U.S. Department of Transportation

May 1981

Energy Saving Traffic Operations Project Guide

Estimating Traffic Operations Benefits

TECHNOLOGY SHARING REPRINT SERIES

Prepared for Illinois Department of Transportation

ESTOP GUIDE FOR ESTIMATING TRAFFIC OPERATIONS BENEFITS

Prepared as part of the
ENERGY SAVING TRAFFIC OPERATIONS PROJECT (ESTOP)
of the Illinois Department of Transportation

By Barton-Aschman Associates, Inc.
Evanston, Illinois

May, 1981

CONTENTS

Chapter 1
OVERVIEW

In this era of unstable foreign oil supplies and the rapidly increasing cost of domestic oil production, the conservation of petroleum-based energy is a major concern. Transportation, being the single greatest user of petroleum products in the United States, is a key target area for reducing the amount of energy consumed. Currently, major efforts are underway to make transportation more energy efficient by improving vehicle fuel consumption rates and by encouraging increased patronage of public transit or other high-occupancy vehicles. A third area now emerging as a promising cost-effective means to increase the energy efficiency of our transportation system is the improvement in traffic operations on our streets and highways.

Traffic operations improvements are aimed at reducing interruption to traffic flow (stops and speed changes) and vehicle stopped time, both being primary factors in the energy waste on our urban highways and street systems.

The 125 million automobiles and trucks in the United States consume over 100 billion gallons of gasoline and diesel fuel each year, or an average of 800 gallons of fuel per year for each motor vehicle. This is enough fuel to power an average automobile about 20,000 miles if driven on a level surface with no curves at a steady speed of 35 mph. However, we know that the average automobile can only be driven about 10,000 miles on 800 gallons of gasoline.[1] There are many factors which contribute to this reduced efficiency. One of the primary factors relates to the frequency of starts and stops and the number of speed changes on a typical trip.

At a presentation before the Institute of Transportation Engineers, Professor Harold L. Michael, head of the Civil Engineering Department at Purdue University and a distinguished leader in highway transportation research and education, stated that one gallon of gas could be saved by eliminating a stop for each of 100 vehicles traveling at 30 mph, and another gallon could be saved for every 150 fewer speed changes of 20 mph.[2]

Signalized intersections are one of the major contributors to the interruption of continuous traffic flow on arterial streets. The Federal Highway Administration estimates that the proper timing of the 130,000 traffic signals in urban areas in the United States could save 36 million barrels of crude oil per year.[3]

As is the unfortunate case with many programs, the step from recognizing the problem to achieving its solution is often difficult. State and local highway officials are constantly fighting the battle of too many projects and too little money. Available resources must be judiciously allocated among necessary maintenance programs, operational and safety improvements, and corridor or system-wide improvements. In addition, there are numerous other concerns, including social, economic, and environmental effects, which must be addressed by every roadway improvement project. Thus, those involved in planning and implementing improvements are faced with the difficult decisions of selecting the "best" projects from a long list of competing projects, and then must decide on the best implementation plan among a variety of alternatives. To do this objectively requires some basis for quantifying the expected benefits derived from different improvement plans.

[1] Harold L. Michael, "Opportunities in Transportation Engineering Funding and Intersection Management," *ITE Journal*, March, 1980.

[2] Ibid.

[3] FHWA, "Traffic Signals: Signal Timing Optimization Project; Solicitation of Interest," *Federal Register Volume 45, Number 58*, March 24, 1980.

Techniques for quantifying the energy impacts of transportation improvements have been available for some time; however, their complexity often has limited their application to traffic operation improvements. Lacking a simple, yet objective, tool for quantifying energy impacts, the traffic engineer was dependent upon his own professional experience and intuitive judgment. The increased concern for energy conservation has resulted in the need to design and evaluate traffic operation projects on the basis of quantifiable energy impacts in addition to the more traditional environmental and transportation issues. Thus, the need has been established for an objective tool for identifying and evaluating the energy efficiency of traffic operation improvements.

In recognition of this need, the Illinois Department of Transportation commissioned a study to develop the necessary tools for identifying and evaluating **E**nergy **S**aving **T**raffic **O**perations **P**rojects (ESTOP). The purpose of the ESTOP study was to:

- ☐ Illustrate the fuel saving benefits which can be derived from typical, straightforward, low-cost traffic operation improvements on major thoroughfares.
- ☐ Develop a *simple* analytical procedure for use by practicing transportation engineers and planners to estimate the reduction in fuel consumption expected to occur as a result of typical traffic operation improvements.
- ☐ Provide sufficient technical documentation of the procedures so that a more detailed evaluation can be conducted, if desired, to compare more precisely alternative traffic control and geometric design strategies.

While the primary emphasis of the study is related to fuel consumption, it was realized that improved traffic operations will have other significant benefits in the form of reduced travel time and reduced carbon monoxide (CO) emissions. Since the impacts of travel time and CO emissions are closely related (in their analytical procedures) to reductions in fuel consumption, analyses of these factors were incorporated in the study.

In addition, reduction of accidents is frequently a concomitant benefit of improved traffic operations. However, analytical procedures for accident reduction are significantly different than those used for fuel consumption and are already well documented.[4] Therefore, the subject is not covered in this document. The user of this guide should contact the division of traffic safety, in the state's department of transportation, to obtain information on analytical procedures for estimating accident reduction, as well as current accident data for the major streets and highways under study.

Project Summary

The ESTOP study included two phases of work. The first phase included a review and analysis of two corridors for which improvement plans already had been prepared. The purpose of the review was to identify and estimate fuel-saving benefits resulting from the projects and to identify additional improvements that could be made to increase the fuel-saving benefits. A summary report[5] was prepared highlighting the benefits of the University Avenue Corridor Project in Urbana, Illinois and the South Grand Avenue Corridor Project in Springfield, Illinois.

The fuel-saving improvements proposed for the Urbana corridor included resurfacing and restriping the street to provide a center left-turn lane, installing traffic actuation of signals at minor signalized cross streets and at separate turning movements, and extending and upgrading signal coordination, equipment, and timings. The Urbana project analysis indicated that for an estimated improvement cost of $600,000, a yearly fuel-saving benefit of 58,000 gallons (a 12 percent reduction) could be expected.

The fuel-saving improvements for the Springfield corridor included intersection widening to increase lane widths, revising signal timings and phasings, removal of stop signs, and extension and upgrading of signal coordination. The Springfield project analysis indicated that for a cost of $1,200,000, a yearly fuel savings of 114,000 gallons (a nine percent reduction) could be expected.

In addition to confirming the premise that significant fuel-savings benefits could accrue from relatively low-cost traffic operation improvements, the Phase 1 studies also permitted the testing of different analytical techniques for estimating fuel savings.

---

[4] One widely used document for the analysis of accident reduction is the *Manual on Identification, Analysis, and Correction of High Accident Locations*, U.S. DOT/FHWA, sponsored by the Missouri Highway Commission, November, 1975.

[5] *Phase I Summary Report, Energy Saving Traffic Operations Project*, Barton-Aschman Associates, Inc., May 1980.

Phase 2 of the study included the refinement of the procedures utilized in Phase 1 and the development of a detailed, step-by-step technical procedure for estimating the fuel consumption, travel time (or delay), and CO emissions resulting from virtually any set of roadway conditions. When applied to both existing and proposed conditions, the detailed procedures can be used to assess the impact of specific projects on travel time, fuel consumption, and CO emissions. This detailed procedure is outlined in the ESTOP Phase 2 technical report.[6]

The Phase 2 work also included the development of a more generalized technique for evaluating traffic operation movements. The key concepts and mathematical models are extracted from the detailed analyses and applied to a defined set of typical traffic conditions (including traffic flow, roadway geometrics, traffic operations and control). The fuel consumption estimates under the various specified conditions are compared in the manner of "before" and "after" analyses with the differences representing the benefits due to the change. The conditions compared are based upon frequently recommended traffic operations improvements, and the calculated benefits are plotted in a series of charts and graphs. These graphs illustrate the general relationship between the amount of fuel saved and one or two variables describing the traffic conditions. The use of the graphs represents a simplified procedure for evaluating different traffic operation improvements. The general directions for using the ESTOP evaluation procedures are presented in Chapter 2 of this report. Chapter 3 describes the specific instructions for evaluating each improvement plan considered by this report and includes all charts and graphs required, as well as example problems.

Conclusions

Application of the ESTOP evaluation procedures indicates that locally significant benefits in terms of reduced travel time, fuel consumption, and CO emissions can be expected through improved traffic operations. By encouraging improvements that reduce the number of vehicle stops, vehicle speed changes, and the time spent idling, thousands of gallons of gasoline can be saved yearly even on minor streets. The study also provided insight on the relative effectiveness of typical improvement schemes. In total, 10 different improvement types have been evaluated, ranging from extremely low-cost improvements such as removing stop signs to higher-cost improvements such as signal installation and system-wide signal coordination plans. Fuel-saving benefits also vary considerably and not always in proportion to costs. A summary of the range of expected fuel savings and approximate range of improvement costs is provided in Table 1.

[6] *ESTOP Manual for Calculating Traffic Operations Benefits*, Barton-Aschman Associates, Inc., May, 1981

Table 1
SUMMARY OF EXPECTED FUEL SAVINGS AND COSTS

Improvement Plan	Approximate Range of Fuel Saved Per Day (gallons)	Approximate Range of Construction Cost
A. Add Exclusive Left-Turn Lane	0- 20	$ 500-100,000[1]
B. Replace Four-Way Stop with Two-Way Stop	0-110	200- 500
C. Replace Signal with Two-Way Stop	0- 25	4,000- 5,000
D. Replace Four-Way Stop with a Signal	0-150	40,000- 80,000
E. Operate Off-Peak Flash	0- 12	500- 3,000
F. Allow Permissive Left-Turns	0- 40	3,000- 5,000
G. Provide Demand-Responsive Timing	0-100	4,000- 25,000
H. Improve Signal Timings	0-150	500- 1,000
I. Upgrade Signal Coordination	0- 90[2]	15,000- 20,000[2]
J. Improve Rough Railroad Crossings	0- 20[3]	30,000- 50,000

[1] Depends on need for new pavement or only new striping.

[2] Savings and cost per coordinated link (or intersection).

[3] Savings per 1,000 daily vehicles.

Chapter 2
PROCEDURES

This chapter outlines the simplified procedures for estimating the expected reductions in fuel consumption, travel time, and CO emissions resulting from various traffic operation improvements. The individual procedures involve the use of graphs and charts which show the change in fuel consumption, travel time, and CO emissions resulting from typical changes in roadway geometrics and traffic control. Analysis techniques are given for each of 10 basic traffic operation improvement plans which are frequently proposed by traffic and transportation engineers. The improvement plans and specific conditions covered by the procedures are listed in Table 2. This table shows the 21 conditions which can be analyzed by the user.

Prior to examining the individual procedures, the analyst should carefully read the following general instructions. Although application of the procedures is straightforward, they should be used with discretion, as they typically incorporate several simplifying assumptions which allow the generalizations to be made.

General Instructions for ESTOP Procedures

To estimate the benefits obtained from any proposed improvement, the analyst must first select the procedure most appropriate for the situation being analyzed. For example, if the proposed improvement is to remove the stop signs from the major street approaches at an existing four-way stop intersection, the procedure listed under "B—Replace Four-Way Stop with Two-Way Stop" should be used. If more than one improvement (i.e., installing a two-phase signal with a left-turn lane) is proposed at a given location, the analyst should select the single procedure which yields the greatest benefits.[1] If no match is found between a proposed improvement and the procedures presented in this report, the analyst can consult the technical report which provides a more detailed analytical procedure for evaluating virtually any set of conditions. The technical report also describes in detail the analytical models used for each of the generalized procedures presented in this report. FORTRAN source programs for each model are provided. These may be modified by the analyst to accommodate any specific conditions.

Having selected the appropriate procedure, the analyst should then identify the set of available conditions which best depicts those under which the improvement is proposed. For example, under "A—Add Exclusive Left-Turn Lane," the basic procedure involves separate analyses for one-lane and multi-lane approach conditions. Similarly, the basic procedure for "B—Replace Four-Way Stop with Two-Way Stop" involves analysis according to three different specific conditions.

The next step is to review the assumptions of the analysis as outlined in the specific procedure description. This will inform the analyst of the effect (if any) that alternative assumptions might have on the end results. Thus, the user is made aware of important qualifications that may need to be placed on the results, if actual project conditions are significantly different from the basic assumptions in this guide. For example, many of the procedures assume an average travel speed of 25 mph, and all procedures assume that existing and proposed conditions do not exceed the capacities of the various components of the situation. (The additional benefit of changing over-capacity situations to under capacity is ignored.)

The final step in each procedure is to enter the necessary input variables into the appropriate figures to obtain the expected reductions in fuel consumption, travel time, and CO emissions. These are represented as daily reductions in each figure. Typically, they can be multiplied by 300 to obtain an estimate of yearly reductions.

[1] A conservative (low) approach to estimating benefits is represented by these procedures. There are numerous cases where benefits of two improvements at one location *are not* additive [benefit (improvement A) plus benefit (improvement B) ≠ benefit (improvements A + B)], while there are many cases where benefits *are* additive. The myriad of improvement combinations possible makes it difficult to discuss, in this report, which are or are not additive. The analyst should consult the technical report for a more detailed assessment of the benefits from improvement combinations. The likelihood of the combined benefit being less than the greater of any one improvement element is expected to be minimal. Therefore, use of the procedure yielding the greatest benefit is recommended.

Table 2
IMPROVEMENT TYPES INCLUDED IN ESTOP EVALUATION PROCEDURES

Improvement Plan	Specific Condition
A. Add Exclusive Left-Turn Lane	1. One-Lane Approach 2. Two-Lane Approach 3. Three-Lane Approach
B. Replace Four-Way Stop with Two-Way Stop	1. 2 X 2 Intersection 2. 4 X 2 Intersection 3. 4 X 4 Intersection
C. Replace Signal with Two-Way Stop	1. All Conditions
D. Replace Four-Way Stop with a Signal	1. All Conditions
E. Operate Off-Peak Flash	1. All Conditions
F. Allow Permissive Left-Turns	1. Two-Lane Street 2. Four-Lane Street
G. Provide Demand-Responsive Timing	1. 2 X 2 Intersection 2. 4 X 2 Intersection 3. 4 X 4 Intersection
H. Improve Signal Timings	1. 2 X 2 Intersection 2. 4 X 2 Intersection 3. 4 X 4 Intersection
I. Upgrade Signal Coordination	1. One-Lane Approach 2. Two-Lane Approach 3. Three-Lane Approach
J. Improve Rough Railroad Crossings	1. All Conditions

In developing the graphs, every effort has been made to limit the number of input variables to the two or three most significant factors. This can result in a lower level of accuracy in using the techniques. However, any resultant error is considered to be acceptable since the procedures are intended only as a *general* traffic planning and evaluation tool. The curves developed for each figure represent the range of conditions most commonly encountered under "real world" conditions. Extrapolation, while possible, is not recommeded.

The following chapter describes each specific improvement plan and the proposed methods for evaluating potential improvements. Each of the 10 basic improvement plans includes a discussion and a set of instructions in the first page of the section. The second page provides a numerical example of the improvement applied to an actual location to illustrate the use of the procedure. The examples use real data to illustrate the procedures under actual on-street conditions. These examples do not, however, represent recommendations for improvement to the situation as they do not consider other vital factors such as policy, continuity, or safety. The remaining pages in each section of Chapter 3 provide the charts and graphs needed for the evaluation of each specific condition covered. The figure numbers are keyed to the capital letter identifying each improvement plan, i.e., A, B, C, etc.

In most cases, the specific condition describes either the number of lanes approaching the intersection on one leg (A1 represents one approach lane) or the number of lanes in both directions on each of the streets at the intersection (G2 represents a four-lane street crossing a two-lane street). It is important to keep these notations straight in the use of the curves.

Chapter 3

ESTOP GUIDE ESTIMATION PROCEDURES

A ADD EXCLUSIVE LEFT-TURN LANE

INSTRUCTIONS

ADDING AN EXCLUSIVE LEFT-TURN LANE TO AN APPROACH AT A SIGNALIZED INTERSECTION

Conditions:

1. Turn lane is being added to an intersection approach on a two-, four-, or six-lane roadway.
2. Benefits are per improved approach; therefore, if an opposing left-turn lane is also added, the results can be doubled (if assumptions can be met for both approaches) or two calculations should be made.

Assumptions:

1. Average vehicular running speed is 25 mph. Higher speeds will produce greater benefits; lower speeds, lower benefits.
2. Seven percent trucks assumed. Percentages ranging from zero to 15 percent will not alter results significantly.
3. Signal control operates with cycle length less than 120 seconds. Cycle length is same for proposed condition. Longer cycle lengths will increase benefits.
4. All movements on roadway being improved occur on a single phase.

Required Input:

1. Two-way peak-hour volume (V) for the street on which the turn lane is being installed. This should be the sum of the two approach volumes for the street.
2. Left-turn volume for proposed lane as a percent of the total approach volume (LT).
3. Green time for approach being improved as a percent of the total signal cycle length (G/CY).

Procedures:

1. Select the proper set of figures to use based on the number of through approach lanes on the leg being analyzed—A1 for one lane, A2 for two lanes, or A3 for three lanes.
2. Using G/CY value, determine in Tables A1, A2, or A3 which set of curves (A, B, or C) to use in the figures. Linear interpolation between the curves can be made as necessary.
3. Enter V and LT into appropriate curve to determine savings in fuel, travel time, and CO emissions. Linear interpolations can be made between the lines for the various left-turn percentages.

EXAMPLE

Description: Illinois Route 31, a major arterial in Dundee Township (Kane County), is a two-lane roadway at its intersection with Huntley Road (a minor two-lane arterial). Traffic counts in 1978 indicated two-way peak-hour volumes on Route 31 to be 1,055 vehicles. The left turn on the south approach is 15 percent of the approach volume. A temporary signal operates with an average cycle length of 70 seconds and an average of 49 seconds of green given to Route 31.

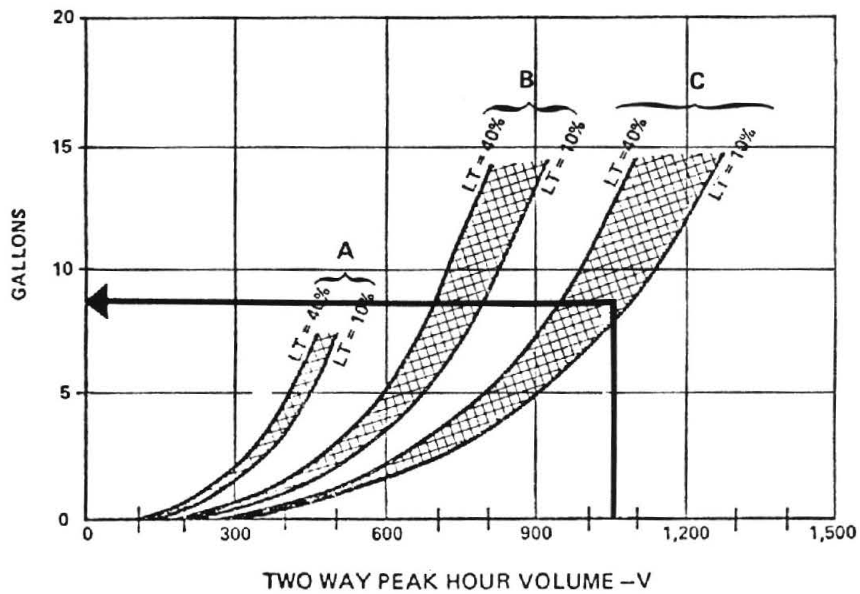
Input:

V = 1,055 vph
LT = 15 percent
G/CY = 49/70 = 70 percent

Charts/Graphs Used:

Use Figures A1-f, A1-t, and A1-e for a single through approach lane.

For G/CY = 70 percent, use Curve C in the figures (Table A1).



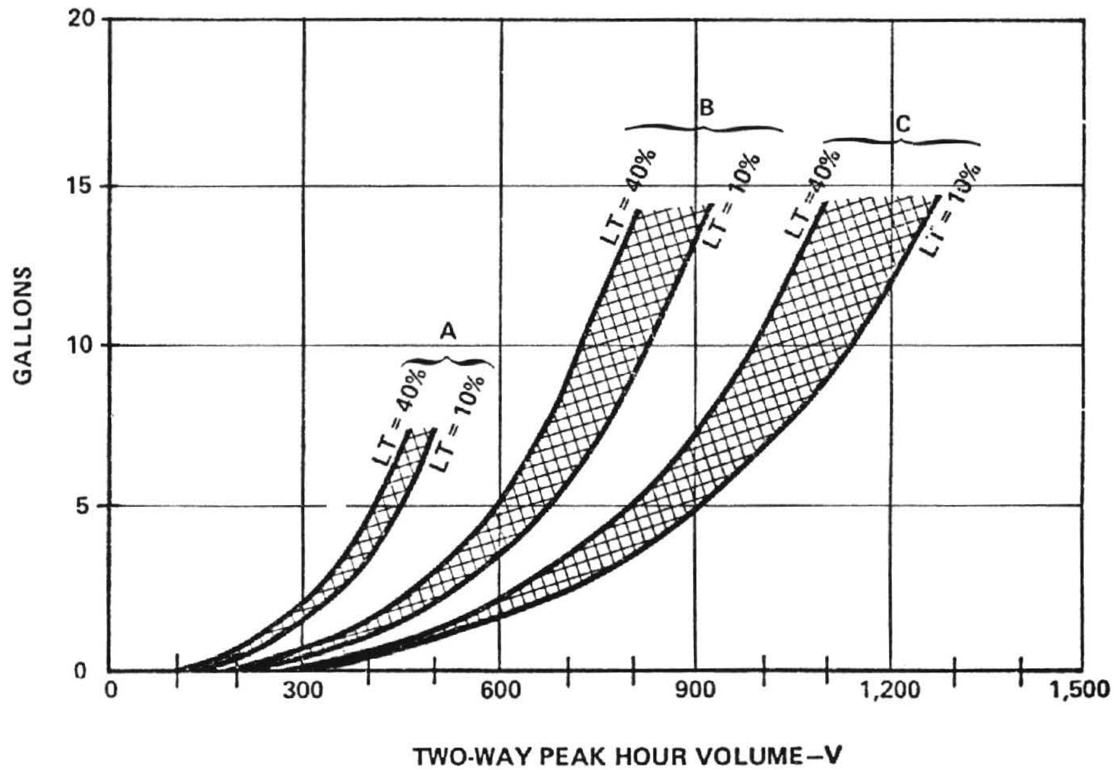
FUEL SAVED PER DAY
Figure A1-f

Final Results:

Gallons of Fuel Saved Per Day = 9
Hours of Travel Time Saved Per Day = 6 (from Figure A1-t)
Kilograms of CO Saved Per Day = 3 (from Figure A1-e)

A ADD EXCLUSIVE LEFT-TURN LANE

1 One-Lane Approach



FUEL SAVED PER DAY
Figure A1-f

Table A1
IDENTIFICATION OF CURVES FOR USE IN FIGURES A1-f, A1-t, AND A1-e

G/CY	Use Curve
30%	A
50	B
70	C

One-Lane Approach 1

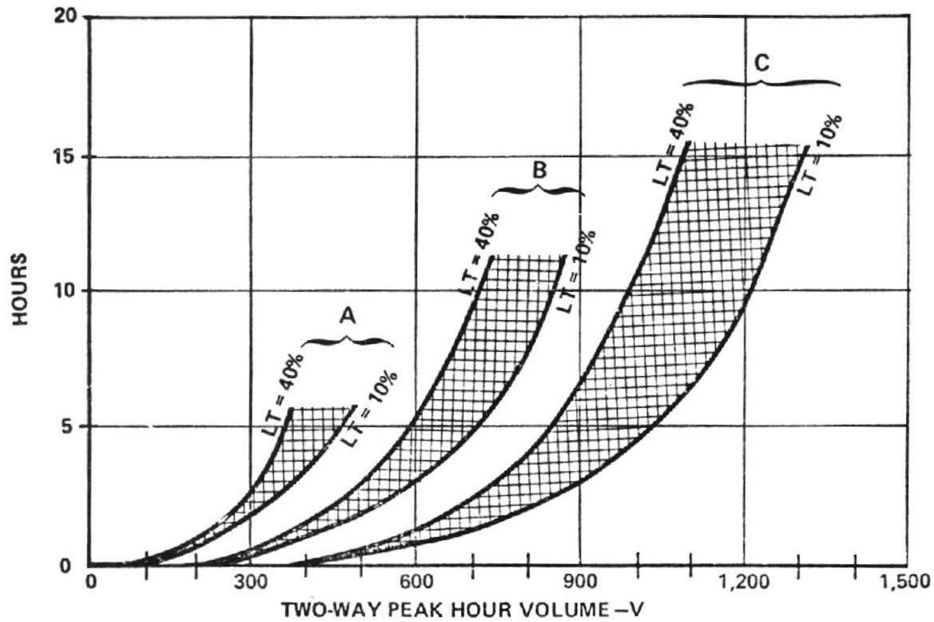


Figure A1-t TRAVEL TIME SAVED PER DAY

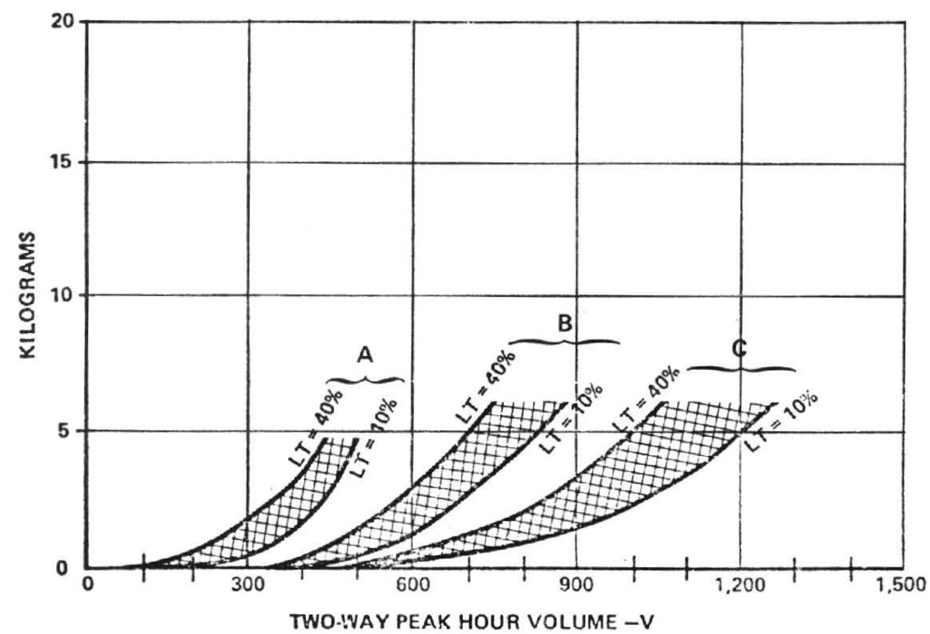
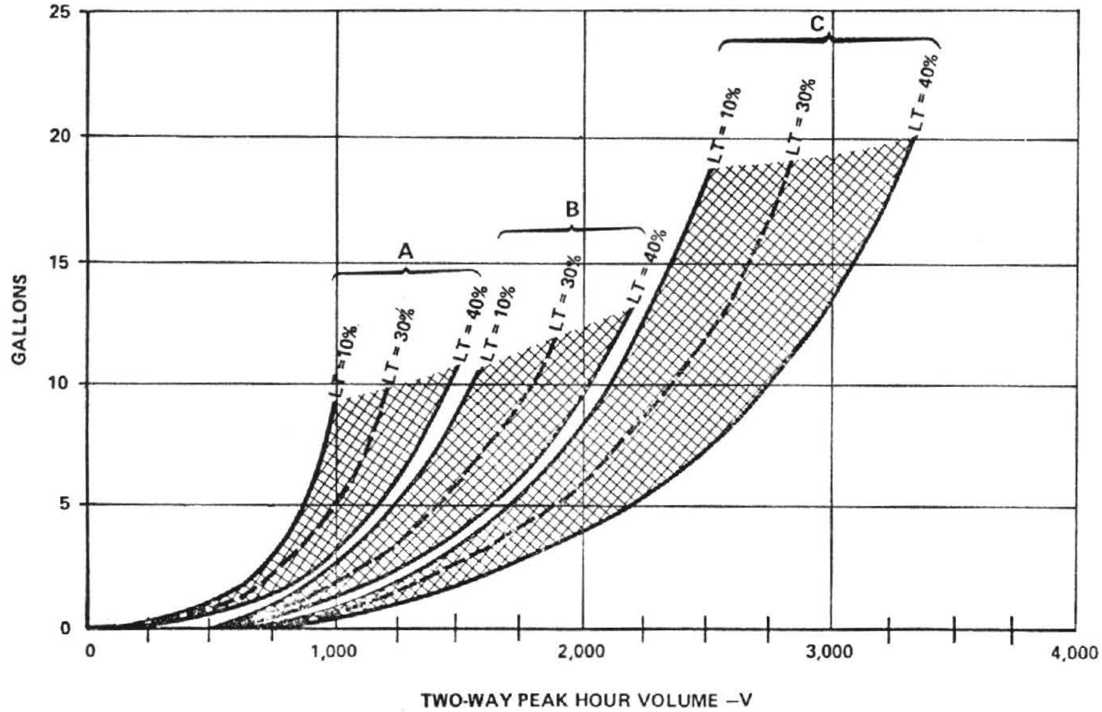


Figure A1-e CO EMISSIONS SAVED PER DAY

A ADD EXCLUSIVE LEFT-TURN LANE

2 Two-Lane Approach



FUEL SAVED PER DAY
Figure A2-f

Table A2
IDENTIFICATION OF CURVES TO USE IN FIGURES A2-f, A2-t, AND A2-e

G/CY	Use Curve
30%	A
50	B
70	C

Two-Lane Approach 2

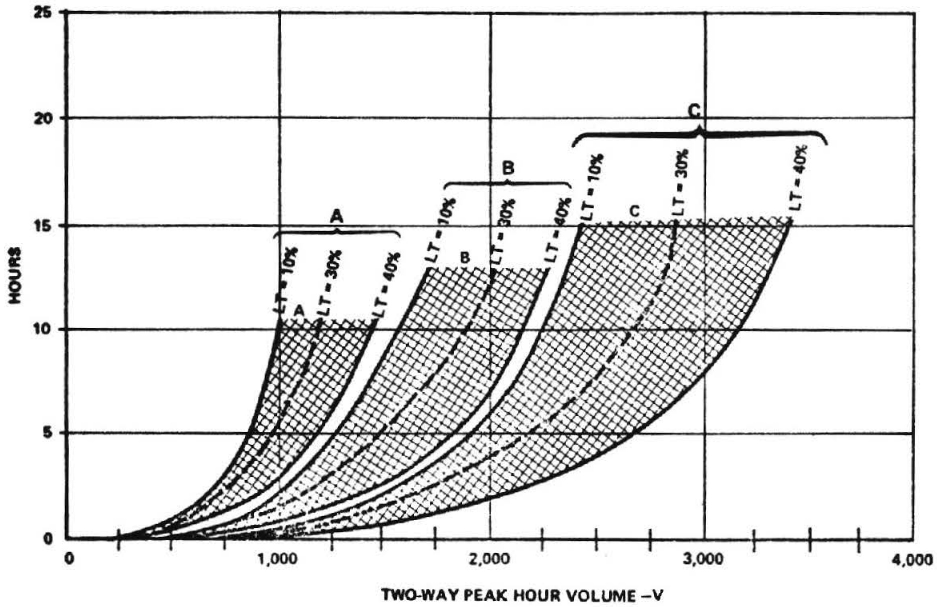


Figure A2-t TRAVEL TIME SAVED PER DAY

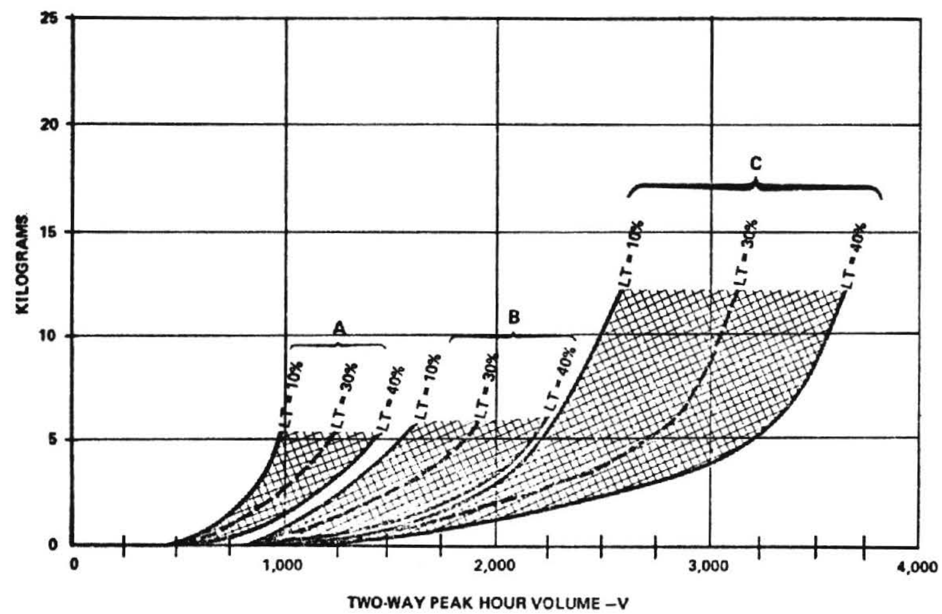
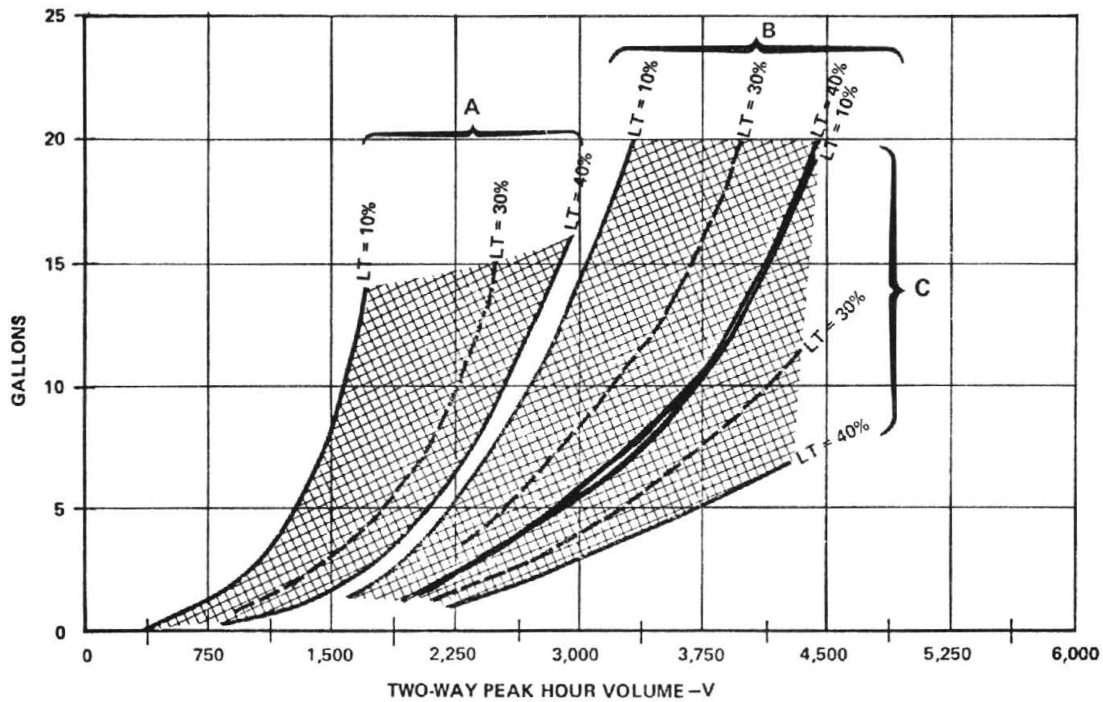


Figure A2-e CO EMISSIONS SAVED PER DAY

3 Three-Lane Approach

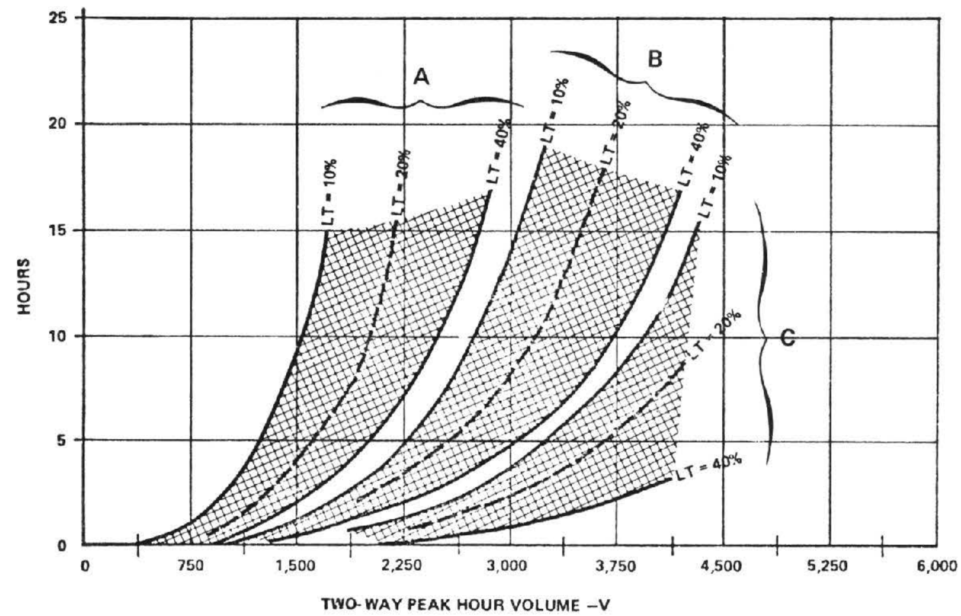


FUEL SAVED PER DAY
Figure A3-f

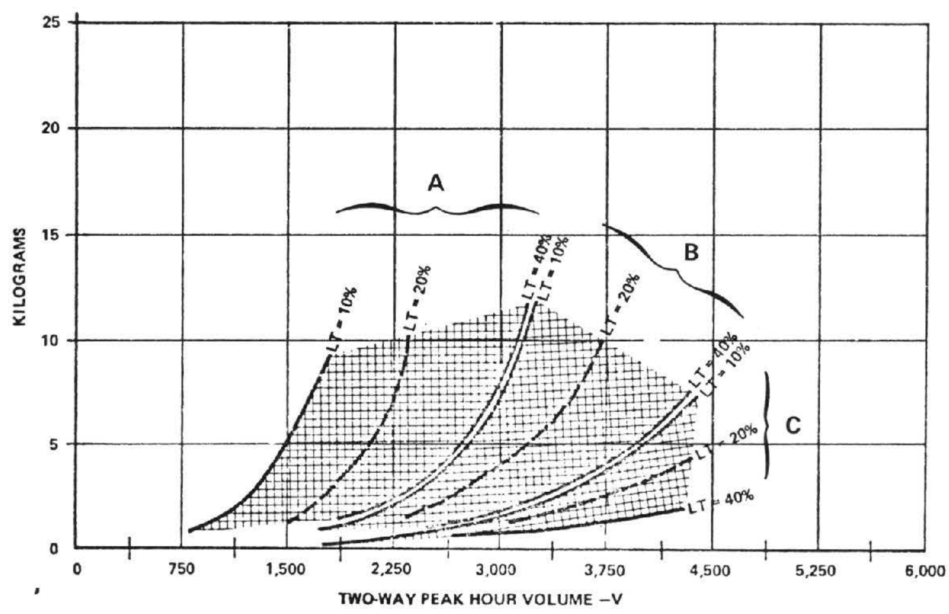
Table A3
IDENTIFICATION OF CURVES TO USE IN FIGURES A3-f, A3-t, AND A3-e

G/CY	Use Curve
30%	A
50	B
70	C

Three-Lane Approach 3



TRAVEL TIME SAVED PER DAY
Figure A3-t



CO EMISSIONS SAVED PER DAY
Figure A3-e

INSTRUCTIONS

REPLACING A FOUR-WAY STOP SIGN WITH TWO-WAY STOP SIGN CONTROL

Conditions:

1. Intersection of two streets, either street having two or four through lanes (total of both directions), controlled by a four-way stop sign.

Assumptions:

1. Left turns on street having stop signs removed represent less than 10 percent of approach volumes. Higher left-turn percentages will decrease benefits. This is of particular concern in the 2 X 2 case.
2. Average vehicle running speed is 25 mph on both streets. Higher speeds will increase benefits. Lower speeds will reduce benefits.
3. Seven percent truck mix. Truck percentages of zero to 15 percent will not significantly affect results.
4. If the intersection is one of a four-lane street crossing a two-lane street, it is assumed that the stop signs to be removed will be for the four-lane street approaches.

Required Input:

1. Total peak-hour volume entering the intersection (V).
2. Volume of traffic on street having stop signs removed as a percent of total intersection traffic (SPLIT).

Procedures:

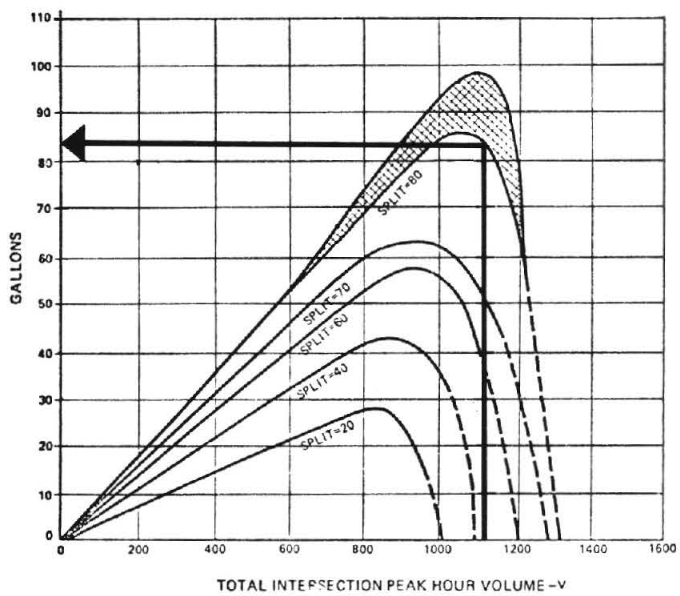
1. Select the proper set of figures to use based on the number of lanes on each street (at the intersection)—B1 for 2 X 2, B2 for 4 X 2, or B3 for 4 X 4.
2. Enter V into selected figures.
3. Using curve for appropriate SPLIT,determine fuel, travel time, and CO emission savings. For SPLITs greater than 80, use SPLIT = 80.
4. In this improvement plan, shaded areas and dotted lines in the figures indicate conditions where estimates are unreliable and/or unpredictable. Conservative estimates qualified by good judgment should be used.

EXAMPLE

Description: The intersection of Farnsworth Avenue and Molitor Road in Aurora, Illinois is controlled by a four-way stop. Farnsworth is four lanes and Molitor is two lanes. The intersection handles approximately 1,100 vehicles in the peak hour, of which 80 percent are on Farnsworth. Average running speeds are approximately 30 mph on all approaches.

Input: V = 1,100 vph
SPLIT = 80 percent

Charts/Graphs Used:
For a 4 X 2 intersection, use Figures B2-f, B2-t, and B2-e.

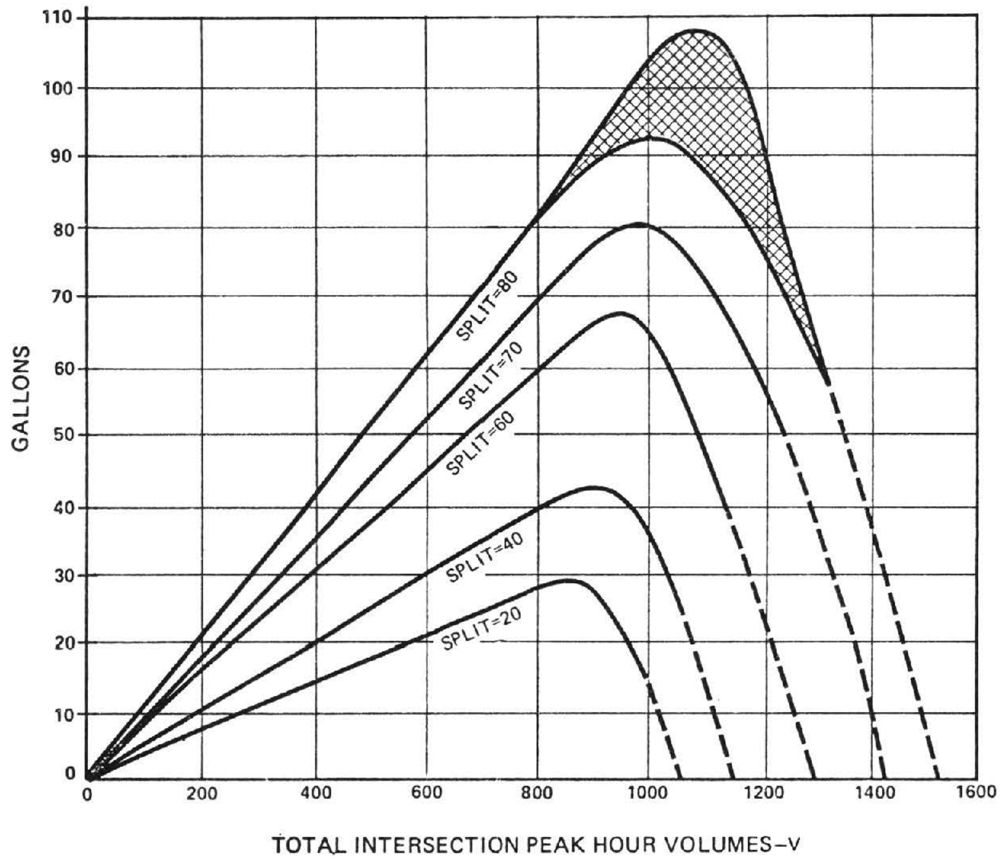


FUEL SAVED PER DAY
Figure B2-f

Final Results: Gallons of Fuel Saved Per Day = 84
Hours of Travel Time Saved Per Day = 30 (from Figure B2-t)
Kilograms of CO Saved Per Day = 68 (from Figure B2-e)

Actual savings will be slightly higher due to higher actual running speed (30 mph) as compared to that which is assumed (25 mph).

1 2 X 2 Intersection



FUEL SAVED PER DAY
Figure B1-f

2 X 2 Intersection 1

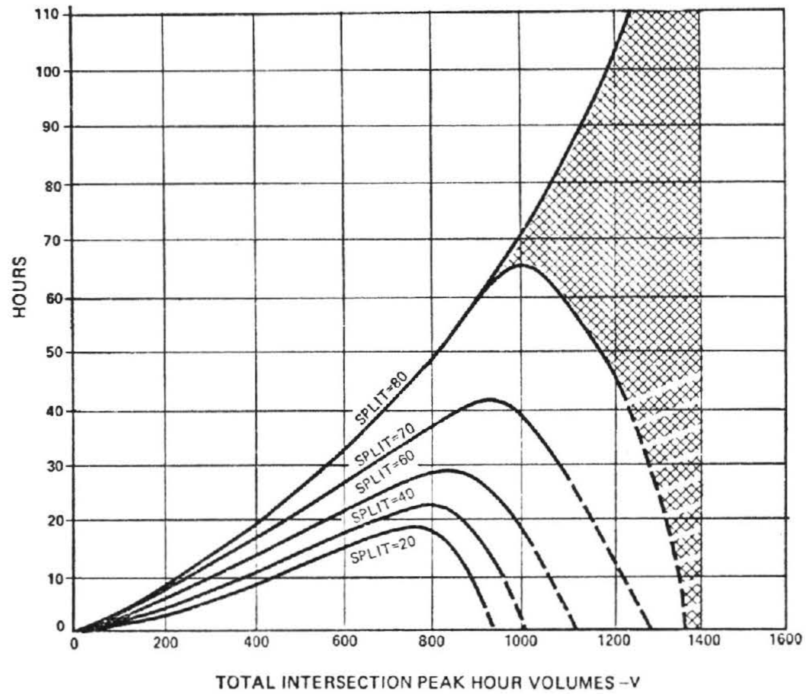


Figure B1-t TRAVEL TIME SAVED PER DAY

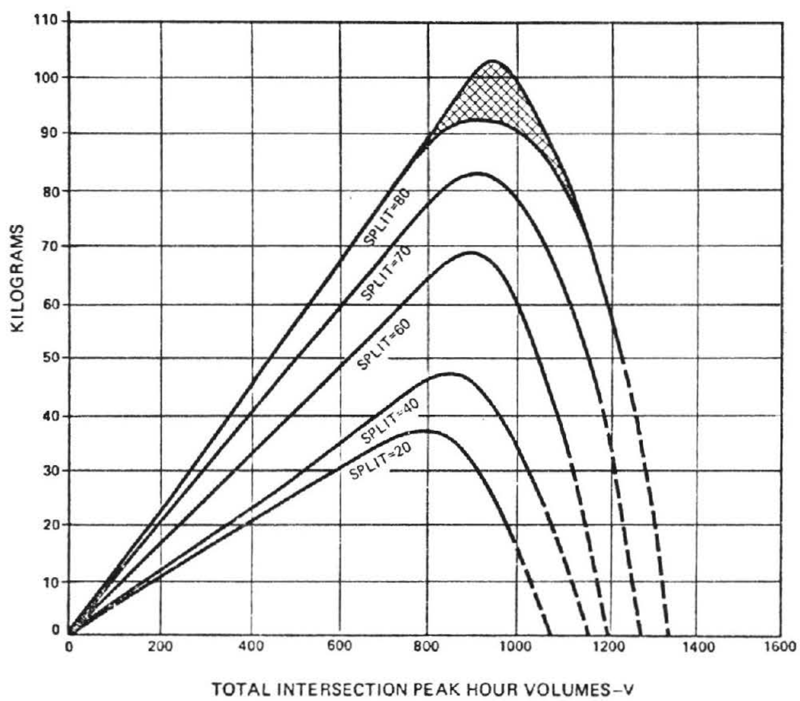
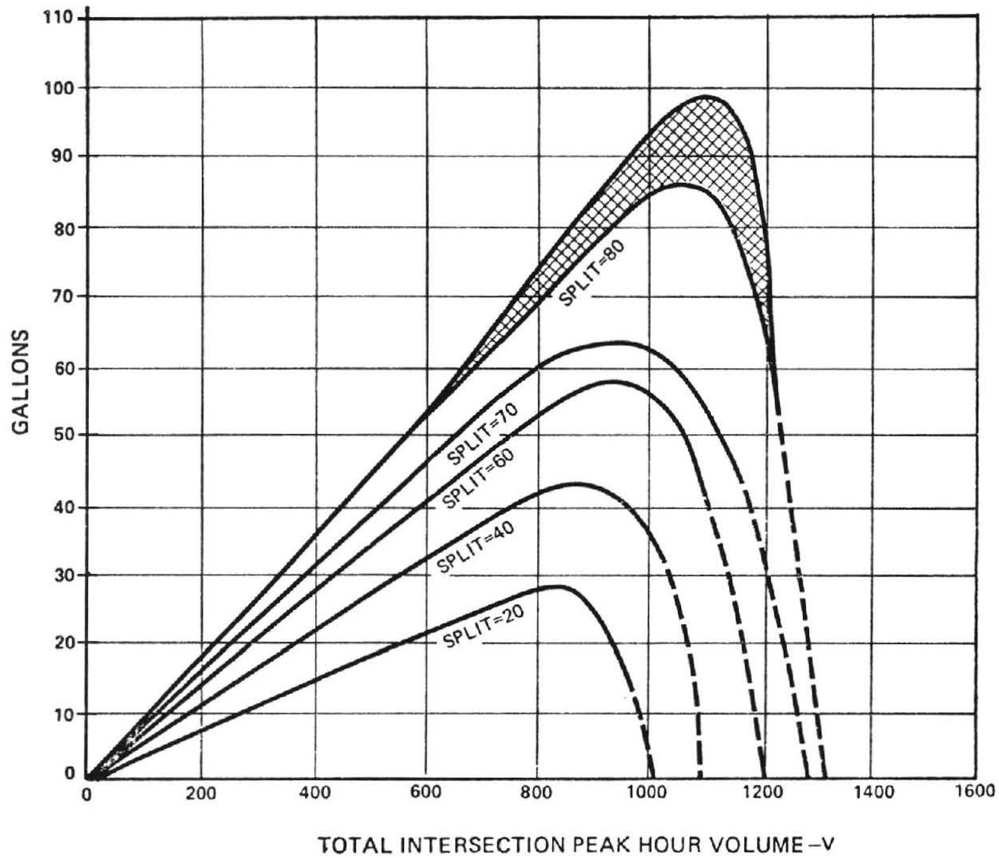


Figure B1-e CO EMISSIONS SAVED PER DAY

B REPLACE FOUR-WAY STOP WITH TWO-WAY STOP

2 4 X 2 Intersection



FUEL SAVED PER DAY
Figure B2-f

4 X 2 Intersection 2

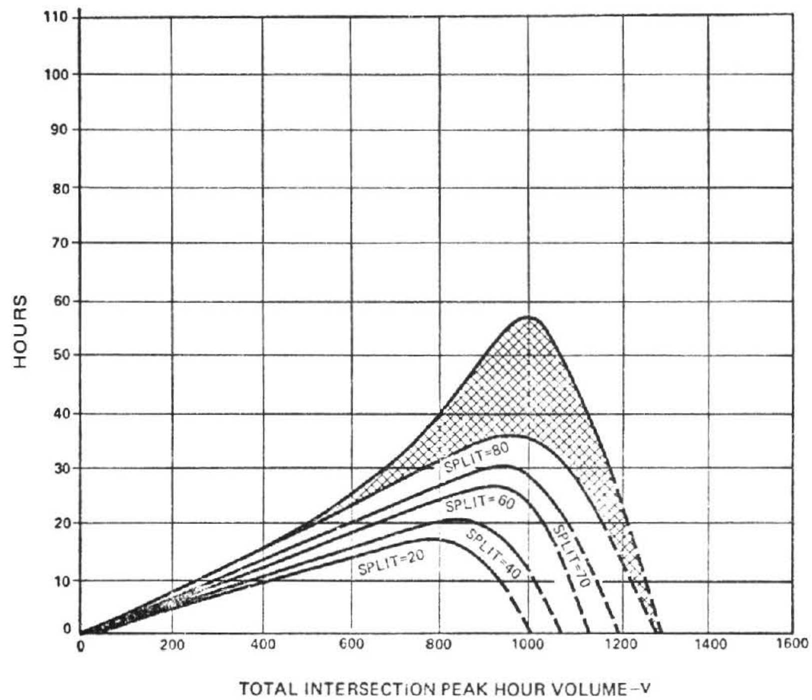


Figure B2-t TRAVEL TIME SAVED PER DAY

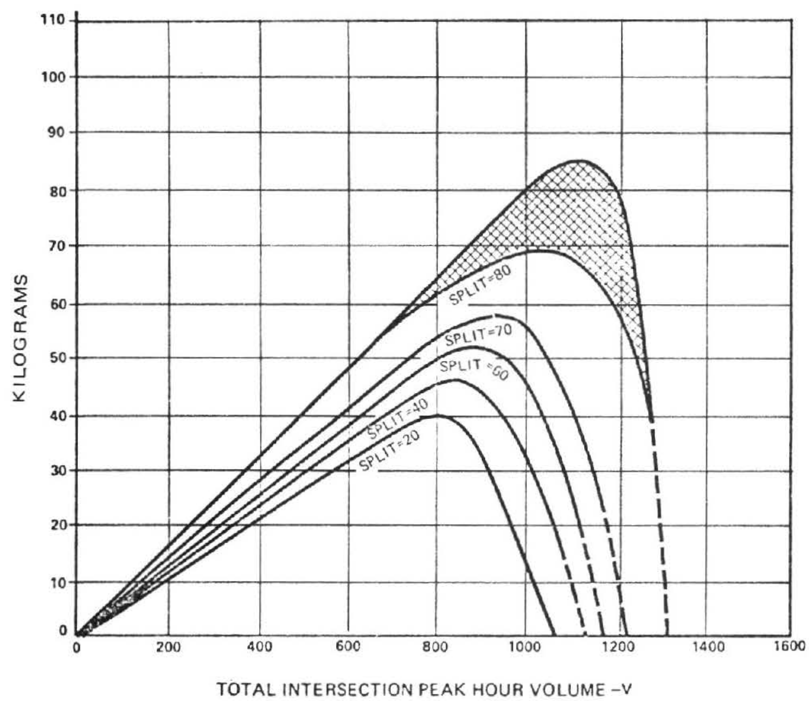
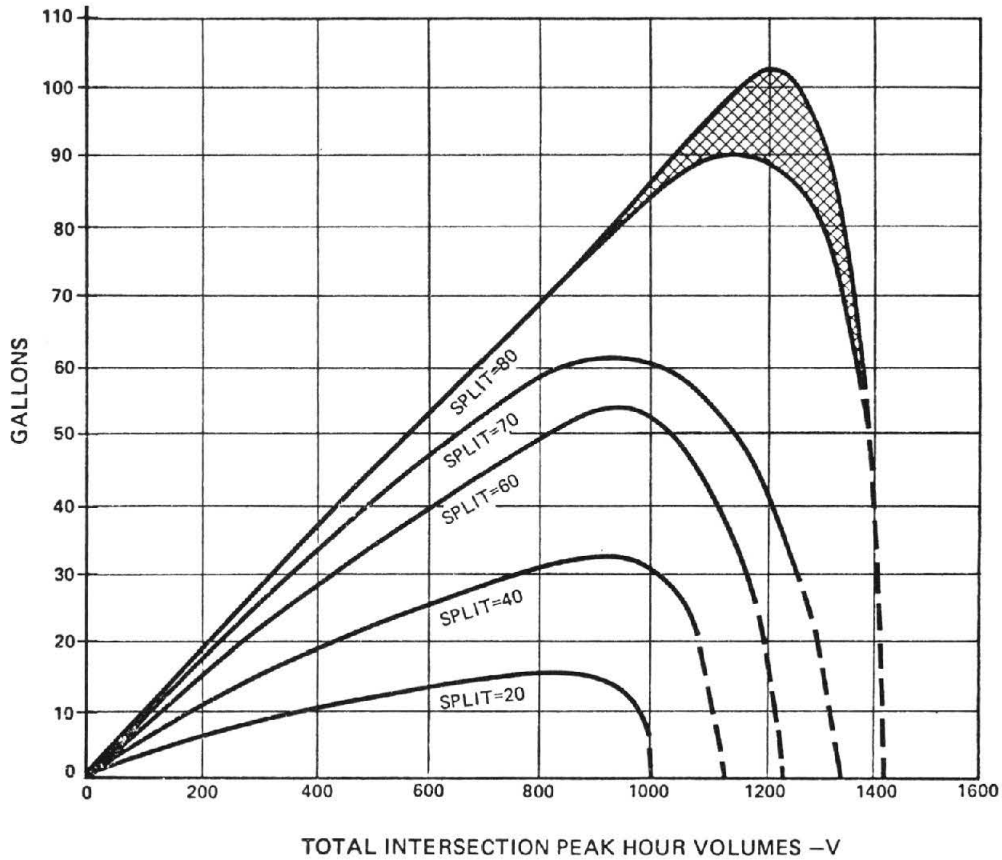


Figure B2-e CO EMISSIONS SAVED PER DAY

3 4 X 4 Intersection



FUEL SAVED PER DAY
Figure B3-f

4 X 4 Intersection 3

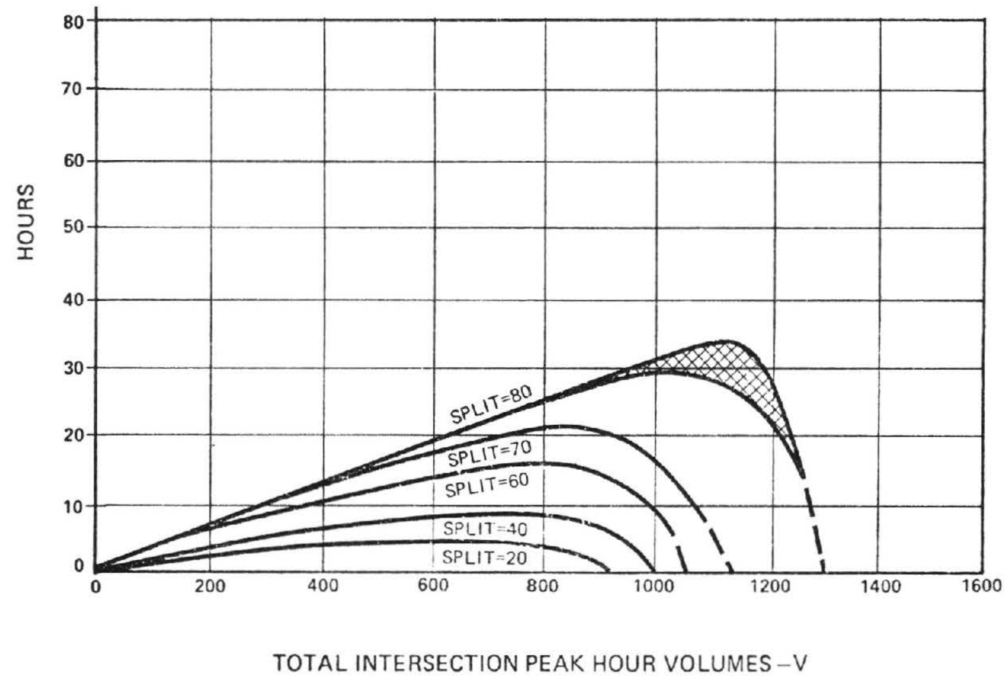


Figure B3-t TRAVEL TIME SAVED PER DAY

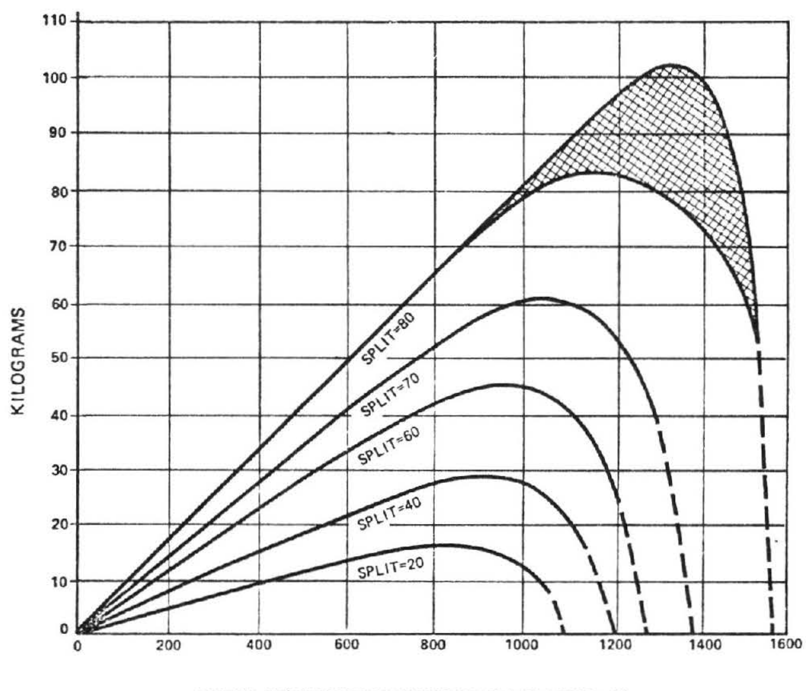


Figure B3-e CO EMISSIONS SAVED PER DAY

INSTRUCTIONS

REPLACING A SIGNAL WITH TWO-WAY STOP SIGN CONTROL

Conditions:

1. Signalized intersection of two, two-way streets.

Assumptions:

1. Average vehicle running speed is 25 mph on both streets. Higher speeds will increase benefits slightly. Lower speeds will reduce benefits slightly.
2. The signal is timing the intersection optimally (best cycle length and splits) under fixed-time, two-phase control. If the timings are not optimal, Improvement Plan H—Improved Signal Timings—should be investigated first.
3. Seven percent trucks assumed. Percentages varying from zero to 15 percent will not alter results significantly.

Required Input:

1. Total peak-hour volume entering the intersection (V).
2. Volume of traffic on major street (street which will not be controlled by stop signs) as a percent of the total intersection traffic (SPLIT).

Procedures:

1. Enter V into Figures C1-f, C1-t, and C1-e.
2. Using curve for appropriate SPLIT, determine fuel, travel time, and CO emission savings. For SPLITs greater than 90, use SPLIT = 90.

Cautions:

1. Note that the dotted lines in Figure C1-f indicate an unreliable area of fuel savings prediction and should be used with caution.

EXAMPLE

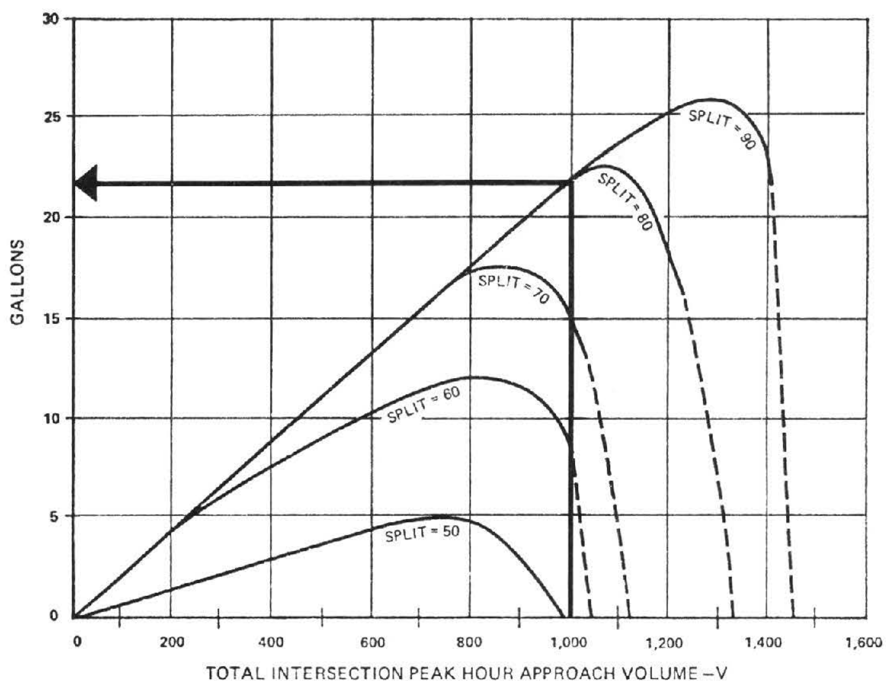
Description: West Broadway in Centralia, Illinois is a minor, four-lane, east-west arterial street serving the downtown area. Its intersection with Chestnut Street is signalized and accommodates approximately 1,000 vehicles during the peak hour, 95 percent of which are on Broadway. Driving speeds are generally low, 15 to 20 mph, due to the local access function of Walnut and an adjacent rough railroad crossing on Broadway.

Input:

V = 1,000 vph
SPLIT = 95

Charts/Graphs Used:

Use Figures C1-f, C1-t, and C1-e for SPLIT of 95 percent (same as 90 percent).



FUEL SAVED PER DAY
Figure C1-f

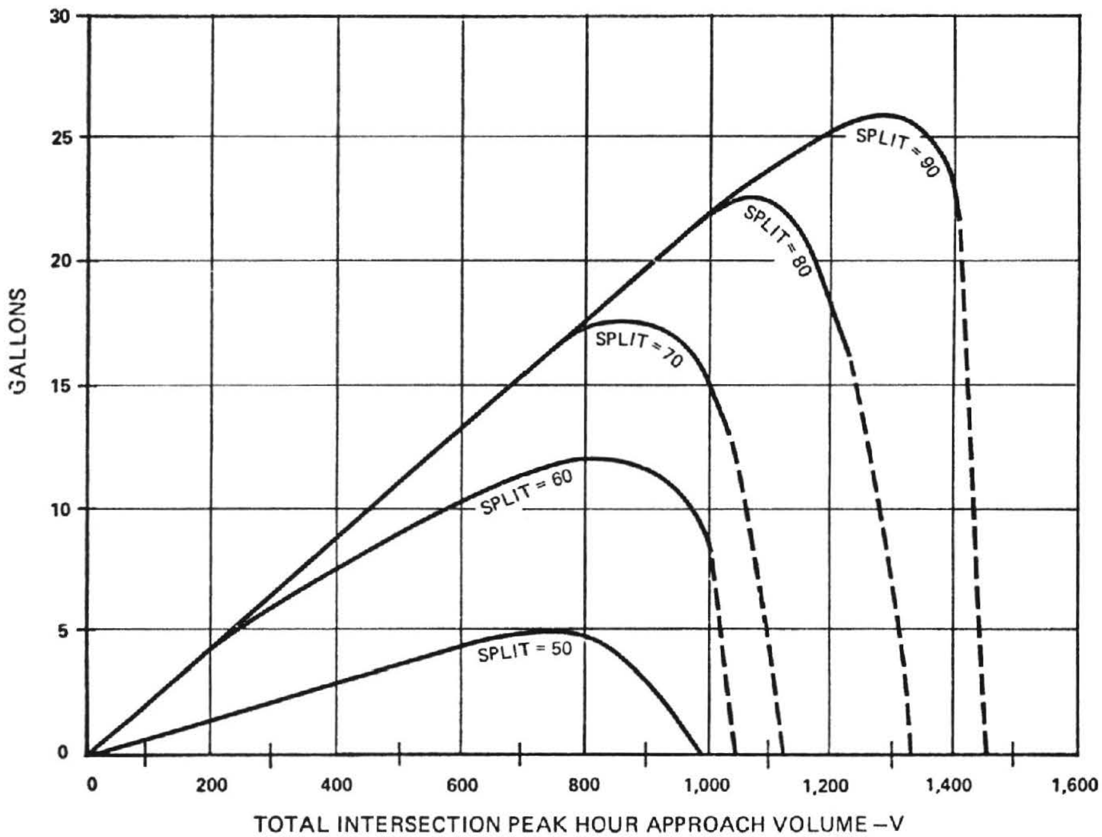
Final Results:

Gallons of Fuel Saved Per Day = 22
Hours of Travel Time Saved Per Day = 3 (from Figure C1-t)
Kilograms of CO Saved Per Day = 12 (from Figure C1-e)

Actual savings will be slightly lower due to lower actual running speed (20 mph) as compared to that which is assumed (25 mph).

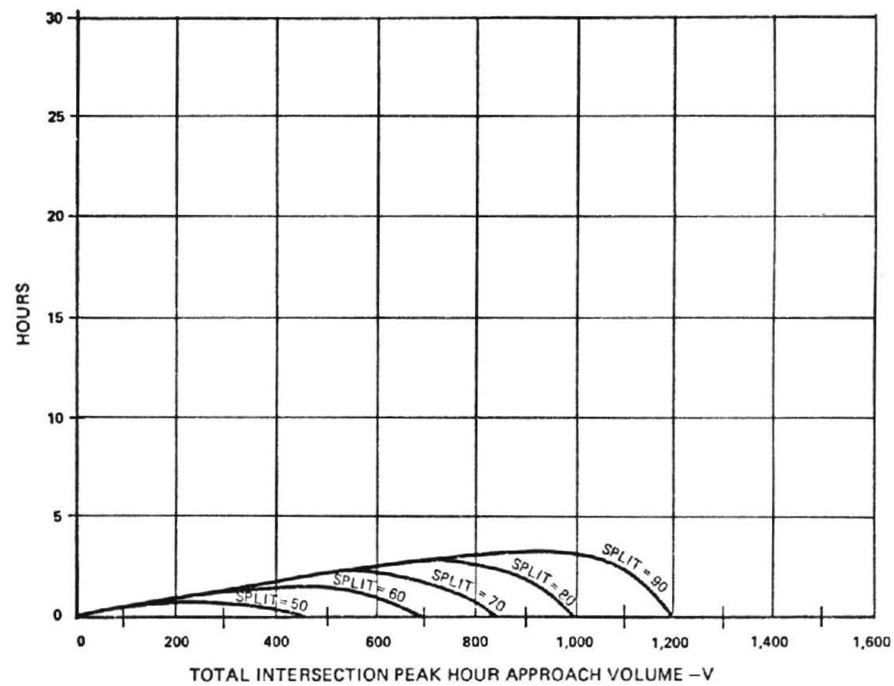
C REPLACE SIGNAL WITH TWO-WAY STOP

1 All Conditions

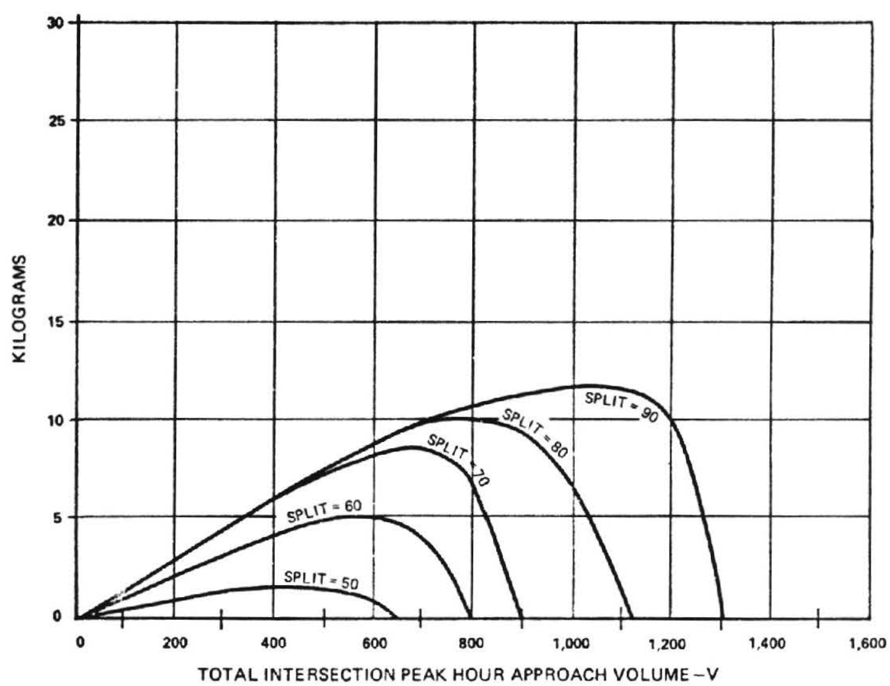


FUEL SAVED PER DAY
Figure C1-f

All Conditions 1



TRAVEL TIME SAVED PER DAY
Figure C1-t



CO EMISSIONS SAVED PER DAY
Figure C1-e

INSTRUCTIONS

REPLACING A FOUR-WAY STOP SIGN WITH A SIGNAL CONTROL

Conditions:

1. Intersection of two, two-way streets, controlled by a four-way stop sign.

Assumptions:

1. Proposed signal is two-phase, fixed-time, with split and cycle length optimally set for peak-hour conditions.
2. Average vehicular running speed is 25 mph. Higher speeds will increase benefits slightly. Lower speeds will reduce benefits slightly.
3. Seven percent trucks assumed. Percentages varying from zero to 15 percent will not alter results significantly.

Required Input:

1. Total volume (V) entering the intersection during the peak hour.
2. Percent of total intersection volume on the major street (SPLIT). For SPLIT greater than 90 percent, use SPLIT = 90.
3. Number of lanes on major and minor street, respectively (2 X 2, 4 X 2, or 4 X 4).

Procedures:

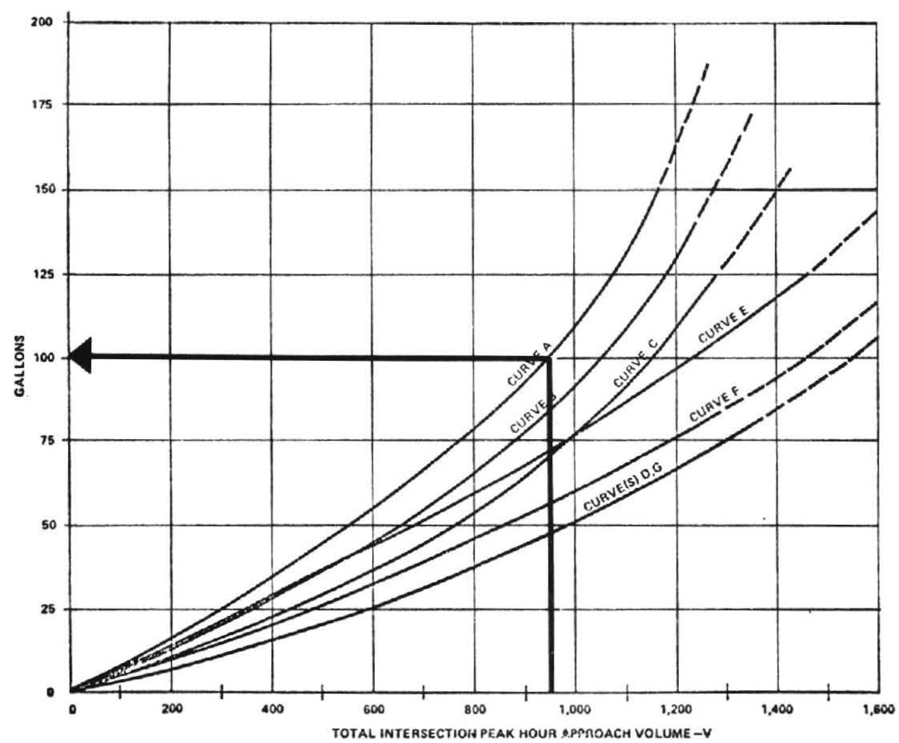
1. For the assumed major street SPLIT and the lane conditions, use Table D1 to determine the appropriate curve (A, B, C, D, E, F, G) to use in Figures D1-f, D1-t, D1-e.
2. Enter V into the figures and, using the appropriate curve, determine fuel, travel time, and CO emission savings.

EXAMPLE

Description: Beckwith Road in Morton Grove, Illinois is a two-lane, minor arterial roadway with four-way stop control at its intersection with Austin Avenue (also a two-lane roadway). Currently, 948 vehicles enter the intersection during the peak hour, 90 percent on Beckwith, the major street. Average driving speeds are 25 to 30 mph on both streets.

Input:
V = 948 vph
SPLIT = 90 percent
Number of Lanes = 2 X 2

Charts/Graphs Used:
Entering 90 percent SPLIT and 2 X 2 intersection into Table D1, curve A is to be used in Figures D1-f, D1-t, and D1-e.

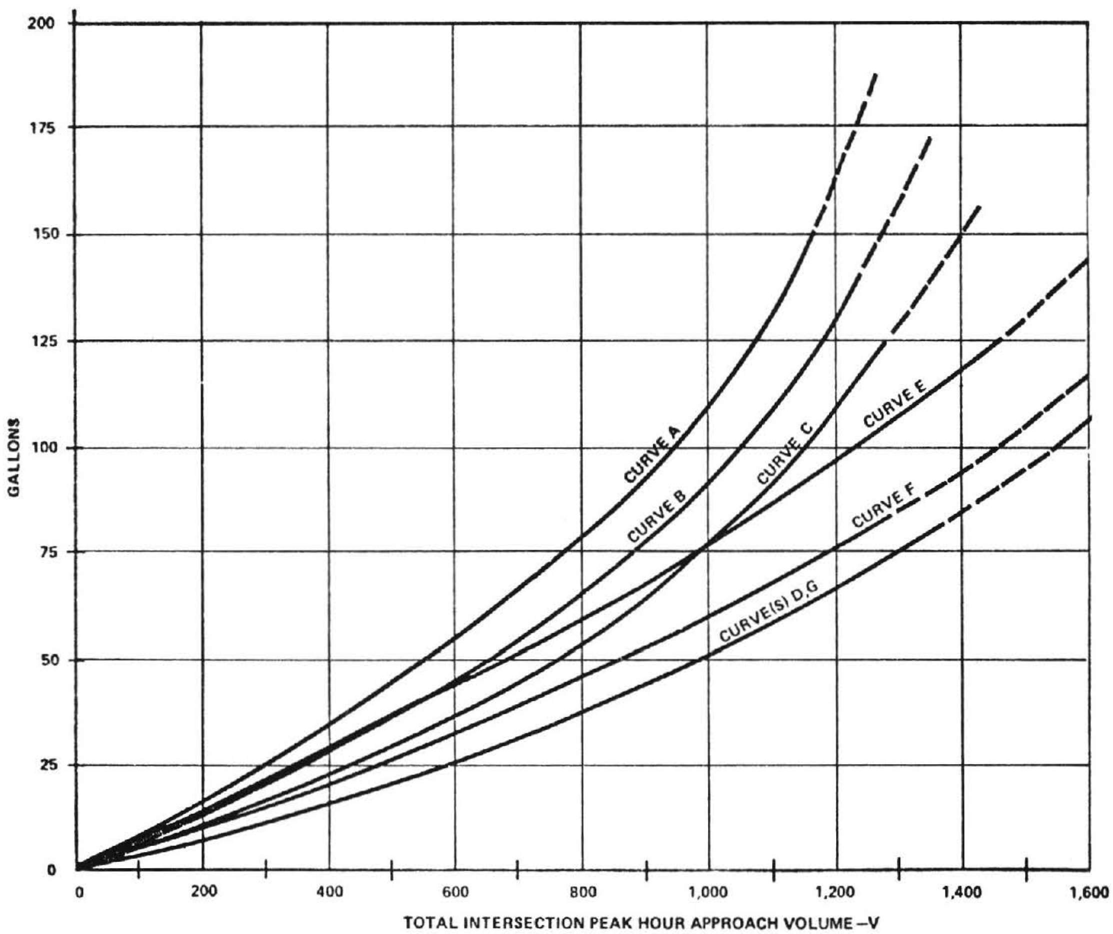


FUEL SAVED PER DAY
Figure D1-f

Final Results:
Gallons of Fuel Saved Per Day = 100
Hours of Travel Time Saved Per Day = 65 (from Figure D1-t)
Kilograms of CO Saved Per Day = 130 (from Figure D1-e)

D REPLACE FOUR-WAY STOP WITH SIGNAL

1 All Conditions



FUEL SAVED PER DAY
Figure D1-f

TABLE D1
IDENTIFICATION OF CURVES FOR USE IN
FIGURES D1-f, D1-t, AND D1-e

	Number of Lanes (Major Street X Minor Street)		
Major Street SPLIT	(2 X 2)	(4 X 2)	(4 X 4)
90	A	A	E
80	B	B	F
70	C	C	G
60	D	D	G
50	D	D	G

All Conditions 1

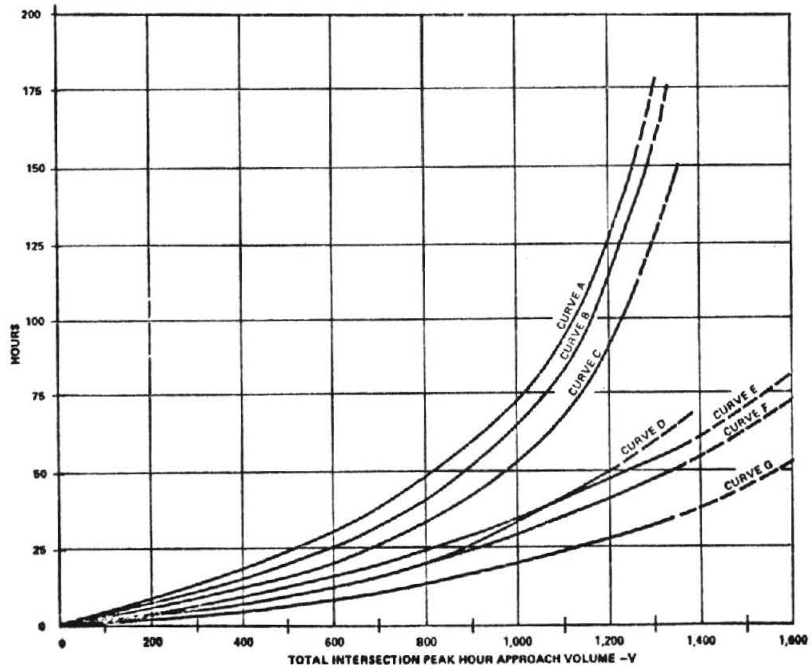


Figure D1-t TRAVEL TIME SAVED PER DAY

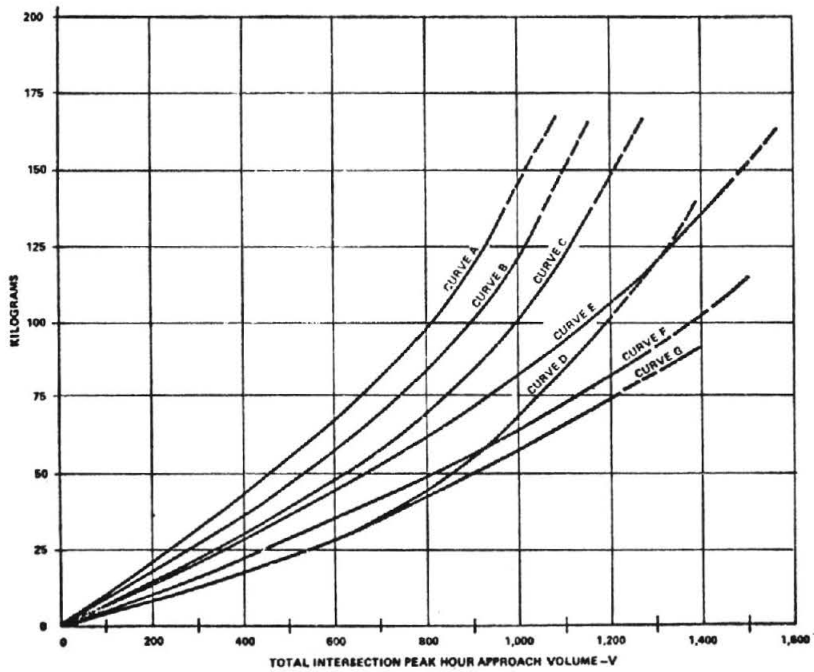


Figure D1-e CO EMISSIONS SAVED PER DAY

E OPERATE OFF-PEAK FLASH

INSTRUCTIONS

OPERATING SIGNAL ON FLASHING YELLOW/RED DURING OFF-PEAK HOURS

Conditions:

1. Signalized intersection of two, two-way streets.

Assumptions:

1. Flashing yellow/red mode is operated for six hours per day. For shorter or longer periods, benefits can be estimated by multiplying results by the actual number of hours of flash operation and dividing by six.
2. Off-peak signal cycle length is less than 100 seconds for a two-phase control.
3. Average vehicular running speed is 25 mph. Higher speeds will produce greater benefits; lower speeds, lower benefits.
4. Seven percent trucks assumed. Percentages ranging from zero to 15 percent will not alter results significantly.

Required Input:

1. Average hourly volume (V) entering the intersection during the period of flashing operation.
2. Volume occurring on street with flashing yellow as a percent of the total intersection volume (SPLIT).

Procedures:

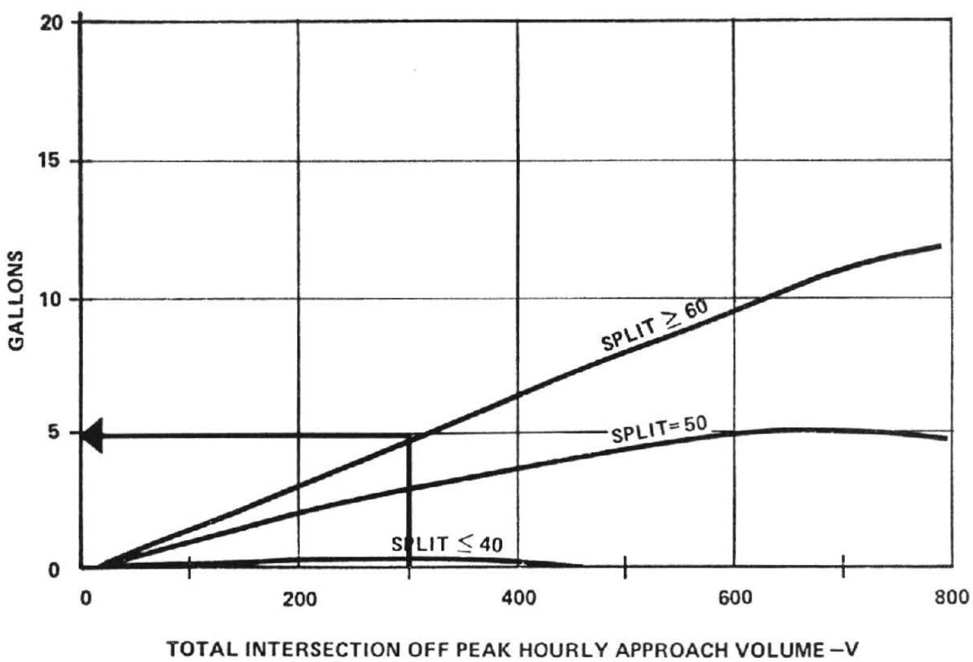
1. Enter V into Figures E1-f, E1-t, and E1-e.
2. Using curve for appropriate SPLIT, determine fuel, travel time, and CO emission savings. For SPLITs greater than 60, use 60; for values less than 40, use 40.

EXAMPLE

Description: Roosevelt Road is a major east-west arterial in the Chicago metropolitan area. At its signalized intersection with Circle Avenue in Forest Park, Illinois, approximately 260 vehicles per hour approach the intersection on Roosevelt and 40 per hour approach on Circle during the midnight to 6:00 A.M. period.

Input: V = 300 vph
SPLIT = 260/300 = 87 percent (use 60)

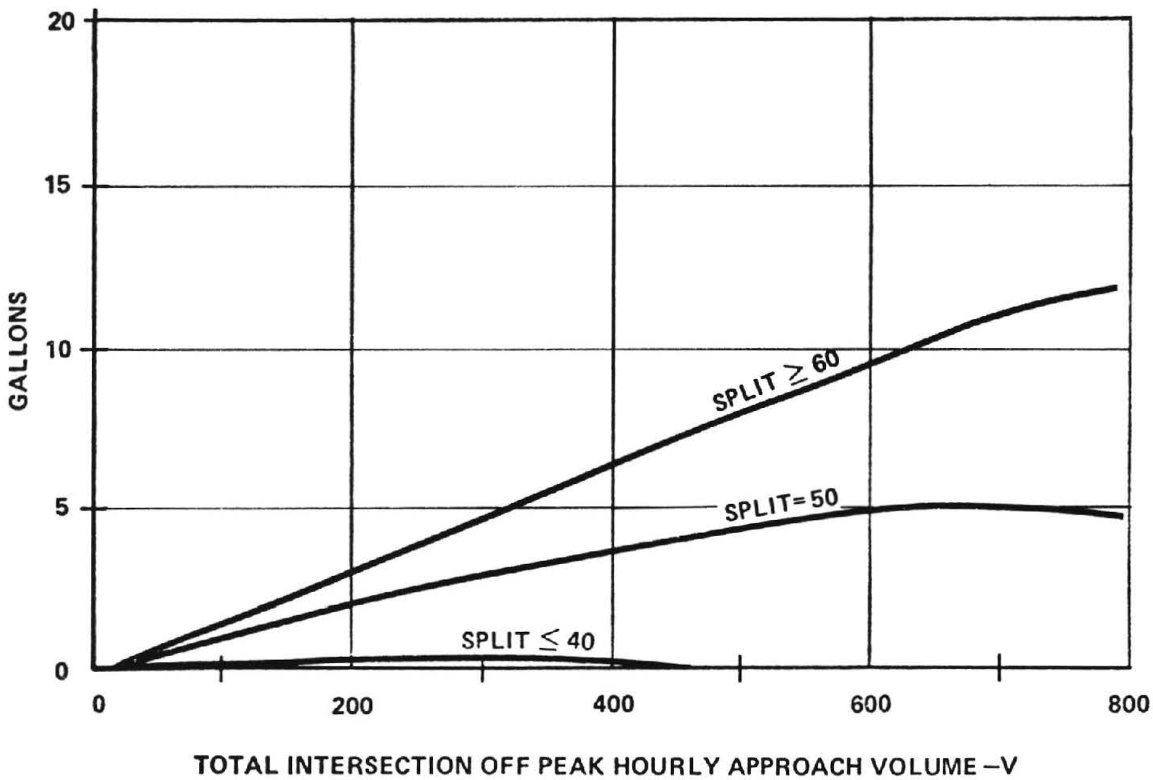
Charts/Graphs Used:
Enter V = 300 into Figures E1-f, E1-t, and E1-e, turning on curve for 60 percent SPLIT.



FUEL SAVED PER DAY
Figure E1-f

Final Results: Gallons of Fuel Saved Per Day = 5
Hours of Travel Time Saved Per Day = 3 (from Figure E1-t)
Kilograms of CO Saved Per Day = 5 (from Figure E1-e)

1 All Conditions



FUEL SAVED PER DAY
Figure E1-f

All Conditions 1

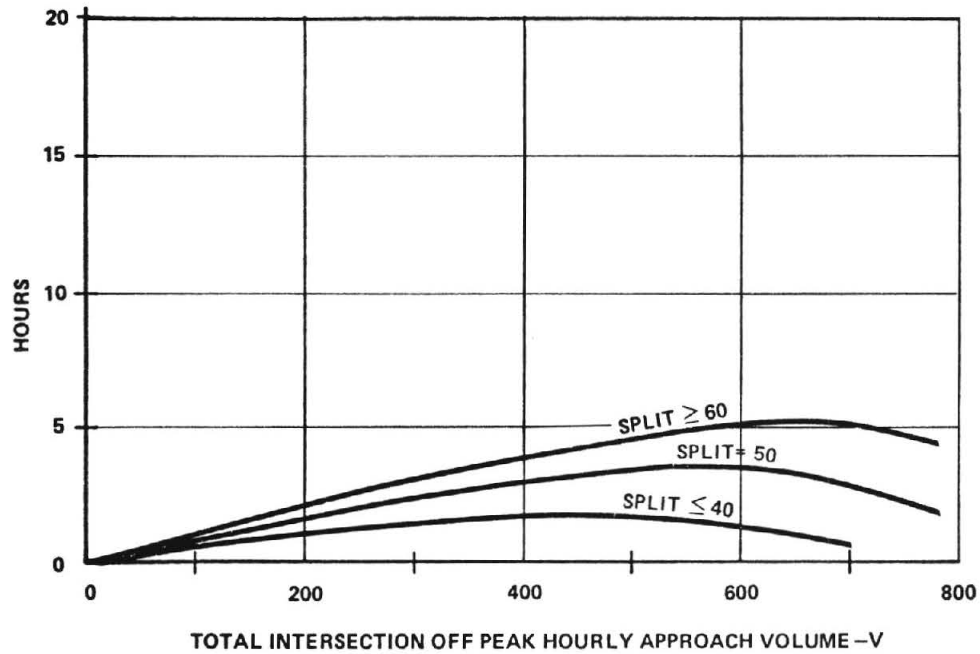


Figure E1-t TRAVEL TIME SAVED PER DAY

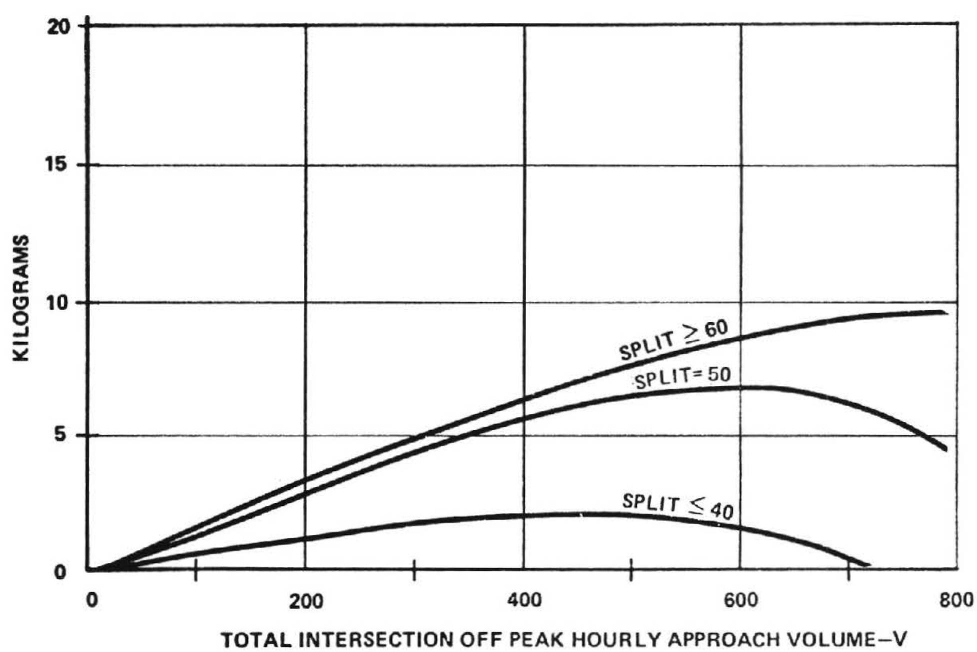


Figure E1-e CO EMISSIONS SAVED PER DAY

INSTRUCTIONS

PROVIDING A PERMISSIVE LEFT-TURN PHASE FOLLOWING AN EXCLUSIVE PHASE

Conditions:

1. Exclusive left-turn lane is provided at a signalized intersection.
2. Under existing conditions, the left-turn movement is opposed by one or two lanes of through traffic and moves only under a green arrow indication.

Assumptions:

1. Benefits analyzed are for the left-turn movement only and do not reflect additional benefits that might be accrued due to the ability to shorten cycle lengths and/or omit phases.
2. Benefits are per approach and, therefore, can be added to benefits calculated for other approaches allowed to operate with permissive lefts.
3. Signal is a single-dial, fixed-time controller. Benefits for demand-responsive equipment may be slightly less.
4. Average vehicular running speed is 25 mph. Higher speeds will produce greater benefits; lower speeds, lower benefits.
5. Seven percent trucks assumed. Percentages ranging from zero to 15 percent will not alter results significantly.

Required Input:

1. The total number of through lanes (both directions) on the street being investigated.
2. Total two-way peak-hour volume (V) for street with left-turn movement being analyzed. This should be the sum of the two approach volumes for the street.
3. Left-turn volume as a percent of its total approach volume (LT).
4. Green time as a percent of total cycle length currently given to the exclusive left-turn movement (GLT/CY).
5. Green time as a percent of total cycle length available for permissive movement under green ball control (GPERM/CY).

Procedures:

1. Select the correct set of figures to use based on the total number of lanes on the street—two-lane roadway uses figures and tables for F1; four-lane roadways use figures and tables for F2.
2. Determine the appropriate curve to use in the figures by entering values of LT, GLT/CY, and GPERM/CY into Table F1 or Table F2.
3. Enter V into the figures and, using appropriate curve (from Step 2), determine fuel, travel time, and CO emission savings.

EXAMPLE

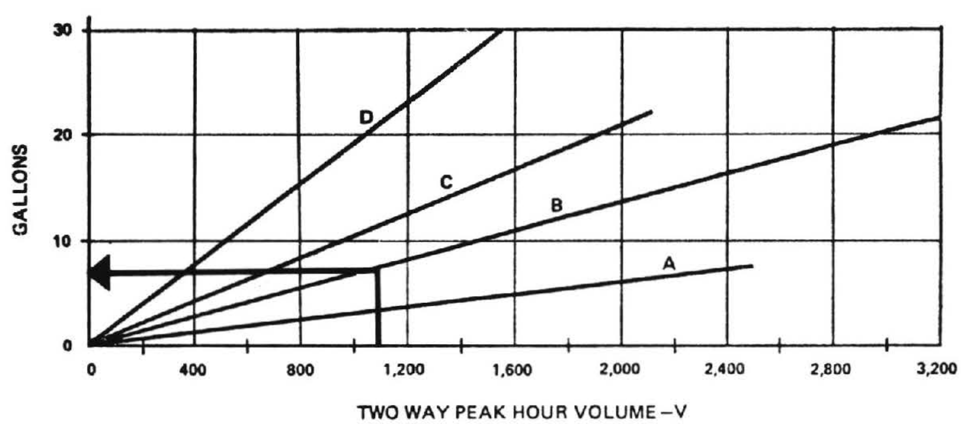
Description: South Dirksen Parkway in Springfield, Illinois is a major four-lane arterial roadway. Exclusive left-turn lanes are provided at its intersection with South Grand Avenue. The left-turn movement on the north operates on an exclusive phase (green arrow) for approximately 35 seconds out of the 100-second cycle. Approximately 20 seconds are available for permissive left-turn movement under the existing phasing sequence. The peak-hour, two-way volume is 1,075 vehicles. The left turn on the north approach represents 40 percent of the approach volume.

Input:
V = 1,075 vph
GLT/CY = 35/100 = 35 percent
GPERM/CY = 20/100 = 20 percent
LT = 40 percent

Charts/Graphs Used:

Since Dirksen is a four-lane roadway, Table F2 and Figures F2-f, F2-t, and F2-e should be used.

For GPERM/CY = 20 percent, GLT/CY = 35 percent, and LT = 40 percent, Table F2 indicates curve B should be used in the figures.

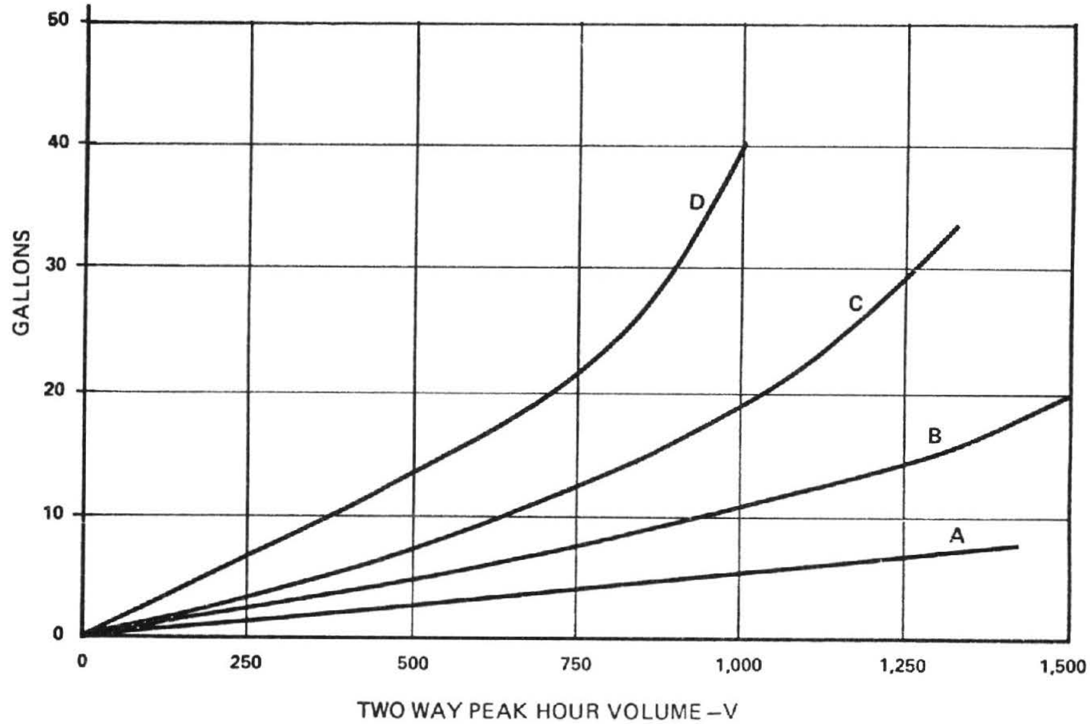


FUEL SAVED PER DAY
Figure F2-f

Final Results:
Gallons of Fuel Saved Per Day = 7
Hours of Travel Time Saved Per Day = 7 (from Figure F2-t)
Kilograms of CO Saved Per Day = 11 (from Figure F2-e)

F ALLOW PERMISSIVE LEFT-TURNS

1 Two-Lane Street



FUEL SAVED PER DAY
Figure F1-f

Table F1
IDENTIFICATION OF CURVES FOR USE IN FIGURES F1-f, F1-t, and F1-e

GPERM/CY	Exclusive Left-Turn Green Phase (GLT/CY)	Curve to Use in Figures for Each Percent of Left Turns (LT) LT = 10 Percent	LT = 20 Percent	LT = 30 Percent	LT = 40 Percent
20%	5%	A	B	C	D
20	10	A	B	B	C
20	15	A	A	B	B
20	25	A	A	A	B
20	35	A	A	A	A
40	5	A	C	C	D
40	10	A	B	C	D
40	15	A	B	B	C
40	25	A	A	A	B
40	35	A	A	A	A
60	5	B	C	C	D
60	10	A	B	C	D
60	15	A	B	C	C
60	25	A	A	B	C
60	35	A	A	A	A

Two-Lane Street 1

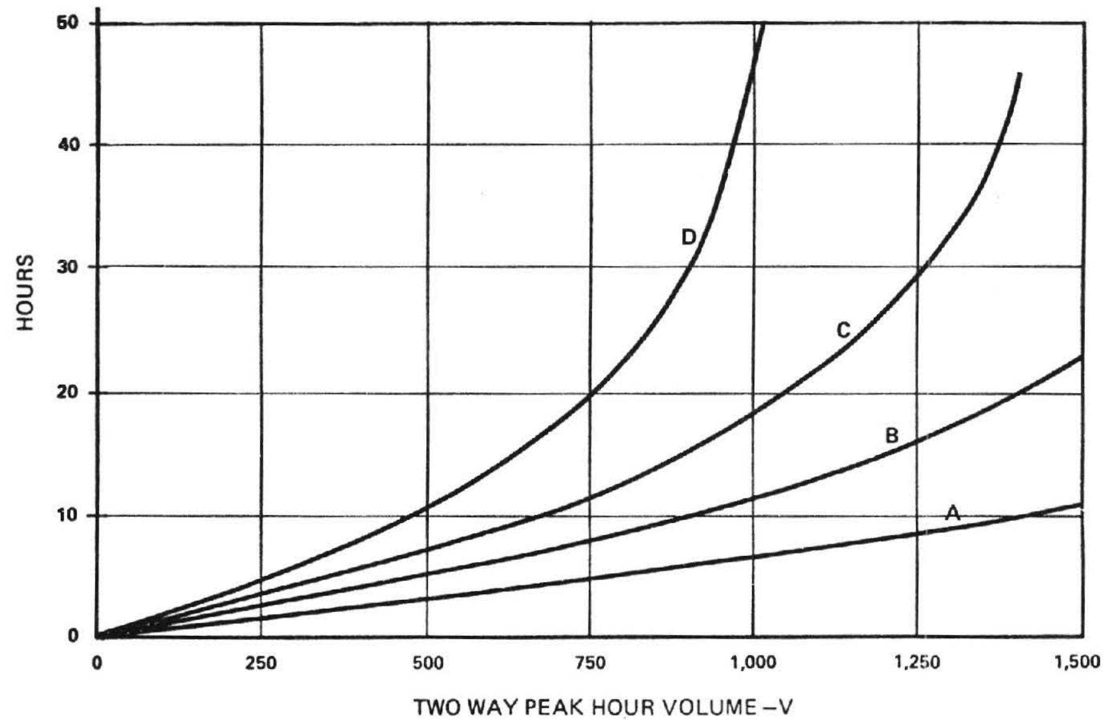


Figure F1-t TRAVEL TIME SAVED PER DAY

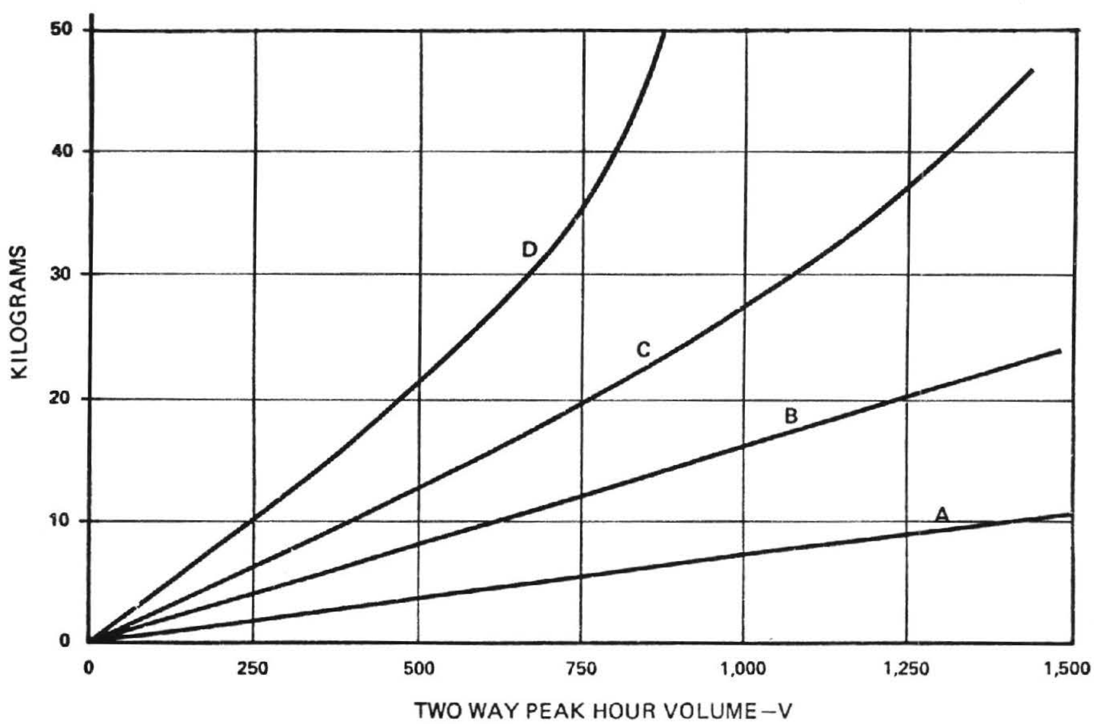
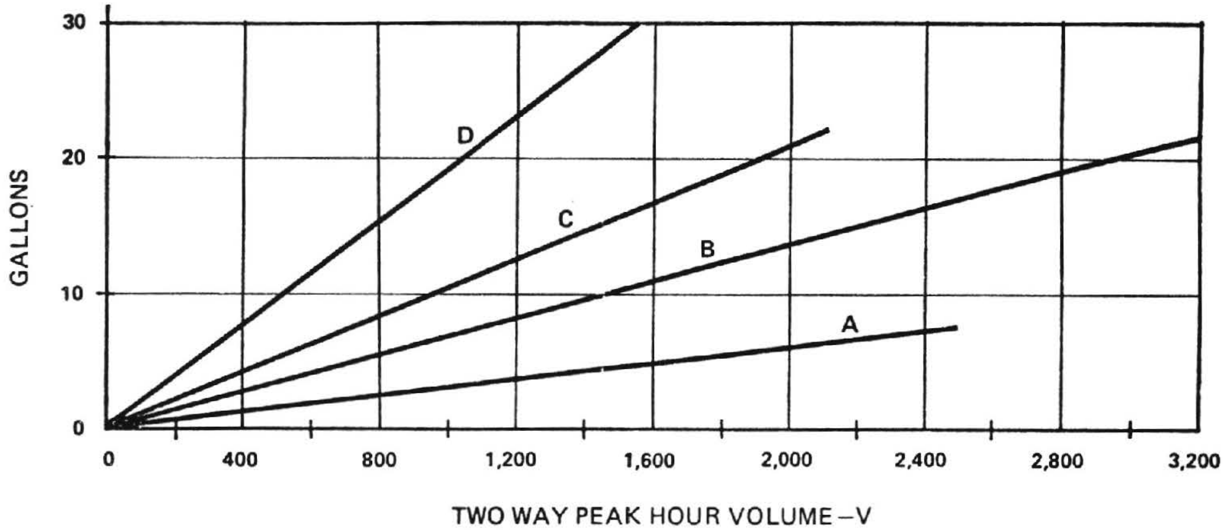


Figure F1-e CO EMISSIONS SAVED PER DAY

2 Four-Lane Street



FUEL SAVED PER DAY
Figure F2-f

Table F2
IDENTIFICATION OF CURVES FOR USE IN FIGURES F2-f, F2-t, and F2-e

		Curve to Use in Figures for Each Percent of Left Turns (LT)			
GPERM/CY	Exclusive Left-Turn Green Phase (GLT/CY)	LT = 10 Percent	LT = 20 Percent	LT = 30 Percent	LT = 40 Percent
20%	5%	B	B	D	D
20	10	B	B	C	D
20	15	A	B	C	C
20	25	A	B	B	C
20	35	A	A	B	B
40	5	B	C	D	D
40	10	A	C	C	D
40	15	A	B	C	C
40	25	A	B	B	B
40	35	A	A	B	B
60	5	B	C	D	D
60	10	B	C	C	D
60	15	A	B	C	D
60	25	A	B	C	C
60	35	A	A	B	B

Four-Lane Street 2

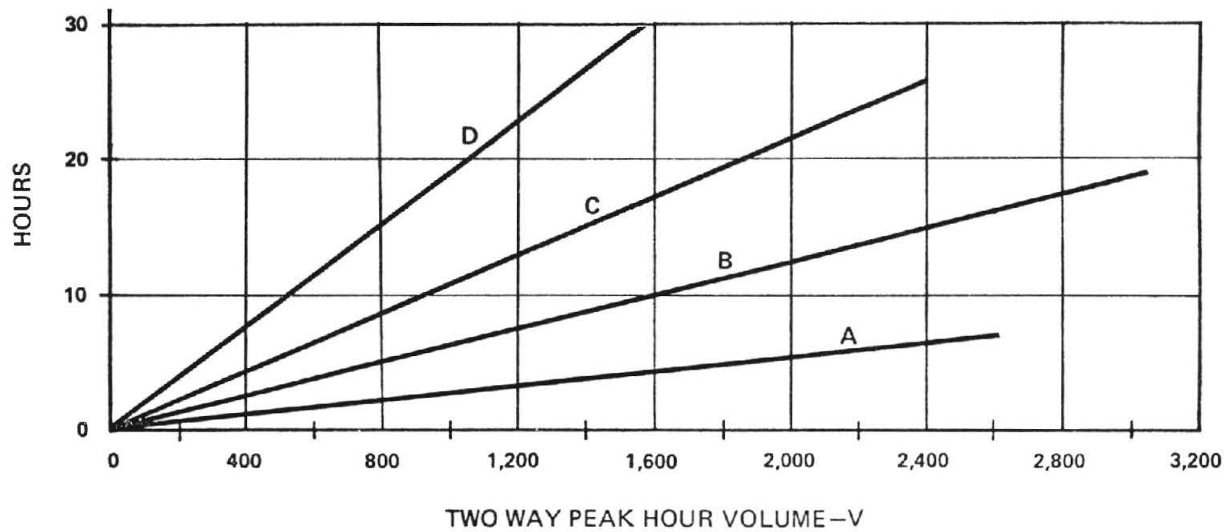


Figure F2-t TRAVEL TIME SAVED PER DAY

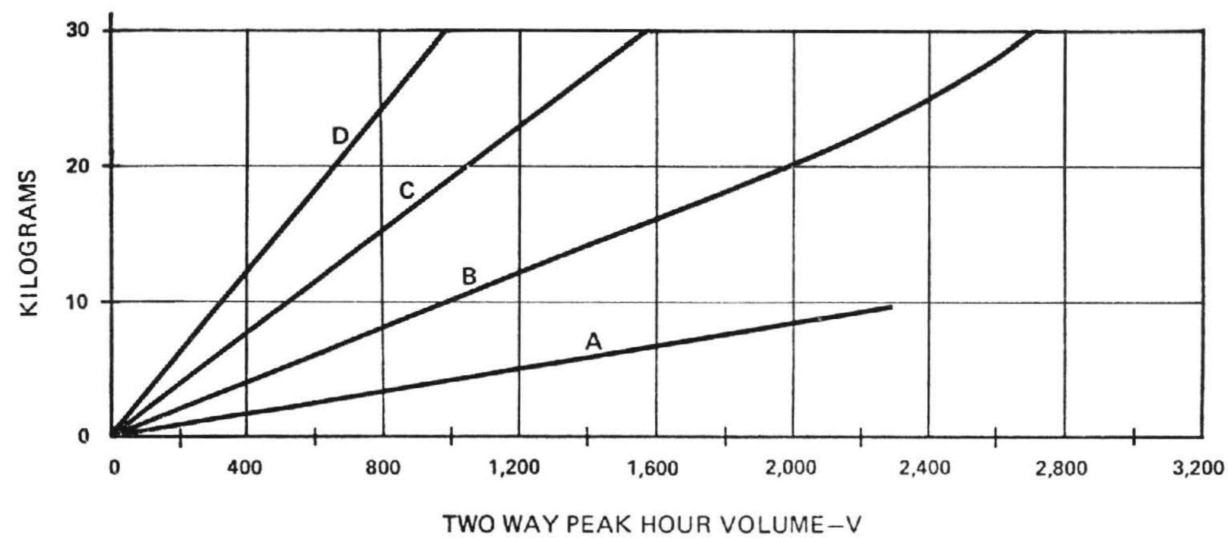


Figure F2-e CO EMISSIONS SAVED PER DAY

G PROVIDE DEMAND-RESPONSIVE TIMING

INSTRUCTIONS

REPLACING FIXED-TIME/SINGLE-DIAL CONTROL WITH DEMAND-RESPONSIVE CONTROL

Conditions:

1. Intersection of two, two-way streets, each having one or two through lanes in each direction.
2. Existing signal control is fixed-time, single-dial, with splits and cycle length optimally timed for peak-hour conditions, but controlling traffic all day long.

Assumptions:

1. Average vehicular running speed is 25 mph. Higher speeds will produce greater benefits; lower speeds, lower benefits.
2. Seven percent trucks assumed. Percentages ranging from zero to 15 percent will not alter results significantly.
3. Proposed control is two-phase with splits and cycle lengths optimally timed for both peak and off-peak conditions. (This may be provided either by activated control or multi-dial operation or both.) Increased benefits may accrue where multiphase demand-responsive equipment is appropriate.
4. The improvement will have its primary effect during the off-peak hours (assumed to exist for 18 hours of the day) due to the ability of the demand-responsive equipment to time optimum cycles and splits during these periods.

Required Input:

1. Total intersection peak-hour approach volume (V).
2. Peak-hour volume on street with heavier traffic as a percent of total peak-hour intersection volume (PKSPLIT).
3. Off-peak hourly volume on street with heavier traffic as a percent of total off-peak intersection volume (OFPKSPLIT).

Procedures:

1. Select the proper set of figures to use, based on the number of lanes on each street (at the intersection)—G1 for 2 X 2, G2 for 4 X 2, or G3 for 4 X 4.
2. Determine the difference between PKSPLIT and OFPKSPLIT. Use the absolute value of this difference as the DIFF value for the curves in the figures. Linear interpolation between the curves can be made as necessary. For DIFF values greater than 40, use the DIFF = 40 curve.
3. Enter V into the figures and, using the curve for the appropriate DIFF value, determine fuel, travel time, and CO emission savings.

EXAMPLE

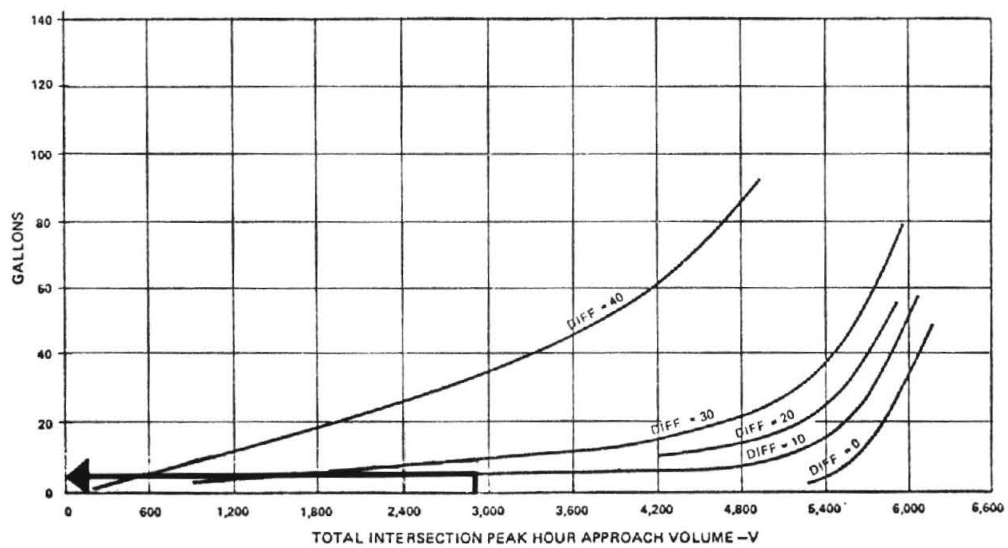
Description: The intersection of Grand Avenue and Lewis Avenue in Waukegan, Illinois is a signalized intersection with a fixed-time, single-dial controller. Both streets are basically four-lane undivided with approximately 2,900 vehicles entering the intersection during the peak hour. Approximately 50 percent of the traffic is on Grand Avenue during the peak hour and 60 percent during the off-peak hours.

Input:
V = 2,900 vph
PKSPLIT = 50 percent
OFPKSPLIT = 60 percent

Charts/Graphs Used:

Since the intersection is four lanes crossing four lanes, use Figures G3-f, G3-t, and G3-e for 4 X 4 condition.

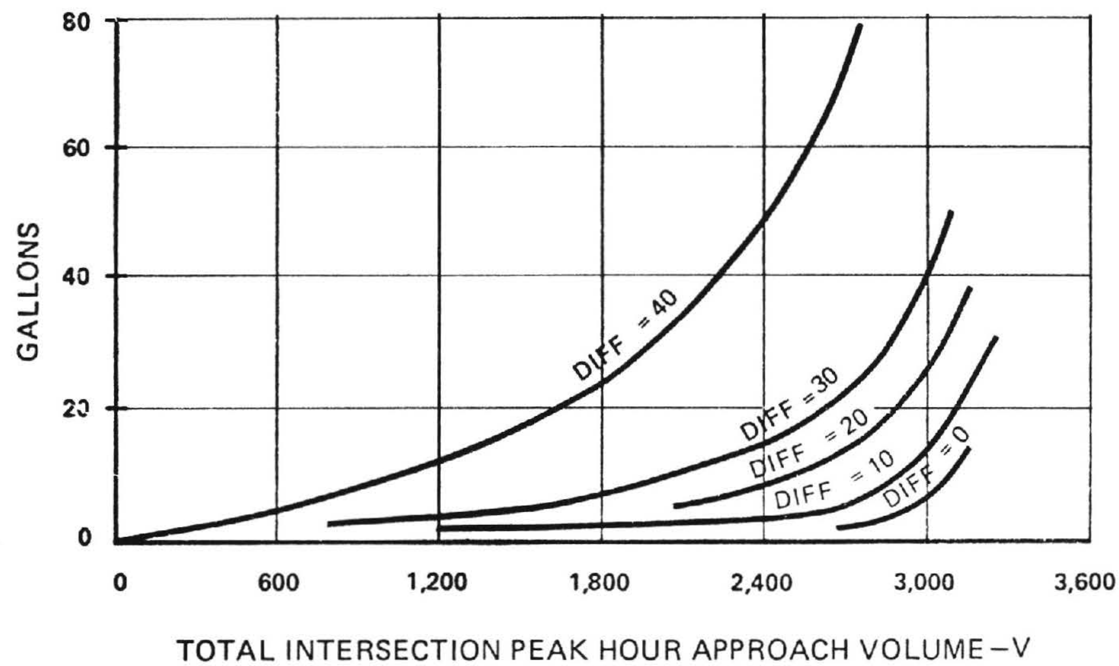
For PKSPLIT = 50 and OFPKSPLIT = 60, DIFF = 10.
Use the curve marked DIFF = 10 in the figures, starting at the point where V = 2,900.



FUEL SAVED PER DAY
Figure G3-f

Final Results:
Gallons of Fuel Saved Per Day = 5
Hours of Travel Time Saved Per Day = 0 (from Figure G3-t)
Kilograms of CO Saved Per Day = 2 (from Figure G3-e)

1 2 X 2 Intersection



FUEL SAVED PER DAY
Figure G1-f

2 X 2 Intersection 1

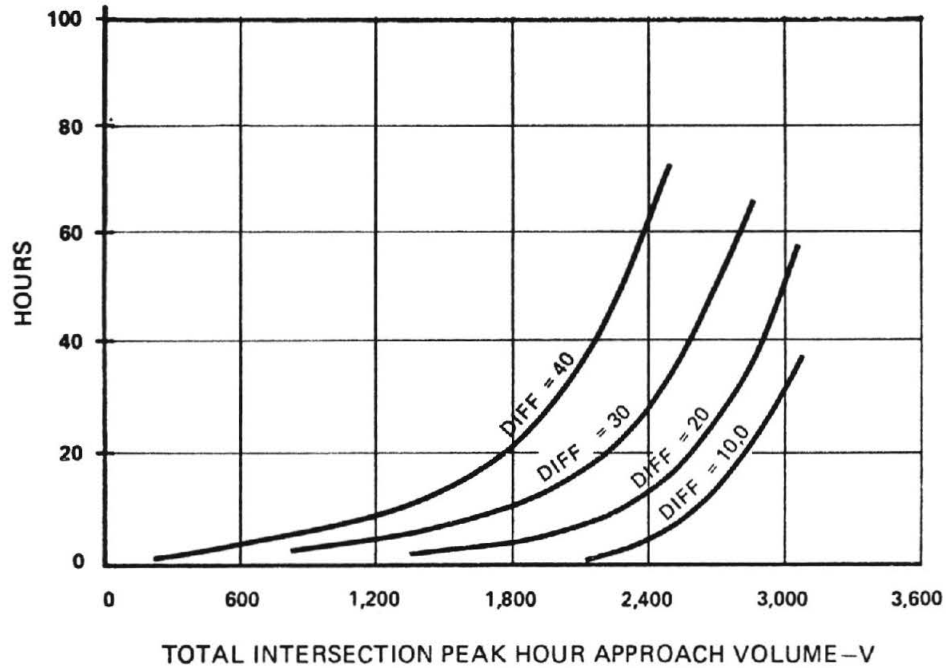


Figure G1-t **TRAVEL TIME SAVED PER DAY**

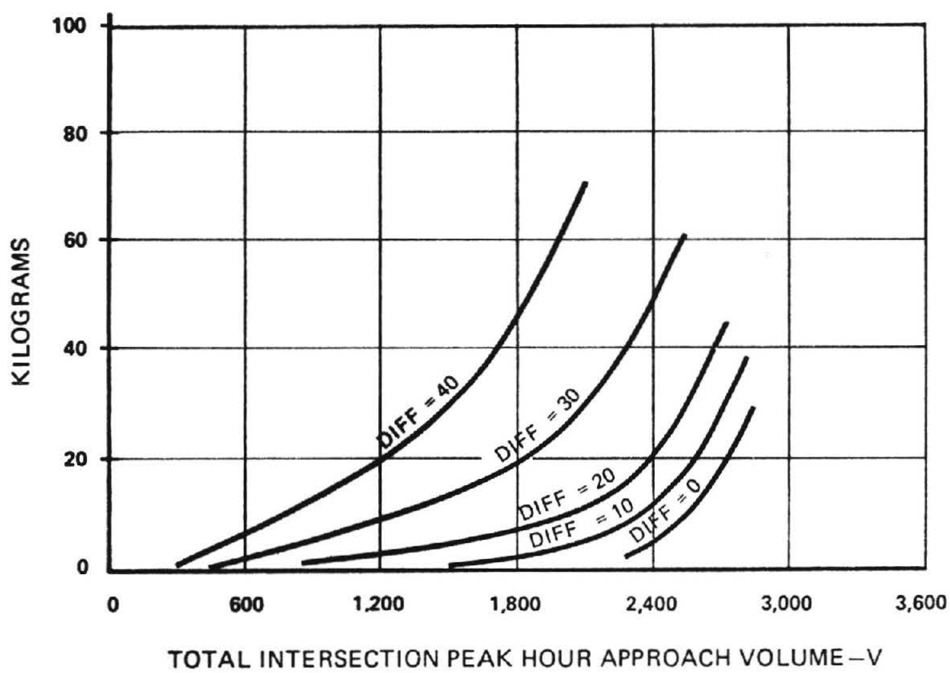
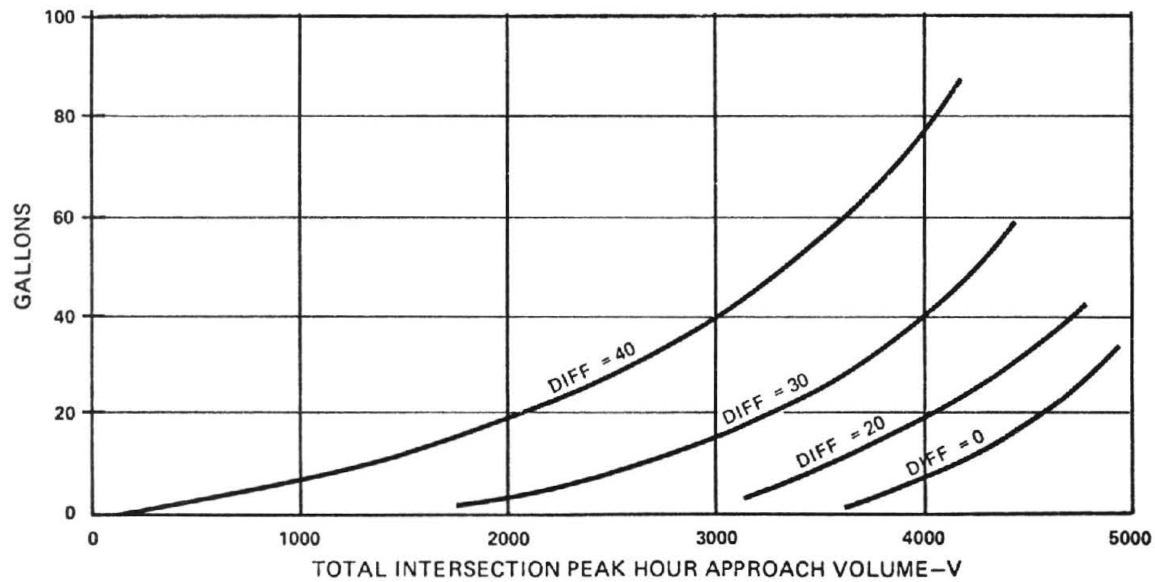


Figure G1-e **CO EMISSIONS SAVED PER DAY**

2 4 X 2 Intersection

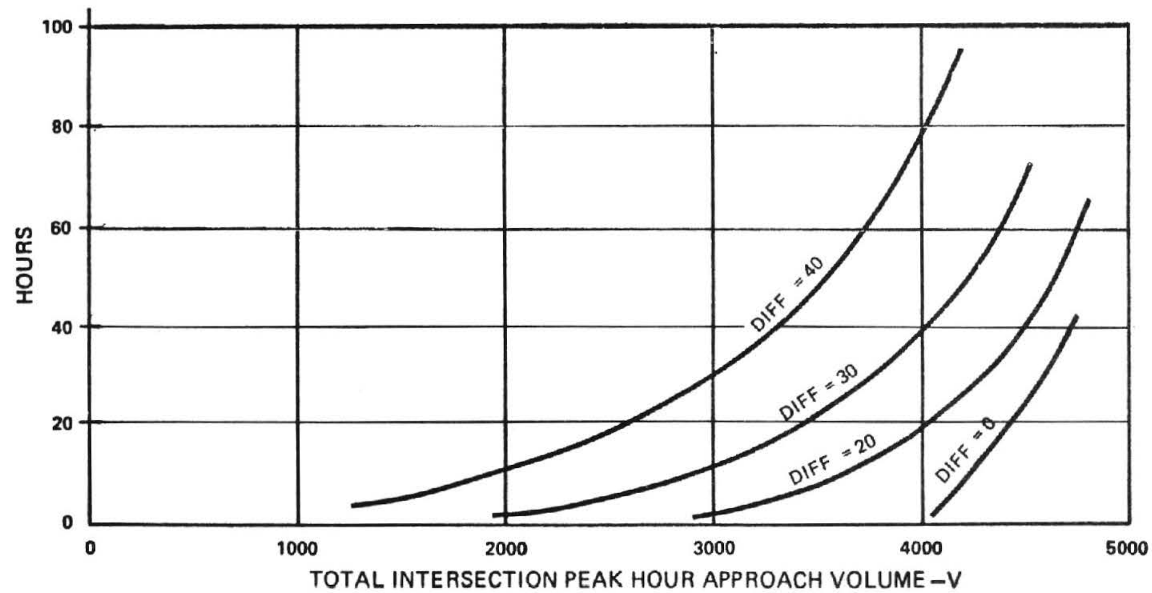


FUEL SAVED PER DAY
Figure G2-f

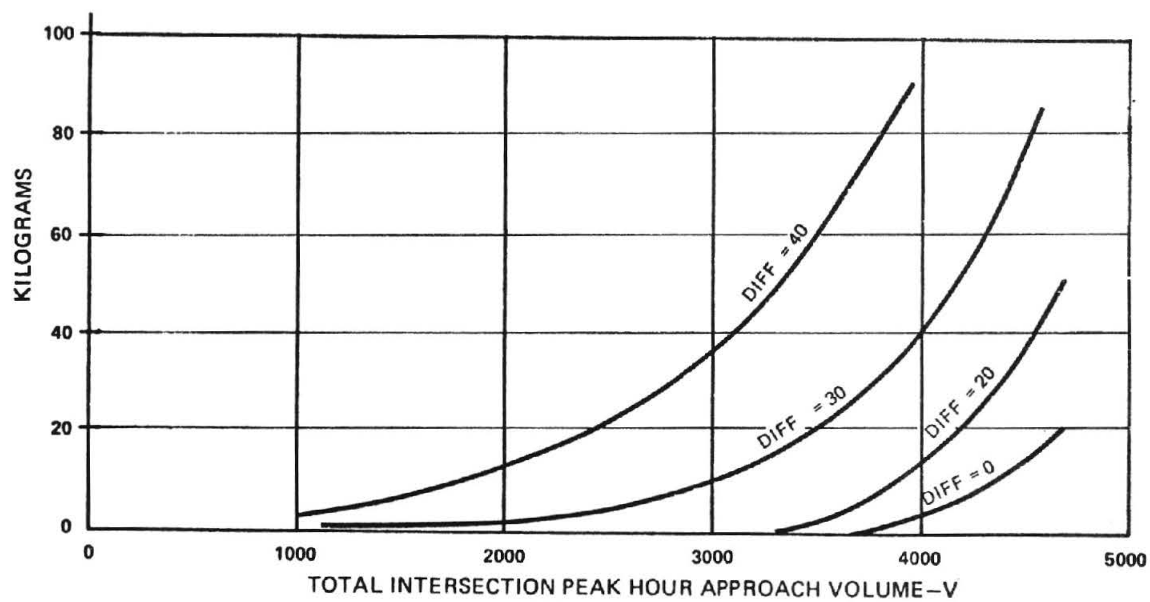
PROVIDE DEMAND-RESPONSIVE TIMING

G

4 X 2 Intersection 2

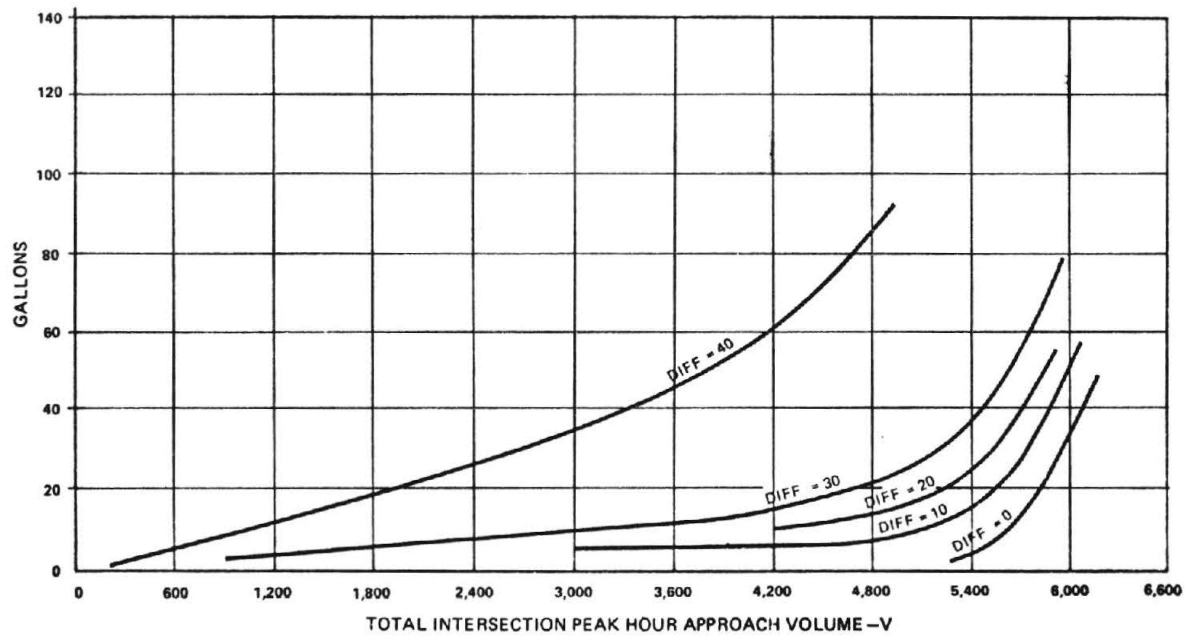


TRAVEL TIME SAVED PER DAY
Figure G2-t



CO EMISSIONS SAVED PER DAY
Figure G2-e

3 4 X 4 Intersection



FUEL SAVED PER DAY
Figure G3-f

4 X 4 Intersection 3

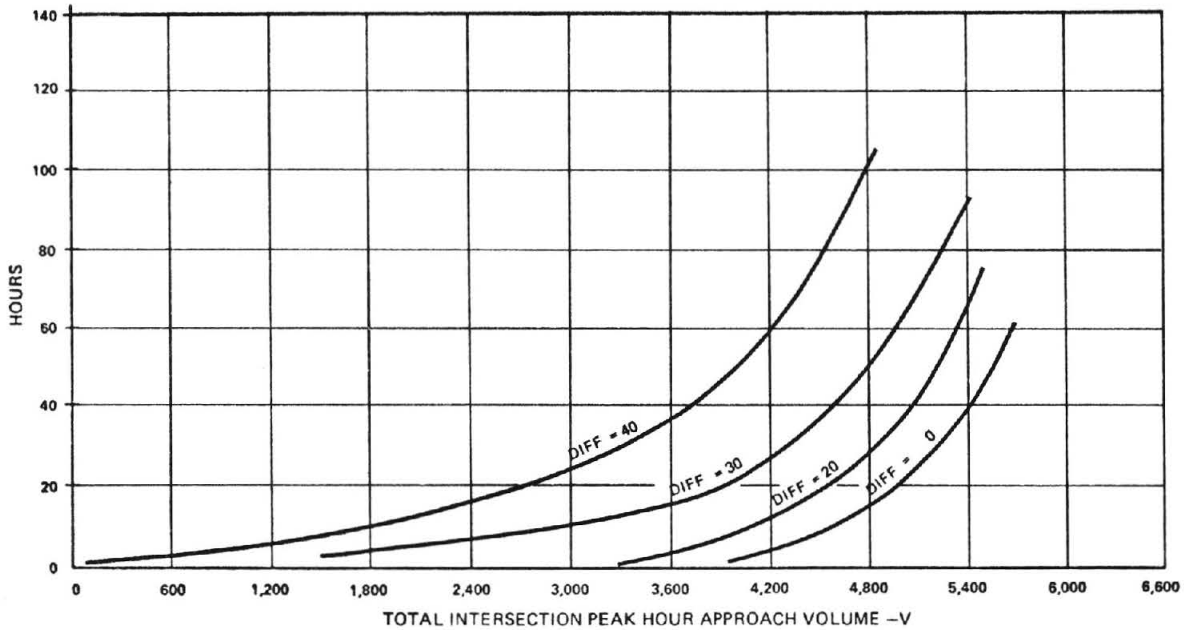


Figure G3-t TRAVEL TIME SAVED PER DAY

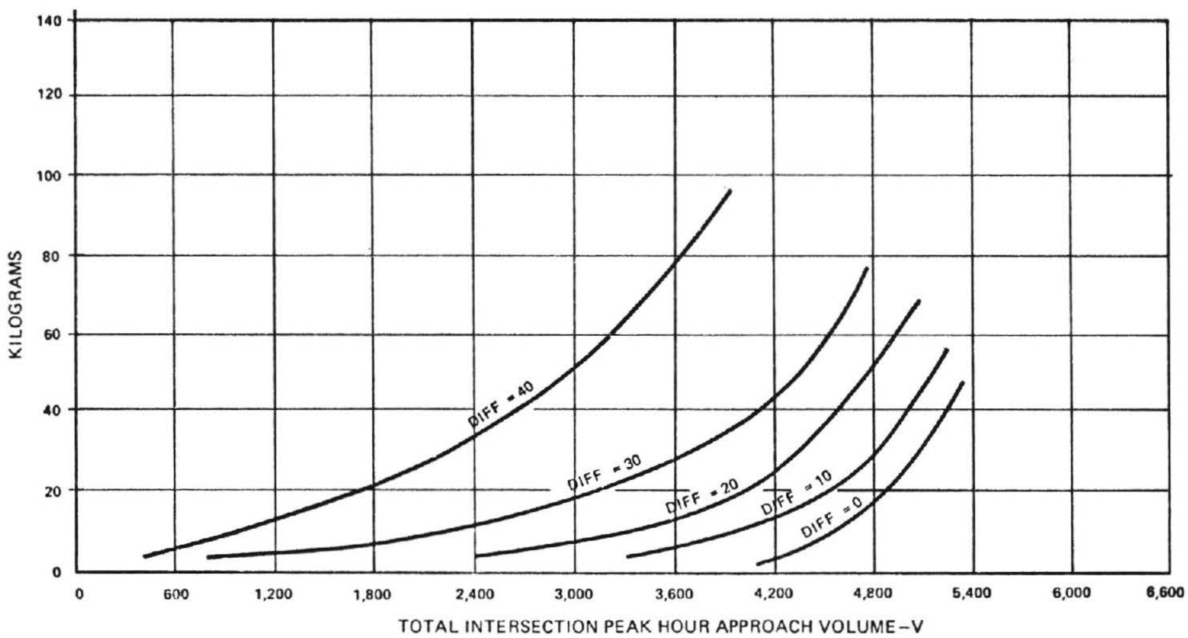


Figure G3-e CO EMISSIONS SAVED PER DAY

INSTRUCTIONS

IMPROVING SIGNAL TIMING AT A SIGNALIZED INTERSECTION

Conditions:

1. Intersection of two, two-way streets, each having two or four through lanes (total of both directions).

Assumptions:

1. Existing and proposed signal control is two-phase. Multiphase operations should not differ significantly from these results unless phases can be omitted.
2. Average vehicular running speed is 25 mph. Higher speeds will produce greater benefits; lower speeds, lower benefits.
3. Seven percent trucks assumed. Percentages ranging from zero to 15 percent will not alter results significantly.
4. It is assumed that pedestrians do not constrain the selection of an optimal cycle length.

Required Input:

1. Total intersection peak-hour approach volume (V).
2. Peak-hour approach volume on street with heavier traffic as a percent of total peak-hour intersection volume (PKSPLIT). (The volume used in the 4 X 2 case should be for the four-lane street.)
3. Cycle length in seconds (CY).
4. Green time provided for street with heavier traffic as a percent of cycle length (GRNSPLIT). (The green time used in the 4 X 2 case should be for the four-lane street.)

Procedures:

1. Select the proper set of figures to use based on the number of lanes on each street (at the intersection)—H1 for 2 X 2, H2 for 4 X 2 and 2 X 4, or H3 for 4 X 4.
2. Determine difference between PKSPLIT and GRNSPLIT. The absolute value of the difference is the DIFF value for the curves in the figures. For DIFF values greater than 20, use the DIFF = 20 curve. For values between zero and 20, interpolation is acceptable.
3. Enter V into the figures. Use the appropriate curve for the values of DIFF and CY to obtain fuel, travel time, and CO emission savings. The analyst can interpolate linearly between the cycle lengths of 150 seconds and 50 seconds. Extrapolation for cycles outside this range is not recommended; use 50 or 150.

Cautions:

1. If pedestrian cross times are a significant factor in the timing of a signal, this procedure may not be accurate. This is due to the fact that the primary benefit is due to use of optimal cycles with only secondary benefits accruing from optimal splits.

EXAMPLES

Description: The intersection of University and Pershing in Decatur, Illinois has a two-phase, semi-actuated control which provides 30 seconds of green time for Pershing out of an average 60-second cycle. The intersection has approximately 1,100 vehicles entering during the peak hour, of which approximately 85 percent are on Pershing. Both streets have two through lanes of traffic (one in each direction).

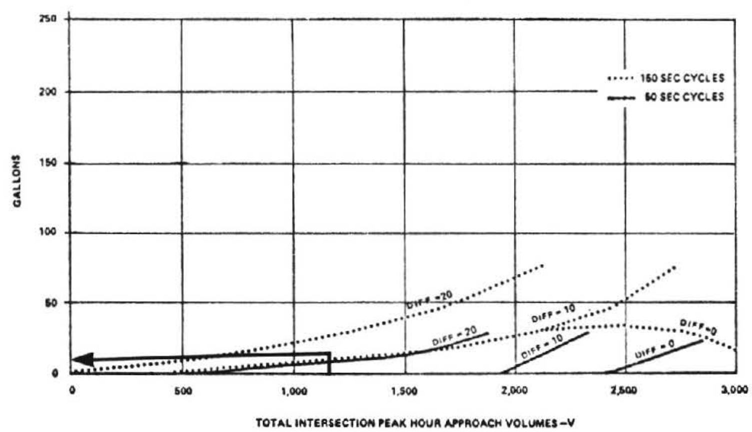
Input:

V = 1,100 vph
PKSPLIT = 85 percent
CY = 60 seconds
GRNSPLIT = 30/60 = 50 percent

Charts/Graphs Used:

Since the intersection is a 2 X 2 type, Figures H1-f, H1-t, and H1-e should be used.

For PKSPLIT = 85 percent and GRNSPLIT = 50 percent, DIFF = 85 - 50 = 35 percent. Use DIFF = 20 in the figures and interpolate between 50-second cycle and 150-second cycle curves.

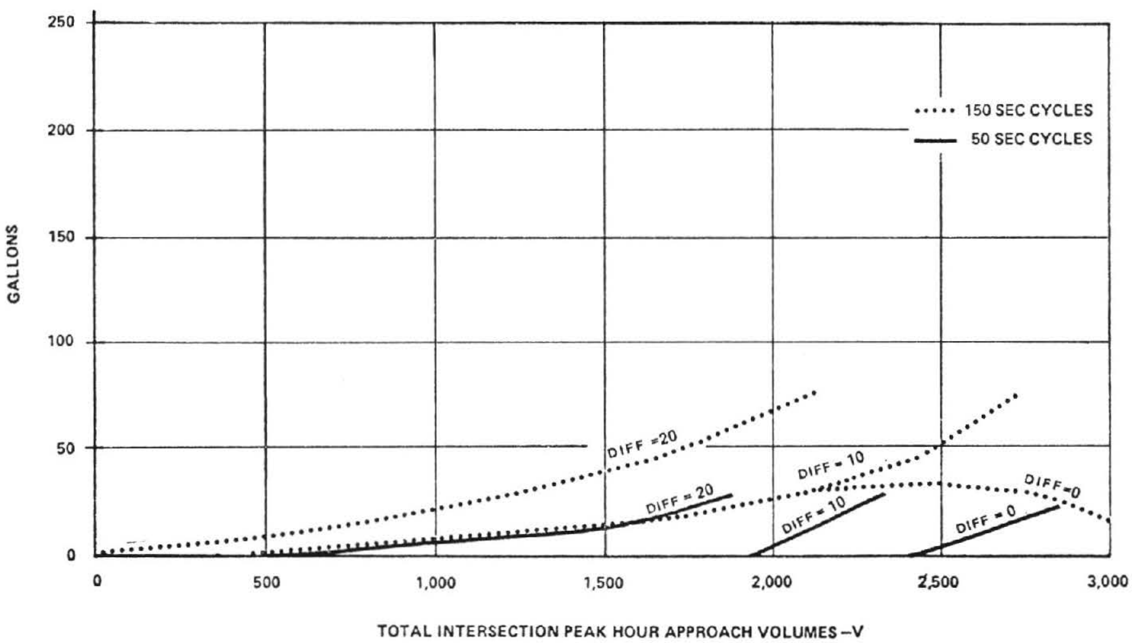


FUEL SAVED PER DAY
Figure H1-f

Final Results:

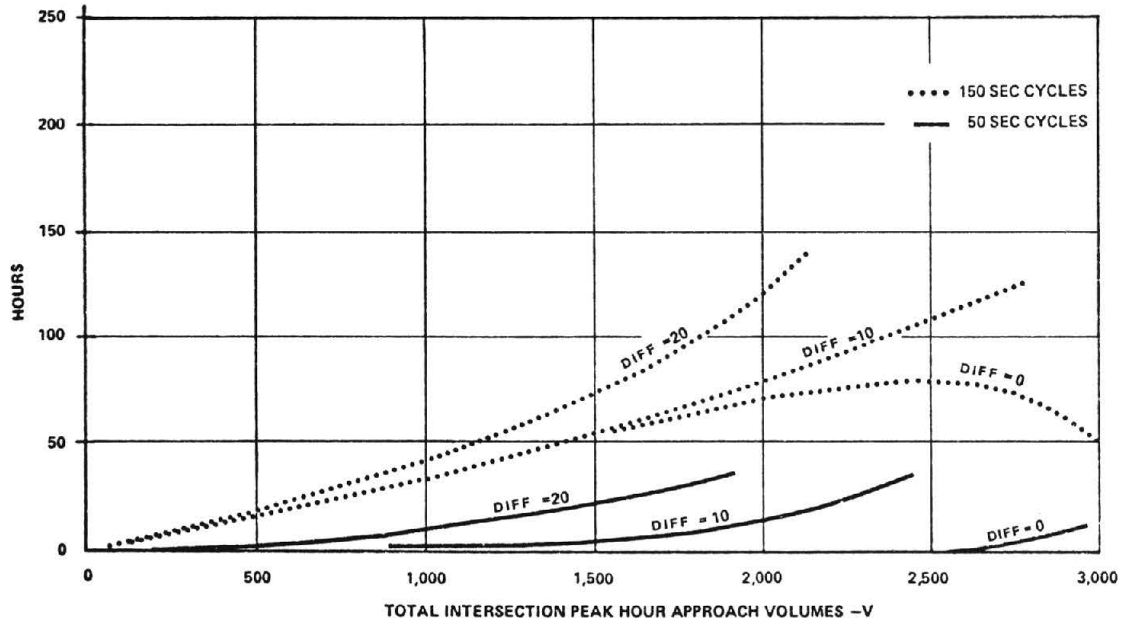
Gallons of Fuel Saved Per Day = 10
Hours of Travel Time Saved Per Day = 15
Kilograms of CO Saved Per Day = 20

1 2 X 2 Intersection

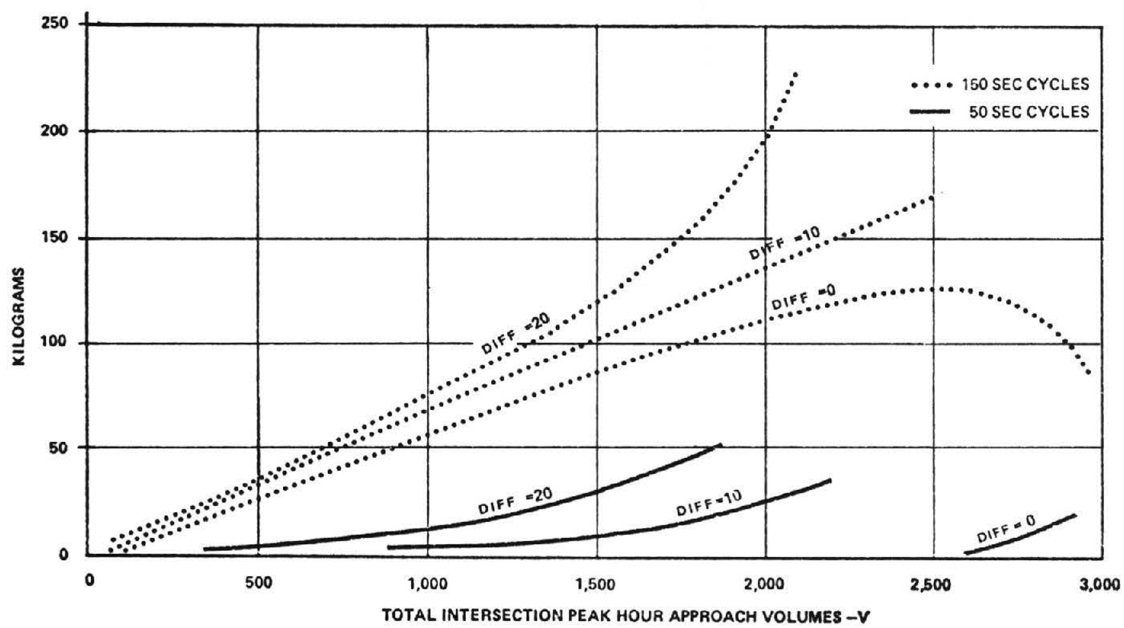


FUEL SAVED PER DAY
Figure H1-f

2 X 2 Intersection 1

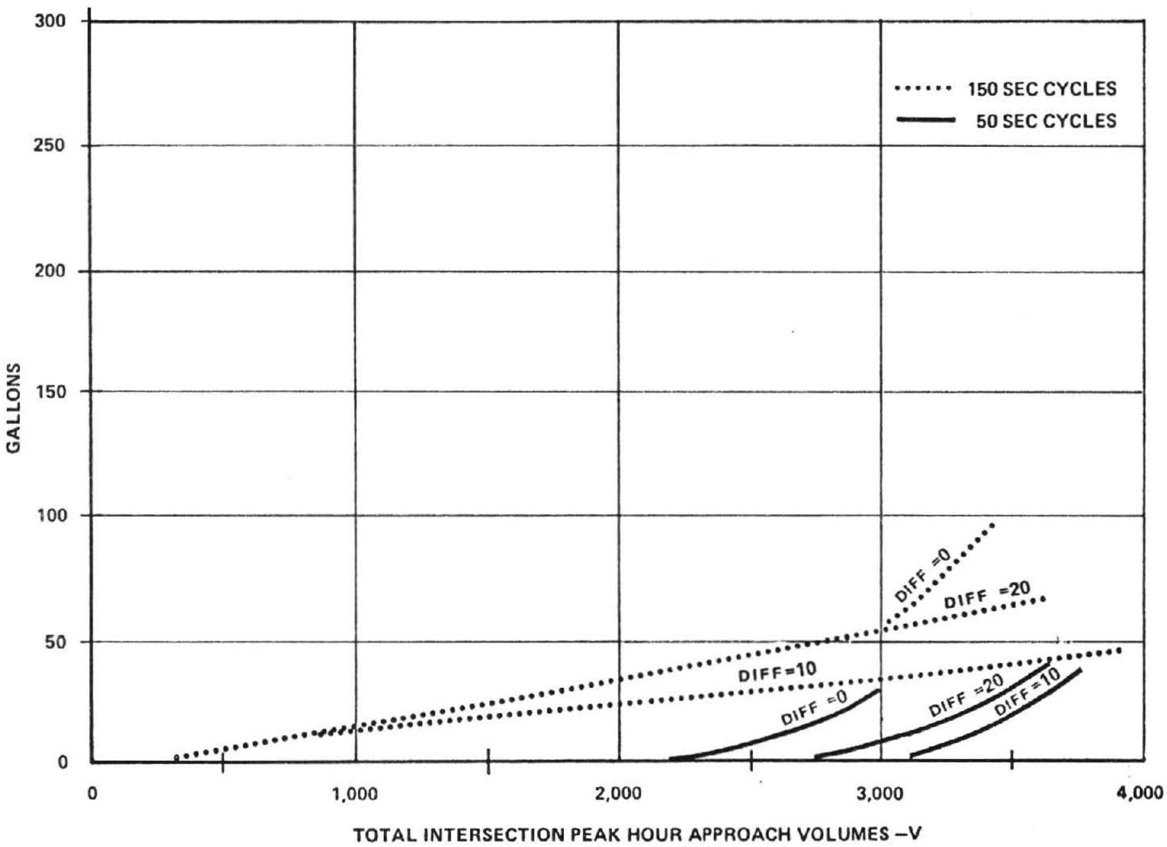


TRAVEL TIME SAVED PER DAY
Figure H1-t



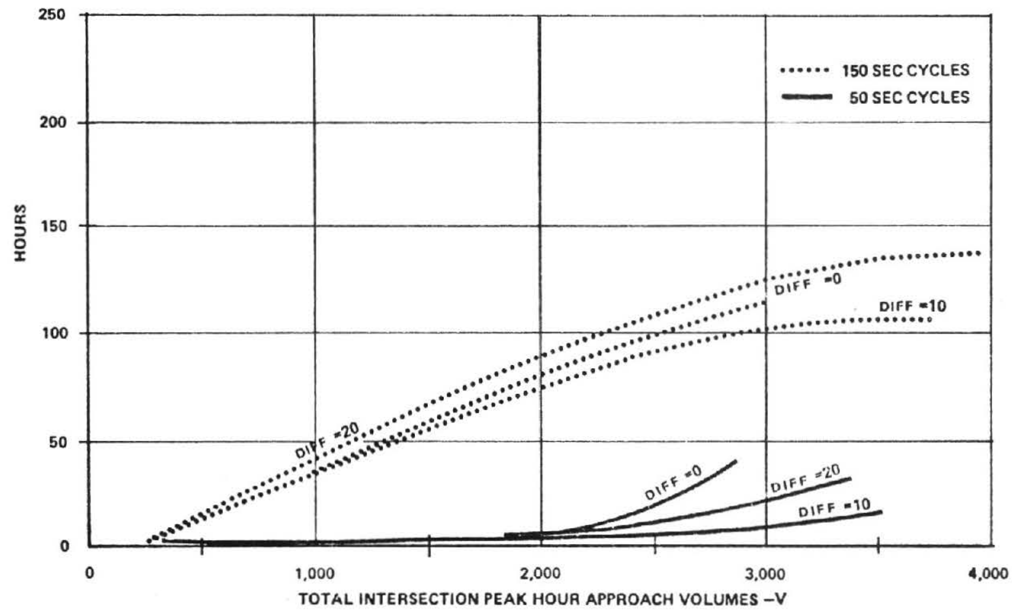
CO EMISSIONS SAVED PER DAY
Figure H1-e

2 4 X 2 Intersection

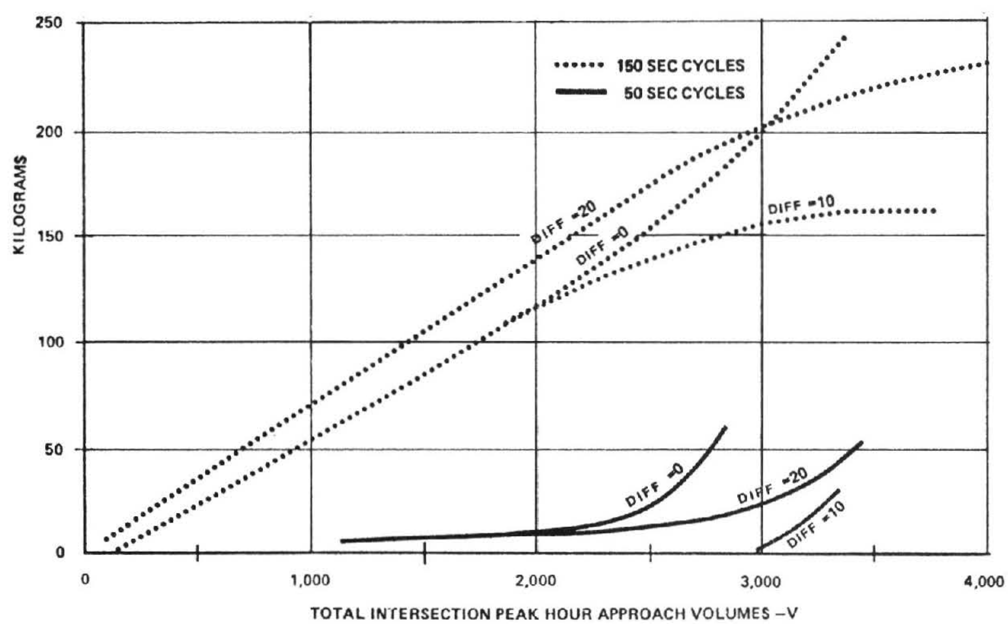


FUEL SAVED PER DAY
Figure H2-f

4 X 2 Intersection 2

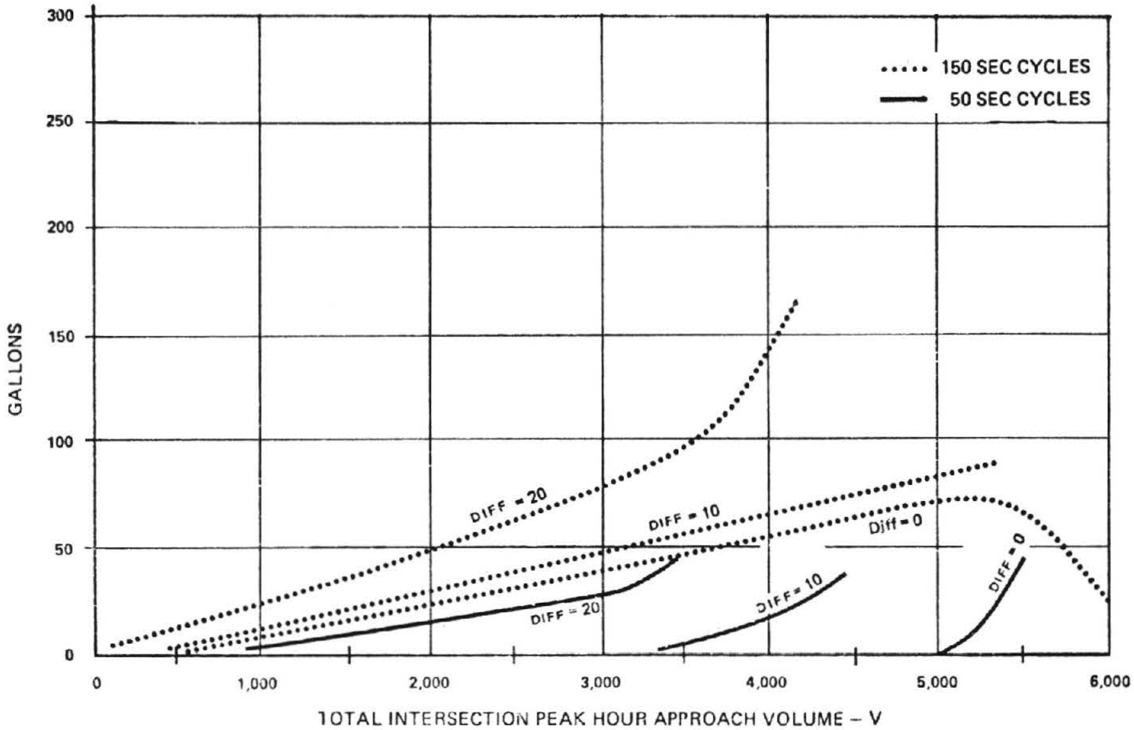


TRAVEL TIME SAVED PER DAY
Figure H2-t



CO EMISSIONS SAVED PER DAY
Figure H2-e

3 4 X 4 Intersection



FUEL SAVED PER DAY
Figure H3-f

4 X 4 Intersection 3

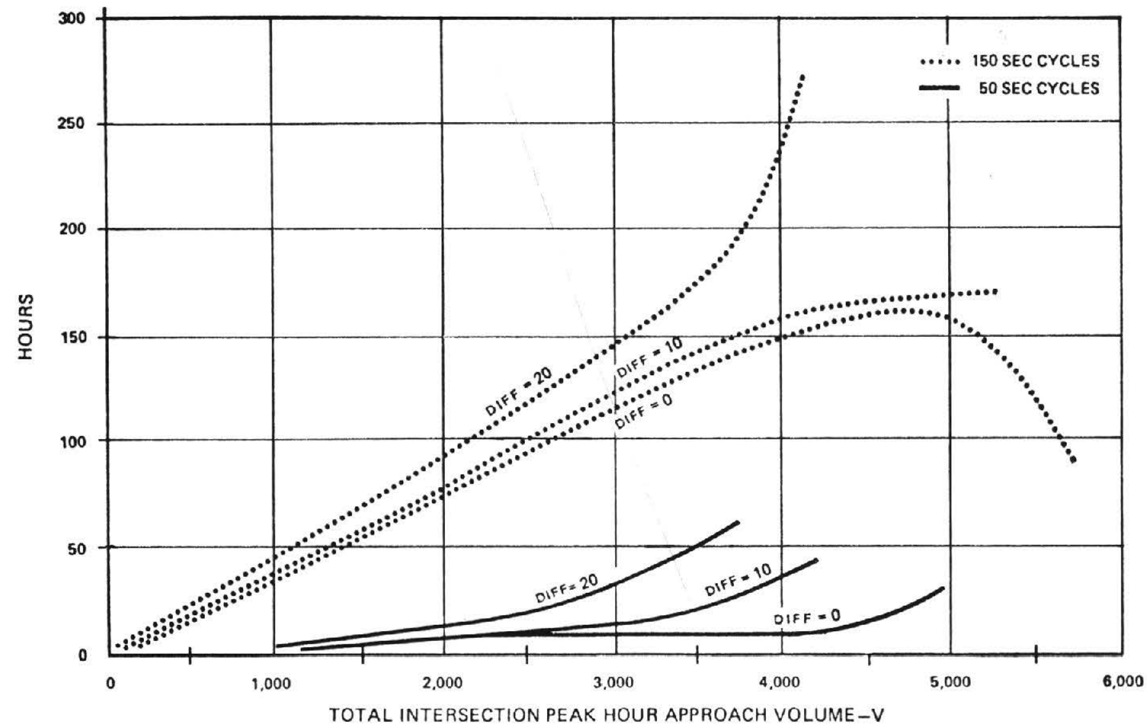


Figure H3-t TRAVEL TIME SAVED PER DAY

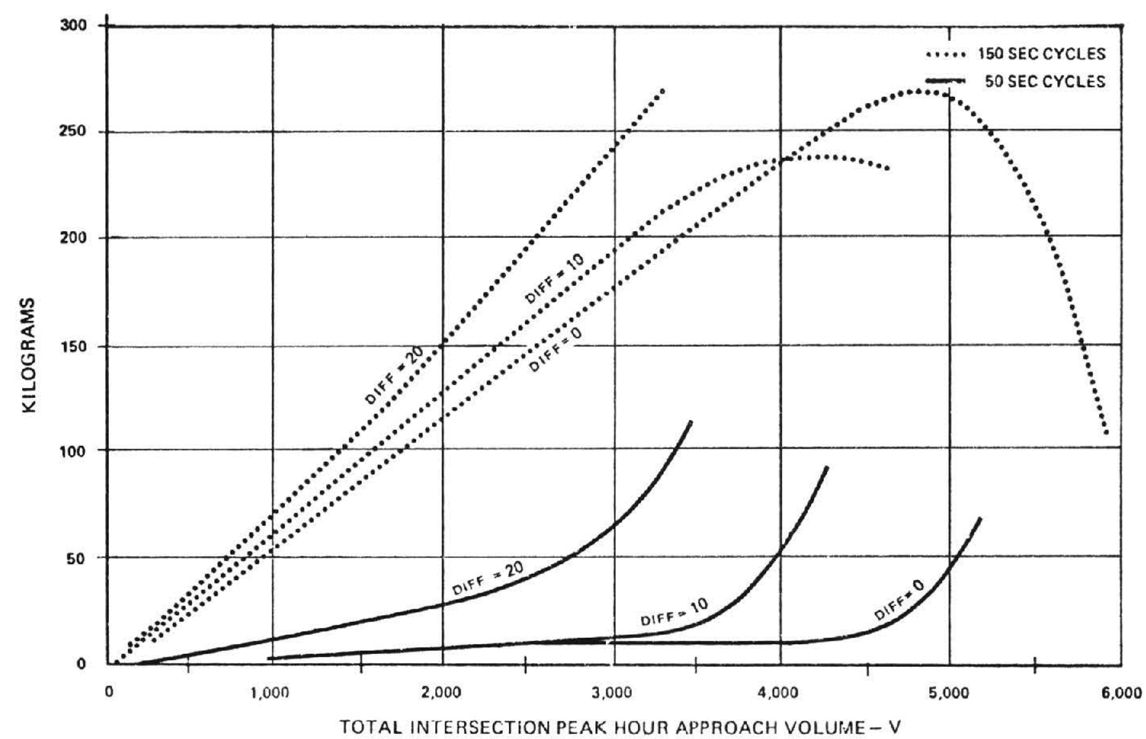


Figure H3-e CO EMISSIONS SAVED PER DAY

INSTRUCTIONS

IMPROVING SIGNAL COORDINATION AT AN INTERSECTION

Conditions:

1. A signalized intersection approach which is currently either isolated (not operating in coordination with any other signals) or coordinated with another signal in an ineffective manner.

2. The signalized intersection to be coordinated has one, two, or three approach lanes (through lanes).

Assumptions:

1. Fifteen percent reductions of delay and stops can be expected by optimal coordination of currently independent signal operations. Reductions of five percent can be expected if system is poorly coordinated at present.

2. Benefits result principally from reduced delay at intersection approaches within the system (mid-block flow conditions are not significantly altered). Total system benefits are estimated as the sum of all of these "coordinated" approach benefits.

3. Signals in the system are primarily two-phase. Multiphase operations may realize slightly lower benefits due to less efficient progression of turning movements.

4. Signal spacing is one-quarter mile or less. Greater spacings will reduce benefits.

5. Average vehicular running speed is 25 mph. Higher speeds will produce greater benefits; lower speeds, lower benefits.

6. Seven percent trucks assumed. Percentages ranging from zero to 15 percent will not alter results significantly.

INSTRUCTIONS

Required Input:

1. Peak-hour approach volume (V).
2. Green time as percent of total cycle length (G/CY) for the coordinated intersection approach.

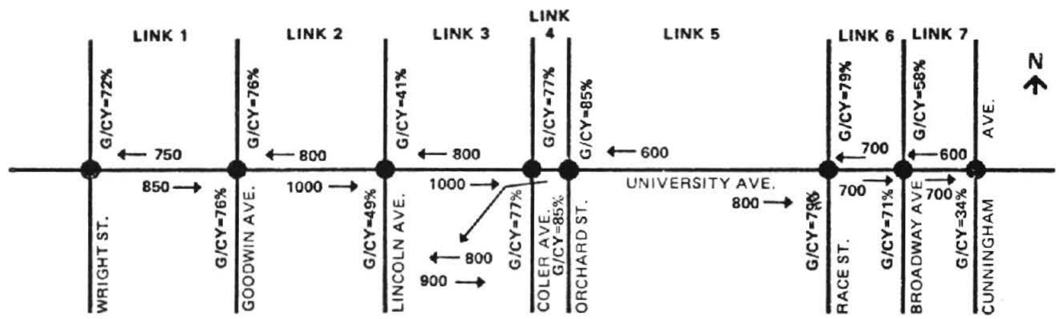
Procedures:

Repeat the following two steps for each intersection approach on each link within the system and sum the results.

1. Select the correct set of figures to use based on the number of lanes on the approach—I1 for one-lane approaches, I2 for two-lane approaches, and I3 for three-lane approaches.
2. Enter V into the selected figures, using the appropriate curve for G/CY to obtain benefits. If the signal associated with the G/CY used is currently coordinated, the scale on the right side of the curve should be used. For uncoordinated signals, use the scale on the left side of the curve.
3. G/CY values between the 20 . . . 50 . . . 80 range can be interpolated between the lines in the graphs. Extrapolation beyond the 20 and 80 limits is not recommended.

EXAMPLE

Description: University Avenue in Urbana, Illinois is a four-lane arterial (two through lanes in each direction). Between Wright Street and Cunningham Avenue, there are eight signalized intersections (existing and proposed). Currently, the signals at Goodwin, Lincoln, and Coler are coordinated as well as those at Broadway and Cunningham. Average driving speeds on University range from 25 to 35 mph. The sketch below summarizes the volumes and green splits for each link along the route.



Input: The input for each link is presented in Table I.

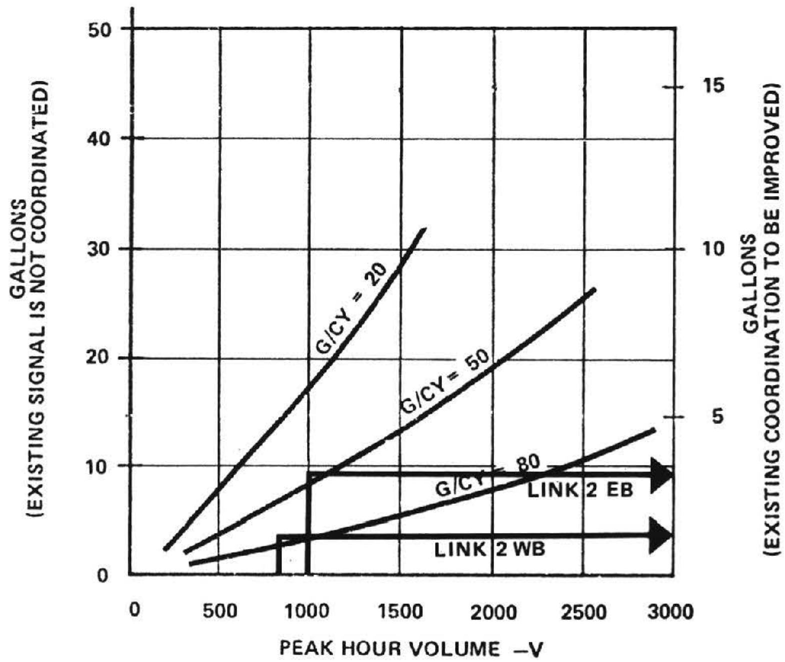
Table I
INPUT AND RESULTS FOR EXAMPLE

Link	Existing Coordination	Peak-Hour Approach Volume	Approach G/CY	Figure I2-f Fuel Benefits (gal/day)	Figure I2-t Travel Time Benefits (hours/day)	Figure I2-e CO Emissions Benefits (kg/day)
1	None	750	WB: 72	3	2	3
		850	EB: 76	3	2	2
2	Poor	800	WB: 76	1	1	1
		1,000	EB: 49	3	2	3
3	Poor	800	WB: 41	3	2	3
		1,000	EB: 77	1	1	1
4	None	800	WB: 77	3	2	2
		900	EB: 85	2	1	1
5	None	600	WB: 85	1	1	1
		800	EB: 79	2	2	2
6	None	700	WB: 79	2	1	2
		700	EB: 71	3	2	3
7	Poor	600	WB: 58	1	1	1
		700	EB: 34	3	2	3
			Total:	31	22	28

EXAMPLE

Charts/Graphs Used:

For a four-lane roadway (two approach lanes), Figures I2-f, I2-t, and I2-e should be used.



FUEL SAVED PER DAY
Figure I 2-f

Intermediate Results/Calculations: (Link 2)

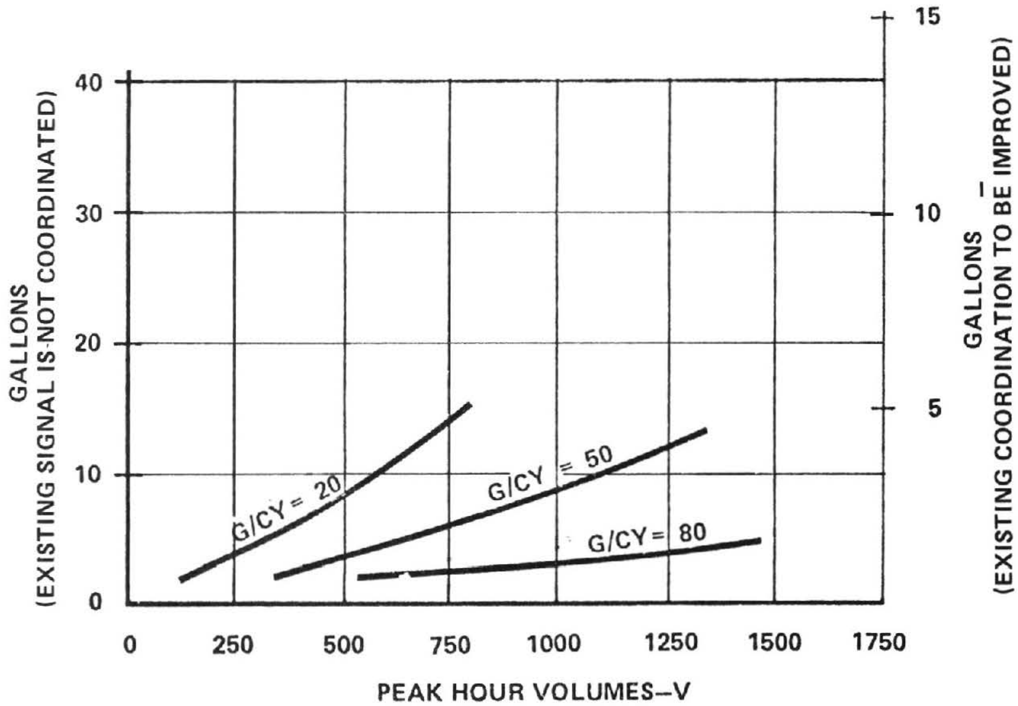
Existing signal coordination is to be improved so right-side scale is used.

Gallons of Fuel Saved Per Day = WB 1, EB 3
Hours of Travel Time Saved Per Day = WB 1, EB 2
(from Figure I2-t)
Kilograms of CO Saved Per Day = WB 1, EB 3
(from Figure I2-e)

Perform similar analyses for all other links, using left-side scale (Links 1, 4, 5, and 6) or right-side scale (Links 3 and 7) as appropriate.

Final Results: See Table 1, previous page.

1 One-Lane Approach



FUEL SAVED PER DAY
Figure I 1-f

One-Lane Approach 1

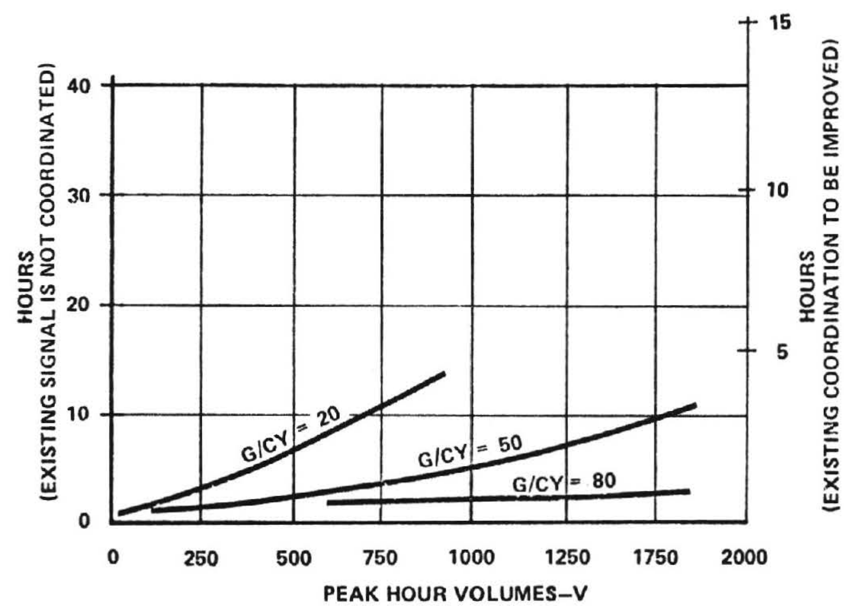


Figure I 1-t TRAVEL TIME SAVED PER DAY

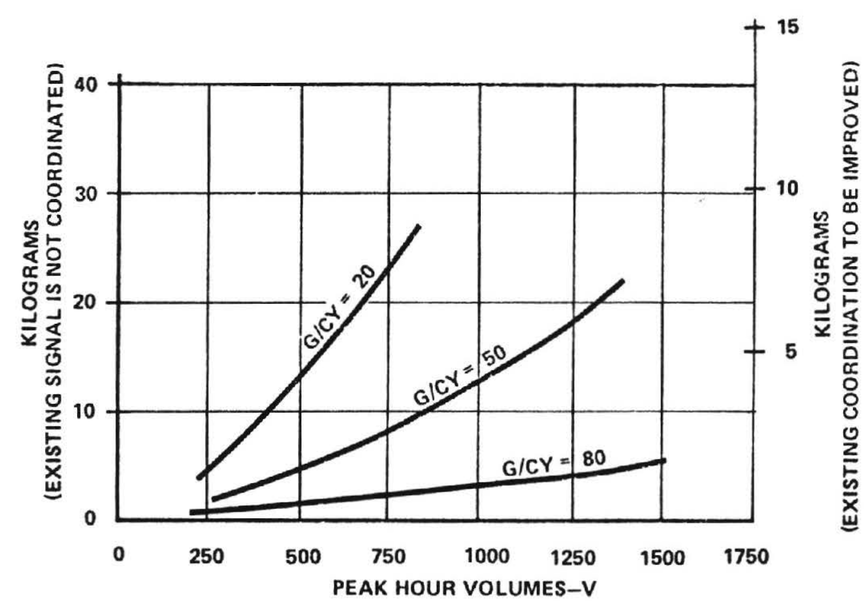
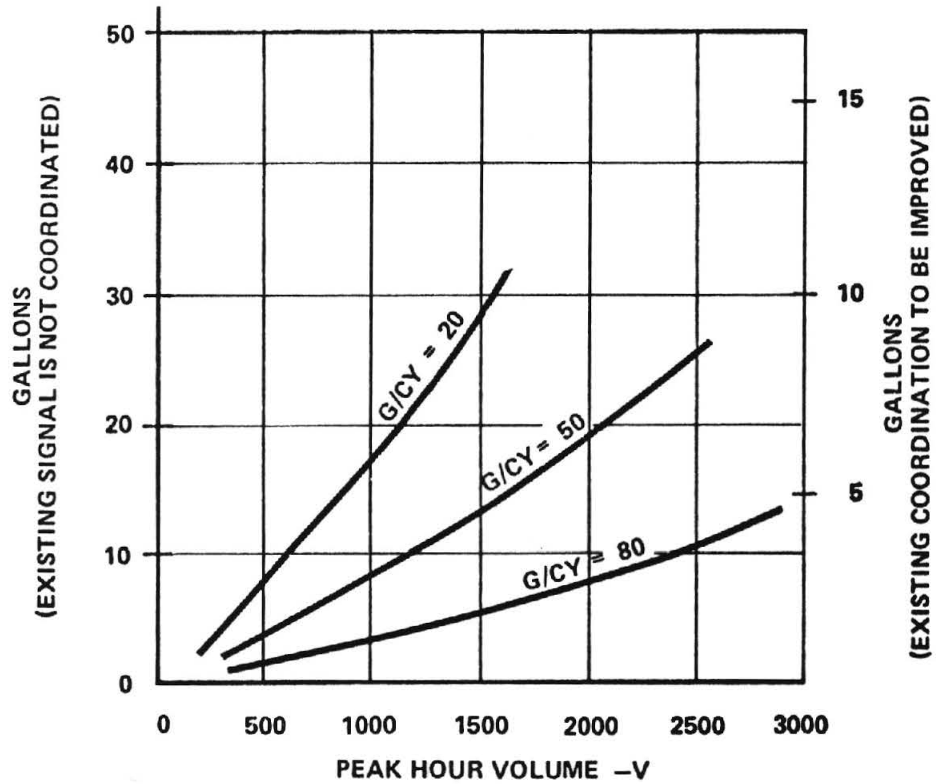


Figure I 1-e CO EMISSIONS SAVED PER DAY

2 Two-Lane Approach



FUEL SAVED PER DAY
Figure 12 -f

Two-Lane Approach 2

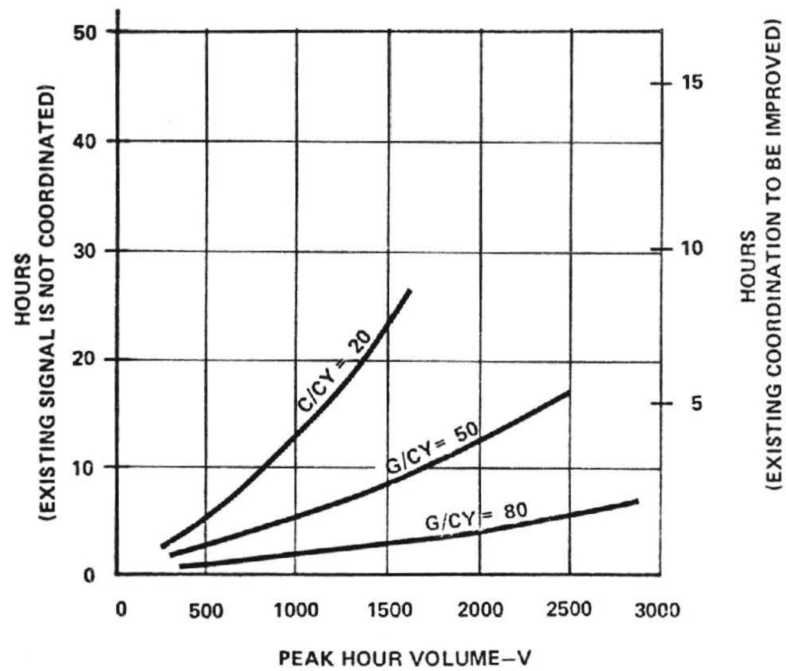


Figure I 2-t TRAVEL TIME SAVED PER DAY

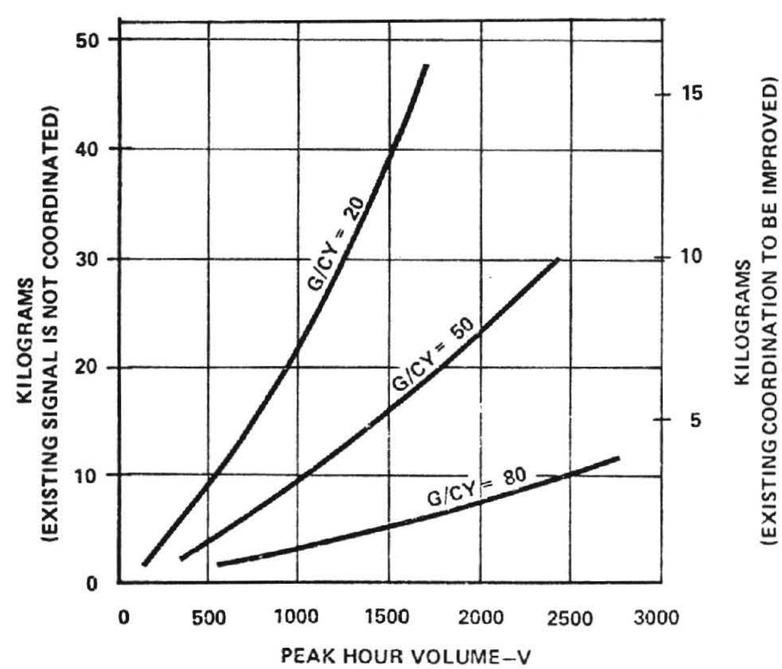
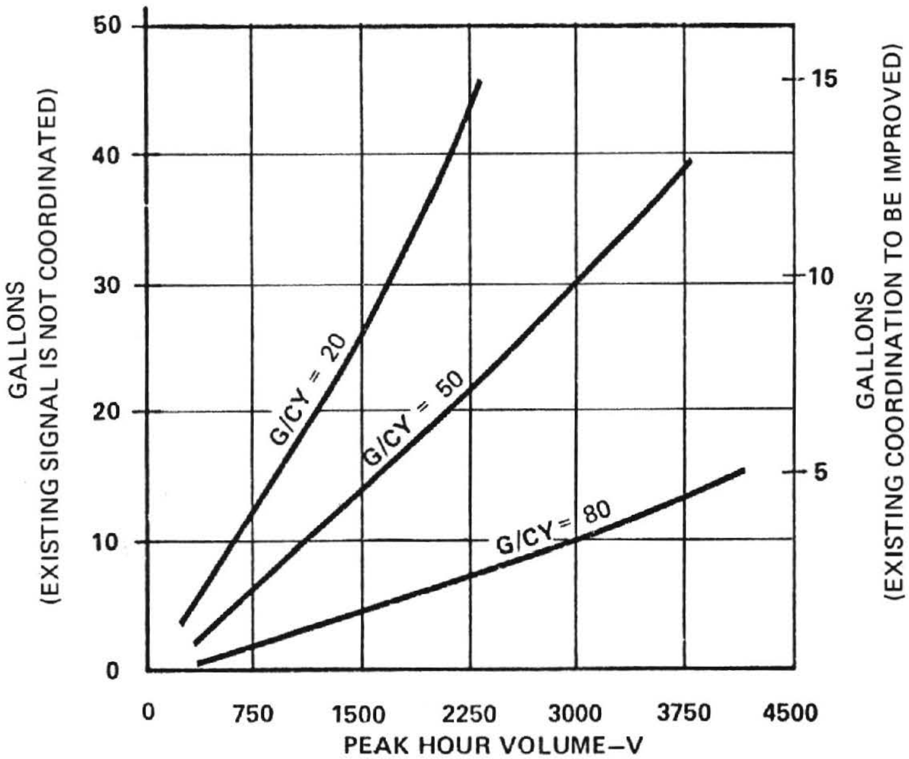


Figure I 2-e CO EMISSIONS SAVED PER DAY

3 Three-Lane Approach



FUEL SAVED PER DAY
Figure I 3-f

Three-Lane Approach 3

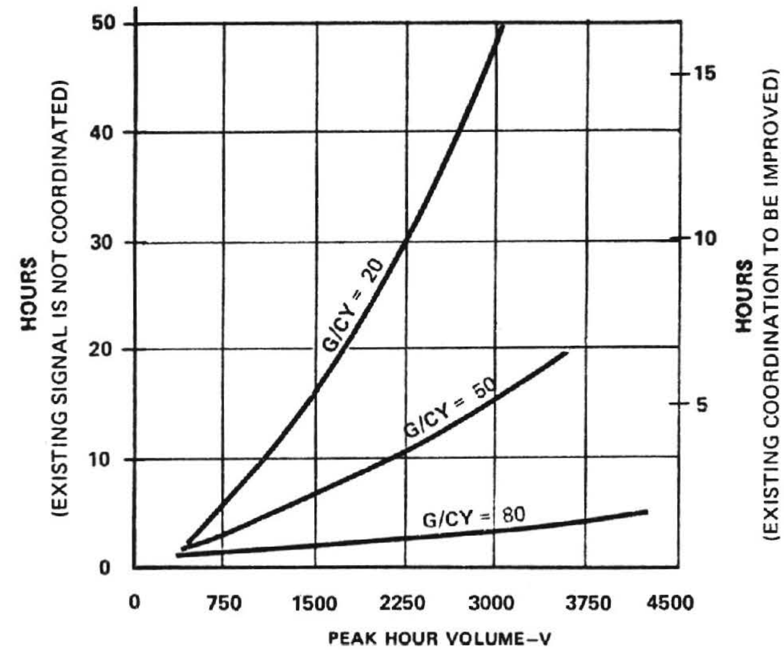


Figure I 3-t TRAVEL TIME SAVED PER DAY

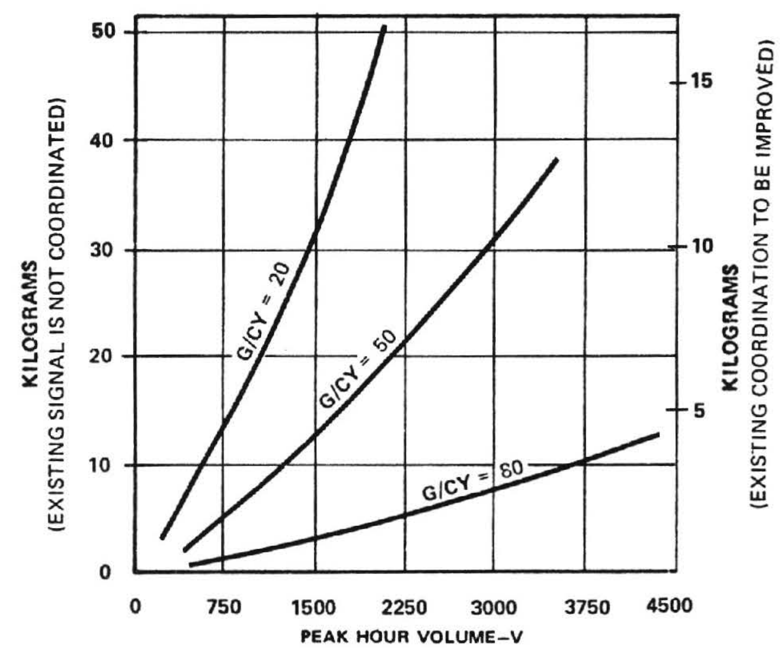


Figure I 3-e CO EMISSIONS SAVED PER DAY

INSTRUCTIONS

IMPROVE ROUGH RAILROAD CROSSINGS

Conditions:

1. Any midblock location with a rough railroad crossing which reduces speeds of crossing vehicles.

Assumptions:

1. Upgrading the crossing will increase the track crossing speed to within five mph of the average running speed. If approach grades are significant or sight distance problems occur, it may not be possible to achieve crossing speeds of five mph below approach speeds even with smooth crossings. Under these conditions, savings may be less than indicated.
2. Seven percent truck mix assumed. Truck percentages ranging from zero to 15 percent will not alter results significantly.
3. Estimates do not reflect the effect of vehicular queuing caused by the interruption to flow and, therefore, on heavily traveled roads, savings may be greater than indicated.

Required Input:

1. Two-way, average 24-hour traffic volumes (V) in 1,000s of vehicles.
2. Average speed of traffic (SR) in mph as it approaches crossing (prior to reducing speed at crossing).
3. Existing average track crossing speed (SC) in mph.

Procedures:

1. Enter SR and SC into Figures J1-f, J1-t, and J1-e to obtain fuel, travel time, and emissions saved per 1,000 vehicles.
2. Multiply fuel, emissions, and time savings obtained in Step 1 by V to obtain daily savings.

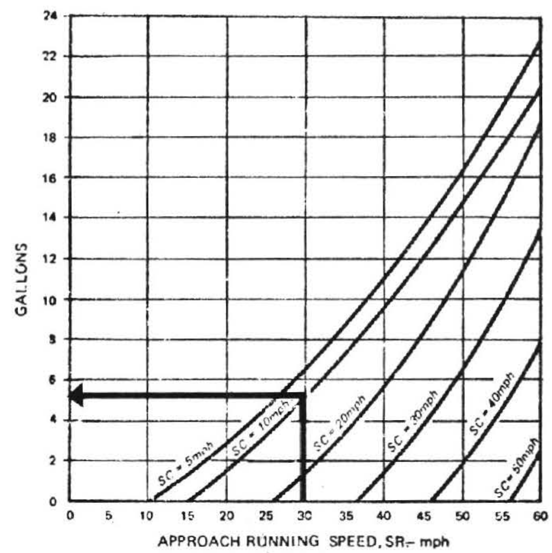
EXAMPLE

Description: Main Street in Evanston, Illinois, between Dodge Avenue and McCormick Boulevard, carries a two-way average daily traffic volume of 15,000 vehicles. The Chicago & North Western Railroad tracks cross Main Street approximately one-fourth mile east of McCormick. Currently, the rough crossing causes vehicles to decelerate from an average speed of 30 mph to 10 mph. Installation of rubberized crossing is expected to increase the average crossing speed to 25 mph.

Input:

V = 15.0 thousand vehicles per day
SR = 30.0 mph
SC = 10.0 mph

Charts/Graphs Used:



FUEL SAVED PER THOUSAND VEHICLES
Figure J1-f

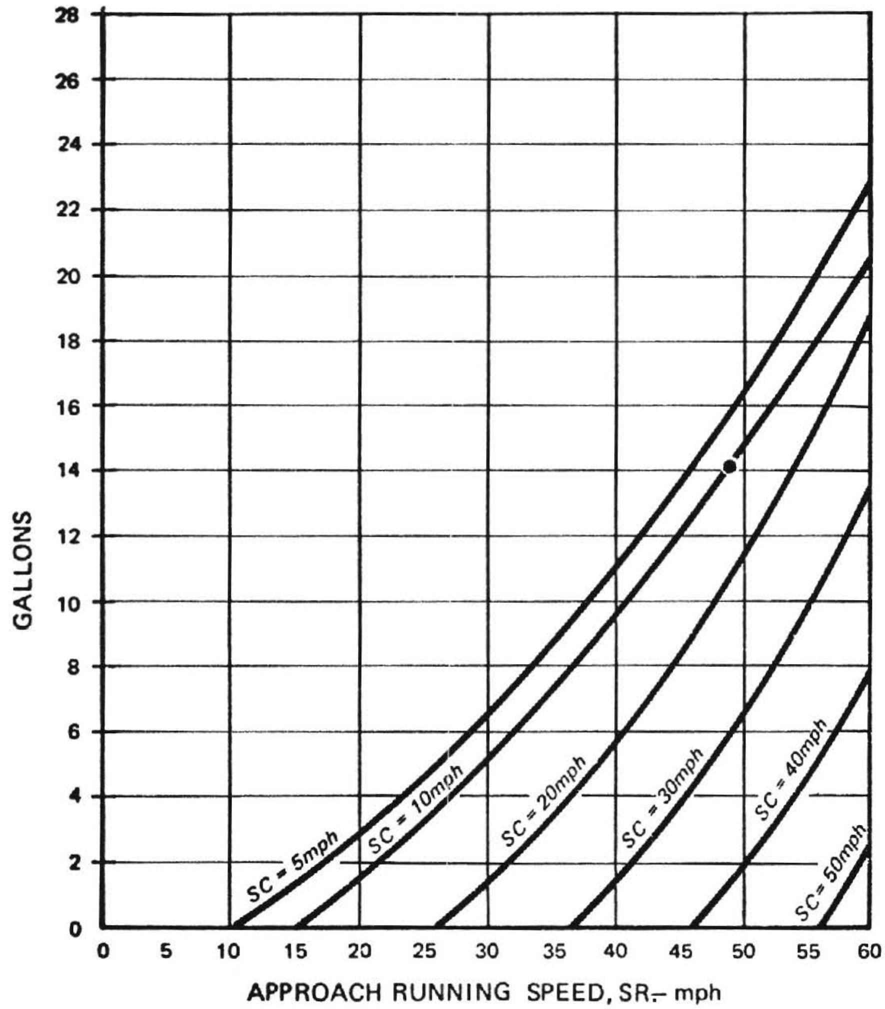
Intermediate Results/Calculations:

Fuel Saved/1,000 vehicles (from Chart J1-f) = 5.1 gal/1,000 vehicles
Calculations: 5.1 x V = 5.1 x 15.0 = 76.5
Time Saved/1,000 vehicles (from Chart J1-t) = 0.8 hours/1,000 vehicles
Calculations: 0.8 x V = 0.8 x 15.0 = 12.0
Emissions Saved/1,000 vehicles (from Chart J1-e) = 3.2/1,000 vehicles
Calculations: 4.0 x V = 4.0 x 15.0 = 60.0

Final Results:

Gallons of Fuel Saved Per Day = 76
Hours of Travel Time Saved Per Day = 12
Kilograms of CO Saved Per Day = 60

1 All Conditions



FUEL SAVED PER THOUSAND VEHICLES
Figure J1-f

All Conditions 1

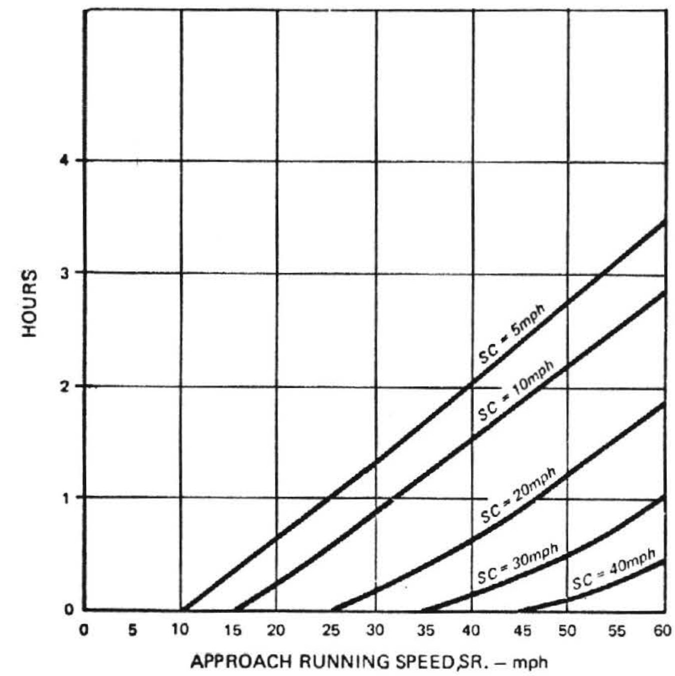


Figure J1-t **TRAVEL TIME SAVED PER THOUSAND VEHICLES**

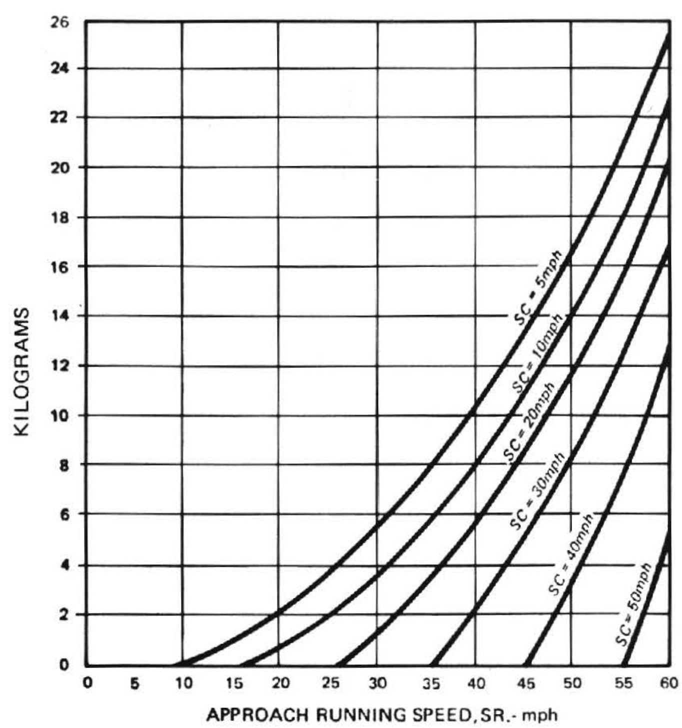


Figure J1-e **CO EMISSIONS SAVED PER THOUSAND VEHICLES**

*U.S. GOVERNMENT PRINTING OFFICE: 1981--361-428/1412

NOTICE

This document is disse
Department of Transp
exchange. The United
for its contents or use

This report is being dis
of Transportation's Te

DOT-I-81-34

DOT-I-81-34

TECHNOLOGY SHARING

A PROGRAM OF THE U.S. DEPARTMENT OF TRANSPORTATION