete stop, 38-44 percent made a rolling stop, and 2-3 percent made a running stop. For the two side streets, the results were 78-89 percent made a complete stop, 11-22 percent made a rolling stop, and 0 percent made a running stop. Forced stops were not recorded separately. For all approaches for both intersections, 62 percent made a complete stop, 37 percent a rolling stop, and 1 percent a running stop.

*Holden Street, Country Club View Community, Fairfax County* [26]

The Country Club View Community has been dealing with the effects of cut-through traffic on Holden Street for many years. Holden Street, which is about 8.3 m (27 ft) wide, was a convenient cut-through for commuters (workers and students) traveling from Zion Drive to Sideburn Road and vice versa (Figure 3). Several years ago, in an attempt to divert traffic from Holden Street, Holden Street was closed using barricades at its intersection with Concordia Street. This effort failed; the temporary barricades ended up on the roof of the local high school near Holden and Sideburn. Poor coordination and communication with the community and commuters were cited as the reasons for the failure. The lessons learned from this experience have resulted in an effective implementation of cut-through measures. Representatives from VDOT, the community, and county government worked together to develop and implement a plan to reduce cut-through traffic during both peak periods using three AWSC intersections.

This countermeasure reduced peak hour peak direction volumes by 180 vph (from 277 to 97, or 65 percent) northbound in the morning, and by 153 vph (from 221 to 68, or 69 percent) southbound in the evening. For a 24 hr period, the total traffic volume was reduced by 635 vehicles (from 2034 to 1299, or 31 percent). There was little change in the average speed which was under 54 kph (30 mph) in the before period. The Country Club View Community was very pleased with the results of the AWSC and the excellent working relationship that it has with VDOT and the county.

A traffic signal was installed at the intersection of Zion and Sideburn two months before the AWSC installations. This addition should have improved traffic flow through the intersection, thus improving the attractiveness of the primary route.

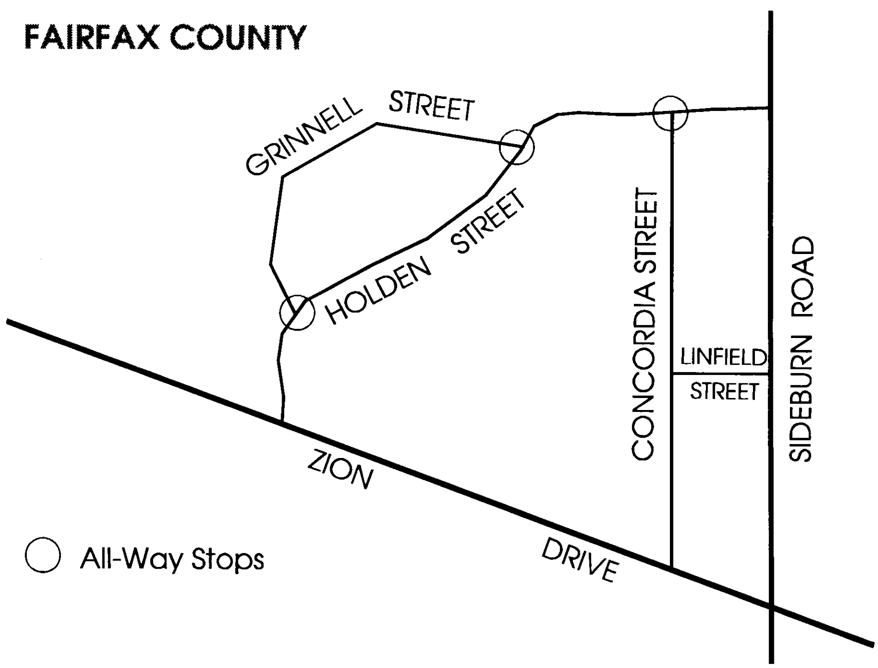


Figure 3. Holden Street.

*Red Fox Drive, Woodland Way, and Queen Elizabeth Boulevard, Canterbury Woods and Red Fox Forest Communities, Fairfax County* [27]

A route from Braddock Road to Red Fox Drive or Woodland Way to Queen Elizabeth Boulevard served as a cut-through route for commuters avoiding the intersection of Braddock Road and Wakefield Chapel Road in the morning peak period. To reduce the right-turning traffic from Woodland Way to Queen Elizabeth Boulevard from 1,005 to 555 during the morning peak hour (Figure 4), a series of AWSC was installed at 11 intersections. The signs were installed in October 1993. Depending on the cut-through route, a motorist would traverse 5 to 9 AWSC intersections-- 5 if one entered from Woodland Way, 7 from the eastern end of Red Fox Drive, and 9 from the western end of Red Fox Drive.

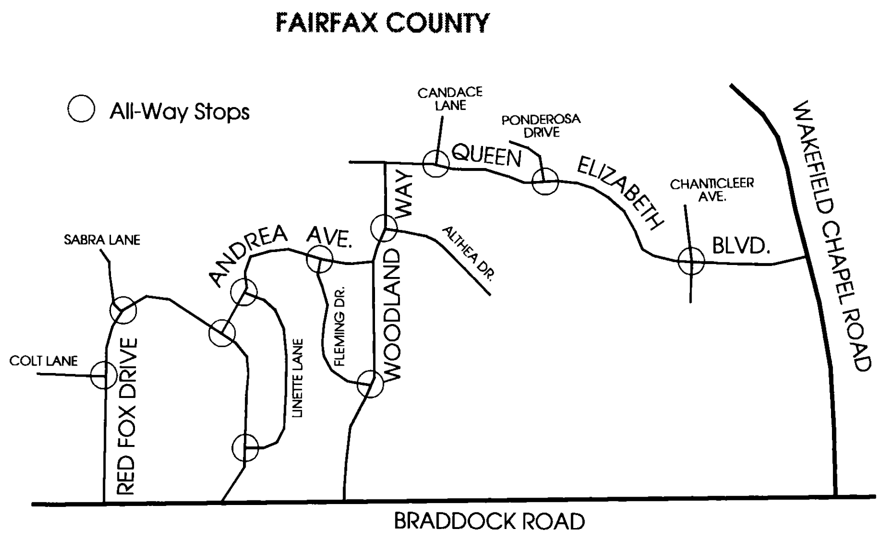


Figure 4. Red Fox Drive, Woodland Way, and Queen Elizabeth Boulevard.

The before-and-after study revealed that the morning peak hour right-turning traffic from Woodland Way to Queen Elizabeth Boulevard was reduced to 670 for a reduction of 335 vph (33 percent). Although the goal of an a.m. peak hour volume of 555 vph was not achieved, the reduction was substantial. The a.m. eastbound peak hour volume on Andrea Ave. west of Woodland Way was reduced 65 percent or 483 vph (from 741 to 258). The a.m. peak hour travel times along the Red Fox Drive route (western end) increased 1 min 40 sec (35 percent) from 4 min 36 sec to 6 min 15 sec. The a.m. peak hour travel times along the Woodland Way route increased 1 min 15 sec (34 percent) from 4 min 42 sec to 5 min 57 sec. The a.m. peak hour cruising speed was basically unchanged with a difference of less than 0.8 kph (0.5 mph) for both routes. The after a.m. peak hour cruising speed was 38 kph (24 mph) on the western Red Fox route and 40 kph (25 mph) for Woodland. While the travel time along the cut-through increased, the travel time along the Braddock Road to Wakefield Chapel to Queen Elizabeth Boulevard decreased about 9 min (55 percent) from 16.3 min to 7.3 min. This was a result of an adjustment in the signal timing to allow more green time for Braddock Road. This adjustment obviously improved the attractiveness of the primary route.

The responses of the residents to the treatment were mixed. Some were satisfied with the current treatment. Several suggested minor changes such as 1) placing stop signs closer to the intersection, 2) mounting the sign posts in concrete to eliminate leaning posts, 3) adding the "ALL WAY" supplemental sign under the stop signs without it, 4) installing stop bars at some intersections to aid motorists in where to stop, and 5) installing a centerline on Queen Elizabeth Boulevard. Other residents felt that VDOT should seriously consider other alternatives suggested by the community. These alternatives include 1) speed humps, 2) signs and lights that flash at certain hours like those used in school zones, and 3) increased police enforcement of the 40 kph (25 mph) speed limit, especially during the peak hours. (It was reported by a resident that police avoided peak hour enforcement because there were too many cars to ticket.) Another issue evident from these alternatives is that some residents perceive that speeding is a major problem. The most recent response from the community was that other alternatives were not being discussed and the residents were split on the need for stop bars. There have been no changes in the original installation of the AWSC signs.

*Implications of the Three Cut-Through Traffic Studies*

All three VDOT cut-through traffic studies involving AWSC resulted in a substantial reduction in cut-through traffic volume, ranging from 33 to 67 percent during the peak hour (Figure 5). For two of the three studies, both with two AWSC intersections, the 24-hr volume was reduced 29 and 31 percent.

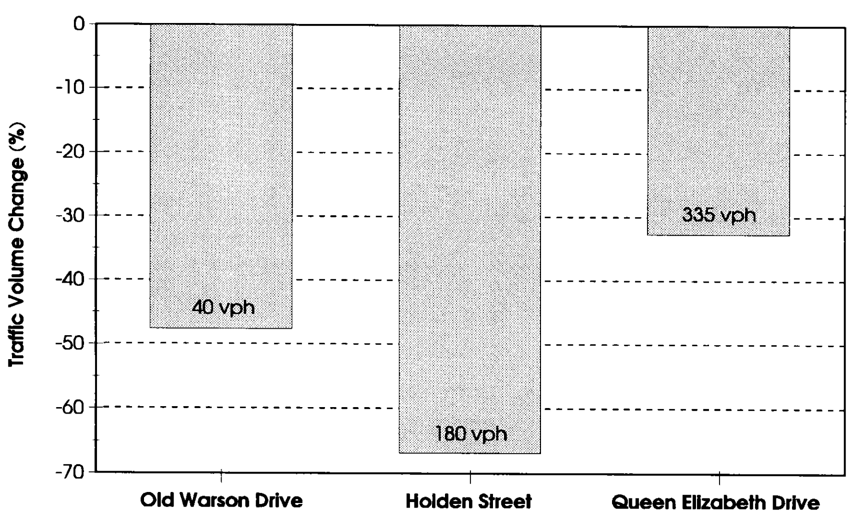


Figure 5. Reductions in cut-through traffic volume.

In all three cases, the travel speeds of vehicles were not affected by the AWSC intersections. Because none of the locations had a speeding problem before the treatment was installed, speeding was not an issue.

One common complaint by traffic engineers is that unwarranted AWSC will result in poor compliance which will, in turn, create a hazard and more accidents. Although other studies have demonstrated that AWSC reduces accidents,[20,21] it is worth reviewing the accident experiences at the 16 intersections in the three studies. Table 8 displays the before-and-after accident data at each intersection. For the Old Warson Drive sites, there were three years of after data. The Holden Street sites had about 31 months each of before and after data and the remaining 11 sites had about 24 months each of before and after data. There were a total of 6 before and 5 after accidents at the 16 intersections. If fixed objects are excluded, there are two before and three after accidents. There is no evidence that the safety of the intersections was impacted by the AWSC. This accident sample size is minuscule compared to the previously cited research. [19,20]

## Guidelines for Use of AWSC

The results of the three case studies provide evidence to support the continued use of a series of AWSC intersections to reduce cut-through traffic volumes. VDOT's Policy and Procedures for the Control of Residential Cut-Through Traffic should be used to determine the need for measures to reduce cut-through traffic. A series of AWSC intersections may be considered as one alternative if intervention is needed. Potential alternatives should be analyzed to determine which one is most appropriate for the specific conditions of the neighborhood under study. The installation of more than two AWSC intersections should be determined by the engineering staff with consideration given to the length and number of intersections along the cut-through route. The route being avoided should also be examined for improvements that would lessen the potential for cut-through actions.

In deciding on a policy to address cut-through traffic problems, VDOT recognized the importance of the qualitative benefits to the residents achieved by reducing cut-through traffic in view of increased user costs that may result from installing countermeasures. In fact, the purpose of most strategies to reduce cut-through is to restrict access to the affected street and/or to make travel on the affected street more difficult and less attractive. The additional delay from interruptions in continuous travel by periodic stops at AWSC intersections is what produces the reduction in cut-through traffic. Some advantages of a series of AWSC intersections as a cut-through traffic countermeasure are: 1) low cost and easy installation; 2) AWSC is a well known, familiar device; 3) they do not restrict access to the neighborhood; and 4) they have proven to be effective. There are many other countermeasures available to reduce cut-through traffic.[28]

Table 8
Accident Data for the Three Case Studies

| County | Intersection | Before Accidents | After Accidents |
|---|---|---|---|
| Chesterfield | Old Warson/Post Horn | NA | 1 RE |
| | Old Warson/Remora | NA | 0 |
| Fairfax | Holden/Grinnel | 0 | 0 |
| | Holden/Grinnel (2) | 0 | 0 |
| | Holden/Concordia | 1FO | 0 |
| | Red Fox/Sabra | 1 FI | 1 FO |
| | Red Fox/Andrea | 0 | 0 |
| | Red Fox/Colt | 0 | 0 |
| | Red Fox/Linette | 1 FI | 0 |
| | Andrea/Linette | 1 FI | 0 |
| | Andrea/Fleming | 0 | 0 |
| | Woodland/Fleming | 1 SS | 1 FI |
| | Woodland/Althea | 0 | 2 RE; FI |
| | Q. Eliz./Chanticleer | 0 | 0 |
| | Q. Eliz./Ponderosa | 1 SS | 0 |
| | Q. Eliz./Candace | 0 | 0 |
| | Total Accidents | 6 | 5 |

FI- fixed object in road FO- fixed object off road RE- rear end SS- sideswipe same direction

Draft revised AWSC warrants that were prepared for the 1997 MUTCD have added three conditions: left turn conflicts based on engineering judgment, pedestrian-vehicle conflicts based on engineering judgment, and limited sight distance. Based on the questionnaire survey results, the author supports the inclusion of limited sight distance as a determining factor in warranting the use of AWSC. Although not in the written warrants, VDOT staff routinely considers sight distance as a factor. The draft warrants do not directly address the fact that the volume warrants are inappropriate for local residential streets. The two new warrants based on engineering judgement may be an attempt to include more low volume streets. Because VDOT's interest is focused on cut-through traffic on local residential streets, the development of general guidelines for AWSC on local residential streets was not pursued. The information from the questionnaire survey would provide a starting point to develop such guidelines if the need arises.

## CONCLUSIONS

### Literature Review

1. AWSC was not effective in reducing vehicle speeds. Because most studies examined were at sites without a speeding problem, one could argue that there was no reason to attempt to reduce speeds.

2. Two studies concluded that AWSC produced little impact in reducing traffic volumes. However, there was some suggestion that volume may have been reduced in some portions of the study sections.

3. Because of out-of-date cost estimates for user costs based on delay, no conclusion was drawn on delay costs from AWSC.

4. Most drivers came to a rolling stop at stop signs. Intersection volumes substantially influenced the percent of drivers making a full stop.

5. Contrary to popular opinion, the conversion to AWSC, warranted or unwarranted, was consistently effective in reducing accidents.

6. Warrants or guidelines that are less stringent than those in the MUTCD are used by several jurisdictions.

### Questionnaire Survey

7. The majority of traffic engineering agencies used the AWSC warrants in the MUTCD. Several agencies used modified MUTCD warrants with lower volume and accident criteria. A smaller number of agencies have developed rating systems as warrants. Adequate sight distance was a criterion used by several agencies.

### Case Studies

8. Based on the three case studies using 2 to 11 AWSC intersections, the series of AWSC intersections resulted in a substantial reduction of cut-through traffic ranging from 33 to 67 percent in the peak hour. There is no evidence to suggest that safety was negatively impacted.

## RECOMMENDATIONS

Although use of AWSC is controversial, it has been demonstrated to be effective in reducing cut-through volumes when installed at a series of intersections. It is recommended that:

1. VDOT continue to use a series of AWSC intersections as one tool to decrease cut-through traffic. VDOT's *Policy and Procedures for the Control of Residential Cut-Through Traffic* should be used to determine the need for measures to reduce cut-through traffic. *An Operating Guide for the Control of Residential Cut-Through Traffic* should be used to develop and analyze alternatives.

2. The installation of more than two AWSC intersections should be determined by the engineering staff, with consideration given to the length and number of intersections along the cut-through route.

The recommendations may be implemented by appending this report or its findings to *An Operating Guide for the Control of Residential Cut-Through Traffic.*

## ACKNOWLEDGMENTS

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## APPENDIX A

## City of Naperville, Illinois
## All Way Stop Warrant Worksheet

# Naperville Department of Public Works
# Traffic Engineering and Safety Division

## Residential All-Way Stop Warrant Worksheet

Passed by Naperville City Council, 7-21-92, Ordinance 92-XXX

Toward determining the appropriate type of traffic control for the intersection of residential streets, a worksheet that comprehensively addresses the concerns of residents has been developed.

Date ______________

Intersection of ________________________________________

and ________________________________________

Existing Traffic Control ______________________________

This Residential All-Way Stop Warrant Worksheet is applicable only to the intersection of residential streets with speed limits of not greater than 30 miles per hour. This procedure is not to be applied to the intersection of a residential street with a collector or arterial street as identified in the City's Master Thoroughfare Plan.

## 1. Classification of Streets

Both intersection streets are classified and function as residential streets, and the posted speed limit of each is 30 mph or lower.

STOP - This procedure is not applicable if either street is designated as an Arterial or a Collector Street on the City's Master Thoroughfare Plan. In these cases, the intersection must meet warrants established for all way stop control in the Manual on Uniform Traffic Control Devices.

## 2. Speed of Traffic

Highest average speed of all approaches (average of 85th percentile speed and upper limit of 10 mph pace. See accompanying work sheet.) **Check only one selection.**

0 points for 15.0 to 32.5 mph
25 points for 32.6 to 37.5 mph
60 points for 37.6 to 42.5 mph
120 points for 42.6 to 50.0+ mph

Highest Average Speed ______ mph = ______ points

Subtotal Item 2 ____________

Location ______________________________

## 3. School Pedestrians

See attached worksheet

**a.) Number of Children Using Safe Walk to School Route.**

Use highest hour during school crossing periods.

Elementary School Children (2 points each) ____ x 2 = ____

Middle School Children (1 point each) ____ x 1 = ____

**b.) Proximity of Intersection to School**
This may be either one or the other but not both.

Intersection is primary crossing at an elementary or middle school, 200 pts. ____________

Intersection is adjacent to an elementary or middle school, 100 pts. ____________

Subtotal Item 3 ____________

## 4. Non-School Pedestrians

See attached worksheet

Average of four highest hours

Pedestrians of middle school age or greater - 1 point each. ____ x 1 = ____

(Separate from those noted in Item 3.)

Pedestrians of elementary school age or less - 2 points each. ____ x 2 = ____

(Separate from those noted in Item 3.)

Pedestrians with physical, visual, or auditory impairment - 50 points each. ____ x 50 = ____

Number of approaches to intersection without sidewalk - 10 points each. ____ x 10 = ____

Subtotal Item 4 ____________

## 5. Accident Experience

Right angle collisions within past 12 months - 75 points each. ____ x 75 = ____

Collisions other than right angle in past 12 months - 20 points each. ____ x 20 = ____

Subtotal Item 5 ____________

## 6 Critical Approach Speed

Lowest critical approach speed of all approaches. Check and enter points below.

Critical approach speed < 20 mph - 20 points ____ ______ mph

Critical approach speed < 10 mph - 50 points ____ ______ mph

Critical approach speed < 5 mph - 75 points ____ ______ mph

Subtotal Item 6 ____________

Location ____________________

## 7. Unexpected Hazards

Bridge or underpass within one block - 20 points. ________

At grade railroad crossing within 300 feet - 50 points. ________

Curve or hill within 300 feet which obscures view of intersection - 50 points. ________

Factors not noted above - 25 points. ________

Subtotal Item 7. ________

## 8. Nearby Public Facilities

25 points for each public facility such as a church, park, swim club, bus stop, library, or shopping center within 300 feet of intersection.

Enter number of applicable facilities here. ________

Subtotal Item 8. ____ x 25 = ____

## 9 Intersection Conditions

Width of any approach < 22 feet - 25 points. ________

No street lighting - 20 points. ________

Roll curb on any approach - 15 points. ________

On-street parking within 50 feet of any approach - 10 points. ________

Subtotal Item 9. ________

## 10. Traffic Volumes

See attached worksheet

Total approach volume - average of 8 hours counted, 1 pt. per vehicle. ____ x 1 = ____

Minor leg volume - ____________

Minor leg adjustment, average of all hours counted. Check one.

Greater than 160, subtract 0 ____
120 to 159, subtract 50 ____
100 to 119, subtract 100 ____
75 to 99, subtract 120 ____
74 to 40, subtract 150 ____

Subtract minor leg adjustment from total approach volume. - ________

Subtotal Item 10. ________

Location ______________________________

## 11. Adjacent Traffic Control

Any adjacent intersection is controlled by all way stop or traffic signal.

Subtract 100 points.____________

Any adjacent intersection stops or yields one of subject streets.

Subtract 50 points.____________

Subtotal Item 11.____________

Item 1 No Total

Item 2 ____________

Item 3 ____________

Item 4 ____________

Item 5 ____________

Item 6 ____________

Item 7 ____________

Item 8 ____________

Item 9 ____________

Item 10 ____________

Item 11 ____________

Total of All Items ____________

**If point total of all items is greater than or equal to 500, the intersection qualifies for installation of all-way stop control.**

# APPENDIX B

## City of Dallas
## Four Way Stop Installation

## FOUR WAY STOP INSTALLATION

In order to initiate a complete study for a four way stop installation, at least one of the following requirements must be met:

A) One or more reported accidents that can be corrected with STOP signs occurring within an 18 month period over the last 3 years prior to the request.

B) Off-peak traffic volume split of at least 75/25. (In other words, the traffic volume in the lesser street should be at least 25% of the total.) One hour counts to be taken on a typical weekday between 9:00 am - 4:00 pm.

If neither requirement is met, a four way stop control should be denied and instead an alternate solution should be tried such as reversing the existing STOP signs, clearing any visibility obstructions, or changing existing geometrics to make for a safer approach.

If either of the above requirements are met, the following methods will be used to study four way stop installation requests:

A) Anytime a **principal** or **minor arterial** is involved, use the criteria set forth in the Texas Manual on Uniform Traffic Control Devices, (Section 2B-6 in the 1980 Texas MUTCD, Rev. #4.)

B) For all other intersections, the procedure outlined below will be used. This procedure takes into account the following criteria:

I. Accident History
II. Sight Distance
III. Traffic Volumes
IV. Major Street Speeds
V. Neighborhood Characteristics
VI. Cross-Street Delays

Each of the six criteria has been allotted a maximum weighted value. An intersection being studied may obtain full, partial, or none of the maximum weighted values for each of the criteria. The cumulative sum of the weighted values for the six criteria must equal or exceed 75 points to become eligible for four way STOP control.

### I. Accident History

Accident types to be used for this criteria:

1) right angle
2) pedestrian related (when crossing thru street and hit by vehicle on thru street)
3) left turn related

The study period will consist of the three years prior to the request. Select the 18 month period that contains the maximum number of correctable accidents.

Accident History Value will be weighted as follows:

| | | |
|---|---|---|
| 0 accidents | = | 0 points |
| 1 accident | = | 15 points |
| 2 accidents | = | 30 points |
| 3 accidents | = | 40 points |

**II) Sight Distance**

Two types of measurements will be conducted:

1) Stopping Sight Distance (SSD): A 6" object will be placed in the street at the intersection and a test vehicle will approach the object at the legal speed limit. When the driver can see the object a point will be recorded and the distance from the point to the 6" object will be recorded. If paving plans are available, SSD will also be checked on them. Measured SSD will then be compared to the required SSD as found in the table. (Reference, Public Works - Paving Manual).

2) Intersection Sight Distance (ISD): An observation vehicle will be located on the cross street at the curb line. A test vehicle will approach the observation vehicle on the thru street at the legal speed limit. The point where the observation vehicle can see the test vehicle will be recorded and the distance from the point to the observation vehicle measured. Measured ISD will then be compared to the required ISD as found in Table 1 (Reference, Public Works Paving Manual). If applicable, make distance adjustments due to grade of street using Table 2 (Refer to Appendix 2A & 2B.)

Depending upon which of the above cases is the most critical, Sight Distance Value (SDV) will be calculated as follows:

$$SDV = \frac{\text{Measured Sight Value (SSD or ISD)}}{\text{Required Sight Value (SSD or ISD)}} \times 100\%$$

SDV will be expressed as a percent.

Either Intersection Sight Distance or Stopping Sight Distance, whichever one is more critical, will be used as the significant value. Sight Distance Value will be weighted as follows:

| Sight Distance Value | Weighted Value |
|---|---|
| Over 98% | 0 |
| 97% to 92% | 5 |
| 91% to 85% | 10 |
| 84% to 75% | 15 |
| less than 75% | 20 |

(Reference: P.W. - Paving Manual & a Policy on Geometric Design of Rural Highways - pg 150 & 188)

III) **Traffic Volumes**

Figure A. located on page 1.14 will be used to determine the weighted Traffic Volume Value.

After calculating the split, locate the corresponding split on the axis labeled Volume Split. Extend a line vertically until reaching the solid diagonal line. At this point, extend another line horizontally until reaching the axis labeled Weighted Value. This point where the y-axis is bisected will be used as the weighted value for the Traffic Volume criteria.

Note: Generally, one hour counts taken on typical days between 9 AM - 4 PM can be used to calculate the traffic volume splits. If the location is within 3 blocks of a school in session, schedule a PM count such that school traffic will be included.

IV) Major Street Speeds

1) Unless otherwise requested, speed surveys will be made between the hours of 9AM -4 PM. If the location is in a 20 MPH School Zone, the survey will be done between the hours of 9:30 AM - 2:00 PM.

2) Follow the speed survey procedure as outlined in this manual (page 1.20).

3) The 85th Percentile Speed will be obtained for the through street and compared to the established speed limit of said street. Based upon this comparison, the Speed Values will be weighted as follows:

| D (MPH) | WEIGHTED VALUE |
|---|---|
| Less than +2 | 2 |
| +3 to +4 | 4 |
| +5 to +6 | 6 |
| +7 to +10 | 8 |
| Over +10 | 10 |

"D" is defined as the differential between 85th Percentile Speed and Speed Limit. D=(85th PS-SL). The result can be either (+) or (-).

Note: Speed surveys and traffic counts need not necessarily be made at the same time.

## V) Neighborhood Characteristics

Information used in this category will be obtained from a field survey. Diagram(s) will be prepared showing street width(s), existing traffic control(s) and any other pertinent information that can be of use in this study. The specific categories and corresponding weighted values are as follows:

| CATEGORIES (On Thru Street) | WEIGHED VALUES |
|---|---|
| School Crossing | +4 |
| Intersection Dip | +2 |
| Homes Fronting | +3 |
| Strictly Residential | +10 |
| Thru Street is Sub-Standard | +2 |
| Existing Warning Signs | -2 |
| Street Used As Cut-Through | +4 |
| Other Conditions | -2 to +2 |

(If it is a Tee Intersection, use -4 for weighted value.)

Each of the above categories will be assigned a value. The weighted Neighborhood Characteristics Value will be the sum of the above categories.

## VI) Cross-Street Delays

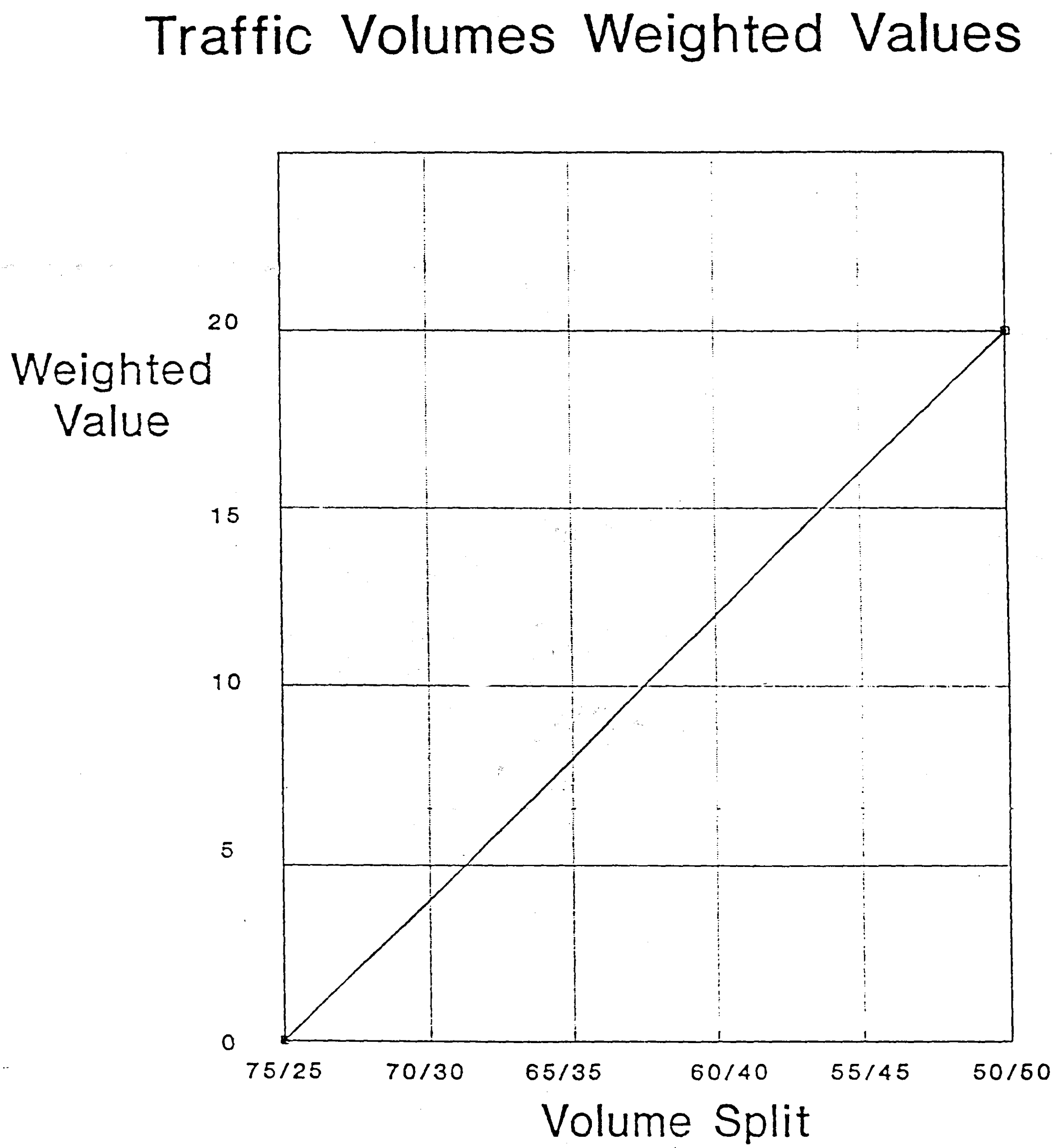
Cross-street delay studies will be performed using the procedures outlined in the Transportation and Traffic Engineering Handbook, Chapter 17. (Second Edition 1982.)

Cross-Street Delay Value will be weighted as follows:

| T (Seconds) | Weighted Values |
|---|---|
| Less than 20 | 0 |
| 21 to 25 | 1 |
| 26 to 30 | 2 |
| 31 to 35 | 3 |
| Greater than 35 | 4 |

Weighted values from the 6 specific criteria will be shown on a Summary Computation Sheet (see attachment) in their respective rows. The rows will then be summed and a Total Overall Weighted Value (TOWV) of the specific location obtained.

A 4-Way Stop control should only be considered if the TOWV equals or exceeds a value of 75. Generally, locations would not be eligible for restudy for 12 months.


Traffic Volumes Weighted Values
Weighted Value
20
15
10
5
0
75/25
70/30
65/35
60/40
55/45
50/50
Volume Split

(Figure A.)

SUMMATION SHEET

| | |
|---|---|
| Location: ____________________ | Date: __________________ |
| **<u>Categories</u>** | **<u>WEIGHTED VALUES</u>** |
| ACCIDENT HISTORY | ______________________________ |
| SIGHT DISTANCE | ______________________________ |
| TRAFFIC VOLUMES | ______________________________ |
| MAJOR STREET SPEEDS | ______________________________ |
| NEIGHBORHOOD CHARACTERISTICS | ______________________________ |
| CROSS-STREET DELAY | ______________________________ |
| TOTAL OVERALL WEIGHTED VALUE (TOWV) | ______________________________ |
| IS TOWV = 75? | YES, NO |

Note:

TOWV=75 points doesn't necessarily mandate the installation of a four way stop control. Before the final decision is made, consider any other factors that could adversely affect the traffic conditions if the four way stop is installed. Sound engineering judgement shall be exercised at all times and particularly when the TOWV is within 5 points of 75.