PB-252-018

DOT HS-801 874

NORTH DAKOTA SELECTIVE TRAFFIC ENFORCEMENT PROGRAM (STEP)

Final Evaluation

Contract No. DOT-HS-224-2-384

April 1976

Final Report

PARED FOR:

DEPARTMENT OF TRANSPORTATION

IONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

HINGTON, D.C. 20590

45603

Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

Prepared for the North Dakota Highway Department in cooperation with the Department of Transportation, National Highway Traffic Safety Administration under Contract DOT-HS-224-2-384. The opinions, findings, and conclusions expressed in this publication are those of the authors andnot necessarily those of the National Highway Traffic Safety Administration.

Technical Report Documentation Page

1. Report No. DOT HS-801 874	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle North Dakota Selective Traffic Enforcement Program (STEP) Final Evaluation		5. Report Date April 1976
		6. Performing Organization Code
7. Author/ Kenneth D. Hackman, Jr. and Lewis B. Hayes		8. Performing Organization Report No.
9. Performing Organization Name and Address North Dakota Highway Patrol Bismarck, North Dakota 58505		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. DOT-HS-224-2-384
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D. C. 20590		13. Type of Report and Period Covered Final Report July 1972-June 1975
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

This report presents an evaluation of the North Dakota Selective Traffic Enforcement Program. Five experiments in two counties were evaluated. It was found that the STEP activities of live patrol and conspicuous observation in Grand Forks County were associated with significant reductions in accidents and injuries during a time when these parameters were increasing in the rest of the State. In Cass county it was found that radar speed enforcement combined with a public information campaign was associated with a dramatic increase in compliance with the speed limit. Notably, most of the change occurred after the public information campaign and before any enforcement. Because of a change to 55 mph speed limit which occurred shortly after the start of STEP in Cass County, before and after comparisons were not used. Instead, monthly accident and injury data were correlated to monthly manpower assignements. It was found that significant inverse correlations existed between manpower and the impact parameters. Portable pre-arrest breath testers were given to enforcement officers assigned to experimental groups and their records were compared to officers assigned control groups. The officers with the device made significantly more arrests with significantly lower BAC's than those without. A special speed enforcement study yielded inconclusive results due to speed recording equipment problems resulting in inadequate data.

17. Key Words STEP, Enforcement, Selective Enforcement, Demonstration Projects, Pre-arrest Breath Testers.		18. Distribution Statement Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 179	22. Price

Form DOT F 1700.7 (8-72)

Reproduction of completed page authorized

TABLE OF CONTENTS

FINAL EVALUATION REPORT ON THE NORTH DAKOTA SELECTIVE TRAFFIC ENFORCEMENT PROGRAM (STEP)

SECTION I

INTRODUCTION

BACKGROUND

The North Dakota Selective Traffic Enforcement Program (STEP) was conducted over a three (3) year period from July, 1972, through June, 1975. The overall program objectives were the same as for other STEP projects funded by the National Highway Traffic Safety Administration: to secure voluntary compliance with existing traffic laws by the motoring public and to provide for a reduction in the number and severity of traffic crashes. Unlike other STEP Demonstration Projects, however, the North Dakota STEP was performed by a State law enforcement agency in relatively low traffic density areas. This difference is reflected in all the experiments during the project, as well as in their results.

STEP operations were conducted in two different counties in North Dakota. From August, 1972, through December, 1973, STEP was employed in Grand Forks County, being phased out during the last three months. During the remainder of the project, operations were conducted in Cass County. In both counties the majority of the enforcement effort was directed at specific stretches of highway (STEP locations) which had had historically high accident levels involving traffic violations. This effort consisted mainly of the use of marked patrol vehicles in a moving observation environment during the predominant time period of accidents at the specific locations (countermeasure P03).

There were five (5) distinct activities or experiments which were evaluated and are the subject of this report. First, the overall effectiveness of the STEP project was evaluated in Grand Forks County. Second, a speed enforcement campaign, incorporating public information and conspicuous stationary radar, at a specific STEP location in Cass County was evaluated. Third, the overall effectiveness of STEP in Cass County was evaluated. Fourth, the effectiveness of portable pre-arrest breath testers was evaluated. Fifth, a 55 mile per hour speed limit enforcement effort with varying levels of enforcement was evaluated. Separate evaluations of each of these experiments are provided in Sections II through VI of this report.

DATA COLLECTION

The data collection requirements of each of the experiments were substantially different. When STEP began in Grand Forks County historical accident records of North Dakota were not automated. Accordingly, it was necessary to search the files manually to obtain baseline data about the accidents in the County. Three years of historical data, beginning in 1969, were tabulated so that changes in accident levels could be evaluated reliably.

During STEP three sources of accident data were employed. First, the STEP Task Force provided monthly summaries of manpower allocation, accidents, and citations. Second, through the NHTSA STEP Data System, various computer generated reports of accidents, manpower, citations and court dispositions were received. Third, listings of accidents from the Highway Department's computer system were obtained to identify the exact location of the accidents.

Data about the first speed enforcement campaign was collected manually by the STEP Task Force. The vehicle speeds were transcribed from a radar unit concealed on an overpass. This provided a profile of vehicle speeds before any special enforcement, after a public information campaign but not enforcement, and after intensive enforcement.

Data used in the evaluation of the portable pre-arrest breath tester was obtained from two different sources. Patrol officers who were issued the device recoded each use of the device on a log sheet, and if an arrest was made, the blood alcohol content (BAC) from an evidentiary test was reported. For officers in the control group, the BAC for each arrest in which an evidentiary test was given, was obtained from computerized arrest records.

The data collection for the final speed enforcement experiment was accomplished through the use of digital recorders. These devices are designed to record the speed of every vehicle crossing sensors laid in the roadway. This data was then decoded and reduced to computer generated reports provided to the evaluator. The reports provided summary statistics by hour and for the eight hour enforcement periods, as well as vehicle counts in two mile per hour increments.

EVALUATION PLAN AND OVERALL DESIGN

The actual evaluation methodologies differed for each experiment. No single approach or experimental design was suited to the different objectives and operational considerations. The national energy crisis and ensuing lowering of speed limits meant that the approach taken in Grand Forks County could not be used in Cass County and the other experiments had sufficiently different objectives to require separate treatment. The original evaluation plan called for the use of before and after comparisons as the primary evaluative technique. This approach was followed in the Grand Forks County evaluation and the first speed enforcement campaign. In these two experiments, outside influences were minimal and there was sufficient baseline data to allow valid inferences to be drawn. Longitudinal analysis was employed in the evaluation of overall Cass County operations and in the second speed enforcement experiment, while the pre-arrest breath tester experiment was evaluated by comparisons between a test group and a control group.

In all cases, impact parameters rather than proxy measures were evaluated. Specifically, each experiment was evaluated on the basis of changes in the parameters the experiment was designed to influence. Intermediate measures, whose role in the "causal chain" could not be measured accurately, were not used to evaluate the effectiveness of the experiments.

Insofar as a reduction in the frequency and severity of accidents is the ultimate objective of STEP, the Cass County and Grand Forks County operations were evaluated on that basis. It was felt that results that could be shown by a performance evaluation of proxy measures would not adequately gauge the effectiveness of the program. Because of the relatively small number of accidents, the results from specific STEP locations were not as meaningful as those obtained when the STEP locations were combined in each county. Furthermore, breaking the enforcement effort into the various countermeasures at each location, resulted in distributions which were not suited to statistical analysis.

The two speed enforcement experiments were evaluated directly on the basis of the observed changes in vehicle speed distributions. Proxy measures, such as the number of citations issued, were not judged to be a meaningful measure of the effectiveness of speed enforcement.

The pre-arrest breath tester experiment was evaluated primarily on the basis of the BAC levels of individuals arrested for driving while intoxicated (DWI) and on the number of DWI arrests made by officers with and without the device. Again, the evaluation focused on the measures the experiment was designed to influence.

In all cases the evaluations were developed to provide as much information as possible about the impact of the experiments in objective terms. Special care was taken to avoid erronious conclusions derived from false assumptions, and each evaluation methodology reflects this.

PROBLEM AREAS

The problems associated with the evaluation of the North Dakota STEP were minor in most instances. With the exception of those associated with the last speed enforcement campaign, all other problems were resolved with no detriment to the project or the evaluations. There were occasional discrepancies in the data reports received by evaluator, however, with the assistance of the Operations Officer, they were all resolved.

The only problem which was detrimental to the evaluation occurred during the final speed enforcement experiment. Due to problems outside of the control of the North Dakota Highway Patrol or the evaluator, the number of speed recorders in use was half of the number specified in the experimental design. Furthermore, because of the delays in a subcontract for data reduction, the first usable data was not received until almost two months after the end of STEP operations. It was only at that time that it was discovered that valid data was available for less than one third of the experiment. By then it was too late to alleviate the situation in any way.

SECTION II

GRAND FORKS COUNTY

INTRODUCTION

This section presents a thorough review and evaluation of the effectiveness of STEP operations in Grand Forks County, North Dakota. Insofar as the primary objective of STEP is the reduction of accidents and injuries, the fundamental approach of this evaluation was the use of statistical analytic techniques to test changes in accident and injury frequencies before and during STEP. Secondary and proxy indicators have not been used as measures of effectiveness although they were examined.

The relatively small number of accidents occurring at any individual STEP site made single site evaluation difficult and not very meaningful. The monthly variation in accidents was often as great as the variation between the STEP period and the baseline, which occasionally resulted in an inability to demonstrate statistical significance even with a 50% reduction. Because of this limitation, the best results were obtained using data from the combined STEP sites.

Due to the substantial seasonal fluctuation of accidents, it was always necessary to perform the statistical tests using like time periods. This meant that no more than twelve months of STEP data could be combined for comparative purposes. As a result, the tests that were performed tend to understate the reductions which actually occurred.

In general, it was found that during, and immediately following STEP operation in Grand Forks County, there was a significant decrease in accidents and injuries (including fatal injuries) at the combined STEP sites. While these results do not prove a cause and effect relationship, it is noteworthy that every indicator improved significantly during the period of operations.

EVALUATION METHODOLOGY

The basis of the statistical evaluation of STEP operations in Grand Forks County is a comparison of baseline accident data against accident data during STEP. Baseline data beginning in January 1969 was collected so that adequate statistical analysis could be performed.

Several different techniques were used in evaluating the data so that the most complete picture possible could be drawn. It is important to note, however, that the evaluation process is based on various reasonable assumptions about the nature of the data which cannot be proven absolutely but which cannot be disproven either. A conscious effort has been made to clearly identify each assumption and to explain the reasons behind it. In general, if any of the assumptions that were made were invalid it would not necessarily mean that any inferences or conclusions drawn from the data were incorrect, merely that the procedures used to evaluate the data were inappropriate. At one extreme, certain fundamental assumptions were made which were necessary for any rigorous evaluation to be performed. At the other extreme, it was possible to test the reasonableness of various simplifying assumptions through the use of techniques such as the F Test for the equality of variances. When these techniques revealed that a specific assumption was unwarranted, an alternate analytic method was employed which did not require that assumption.

Insofar as possible, outside influences on the accident experience in Grand Forks County during STEP operations were operationally controlled or eliminated. Furthermore, the evaluation concentrated on an analysis of the recorded data for STEP sites rather than the whole county. Therefore, while it is reasonable to conclude that significant changes in accident experience can be attributed to STEP, the project was not conducted in a laboratory and is not exactly repeatable. The evaluators would like to stress that statistical analysis is useful in making probability statements which can contribute to sound managerial decisions, but it does not "prove" anything. All conclusions reached in this evaluation should be taken in that light.

The procedures used in the statistical analysis generally have been structured to test various hypotheses based on STEP and baseline accident experience. The data has been treated as sample data from two theoretical populations whose characteristics are represented in the samples. One theoretical population has been assumed to be sampled by the baseline data, the other population, similar to the first but including selective enforcement, has been assumed to be sampled by the STEP data. Furthermore the samples are assumed to have been randomly drawn from the theoretical populations. These assumptions are fundamental to this evaluation. Statements of fact can be made about the STEP experience as compared to the three previous years in Grand Forks County but these are meaningless in any other context. To learn from the experience of STEP, and to draw conclusions that will be meaningful in other areas at other times, the data must be treated as sample data.

As there are too few data points under STEP (fewer than thirty) to justify the use of the Central Limit Theorem, the Likelihood Ratio Technique and the "t" distribution were employed for most of the hypotheses tested. The use of this technique requires that the samples in the test be from two normal populations having equal variances.

The assumption that the samples are from normal populations, or at least populations with distributions which closely approximate the normal, is reasonable. The frequency distribution defined by the variable "number of accidents during one month" is very close to a normal curve with the same mean and standard deviation. Figure II-1 graphically depicts the relationship between a normal curve having a mean of 18.64 and a standard deviation of 4.18 (the statistics from the 36 months of baseline data) and a linearly smoothed accident frequency distribution for the same time period. Visual inspection of this graph reveals an exceptionally good fit between the theoretical curve and the smoothed accident frequency distribution. Additional tests were performed in an attempt to determine if the assumption of a normal population is valid. A Chi Square test was performed comparing observed accident frequencies to the theoretical frequencies that would occur if the population were normal. To accomplish this, the data was combined into seven groups with identical expected frequencies which were then compared to the actual frequencies falling in each group. Table II-1 shows this grouping.

With this data it is possible to test the hypothesis that the sample data has been drawn from a normal population having the same mean and standard deviation. This test is accomplished by attempting to show that the contrary is true; namely that the population from which the sample is drawn is not normally distributed. In fact, the test shows that since the Chi Square of our data (4.055) is less than the Chi Square with four degrees of freedom, at as low as the 70% confidence level, it is not reasonable to assume that the sample is not from a normal population. Therefore, we are safe in assuming that the population is normally distributed.

Relationship of Smoothed

Accident Frequency Distribution to

Normal Curve

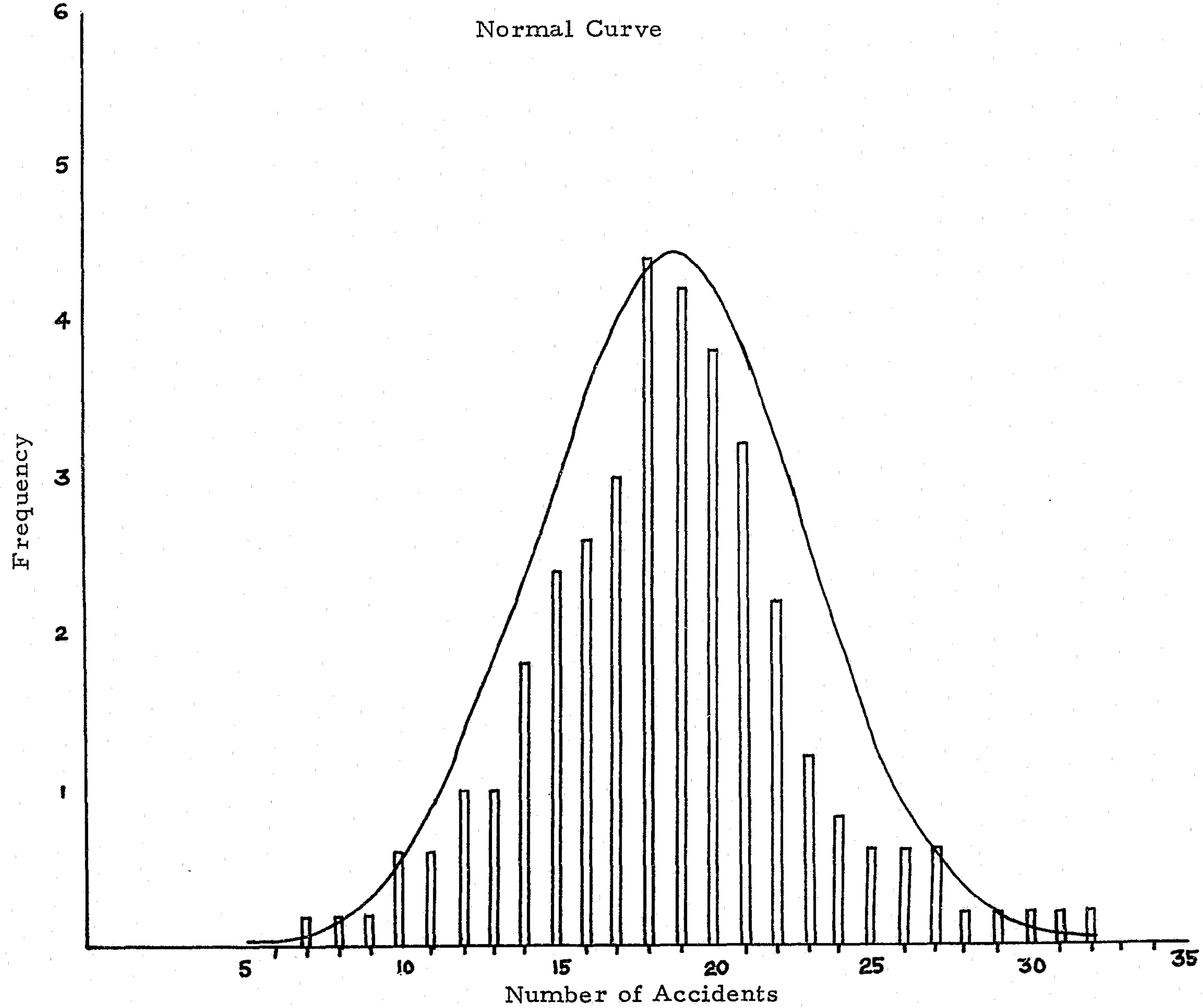


FIGURE II-1

Table II-1

Group	Observed Frequency	Expected Frequency
Less than 14.164	6	5.143
15.164 to 16.297	4	5.143
16.298 to 17.886	3	5.143
17.887 to 19.392	8	5.143
19.393 to 20.981	7	5.143
20.982 to 23.114	4	5.143
Greater than 23.114	4	5.143

Chi Square = 4.0554

Other evidence supporting this assumption is the extremely high correlation (.98) between the cumulative frequency distribution of the sample data, and that which would be expected from a normal population. Figure II-2 shows the cumulative frequency distribution of the accident data plotted on probability graph paper. The scale of this paper is such that the cumulative frequency distribution of a normal population will appear as a straight line. This scale can also be translated into a linear scale of z or $\frac{x - x}{\sigma}$ so that a linear regression (least squares) line can be determined. In this case, the least squares line was determined to be y = .251 x - 4.434; where y is expressed in units of z and x is expressed in accidents occurring during one month. The closer our data is to fitting this line, the more normally distributed it is. Two measures of the closeness of fit of the data to this line are the correlation coefficient and the standard error of the estimate, measured by the difference between the actual points and the points predicted by the regression equation. As was mentioned above, this correlation co-

Cumulative Accident Frequency Distribution

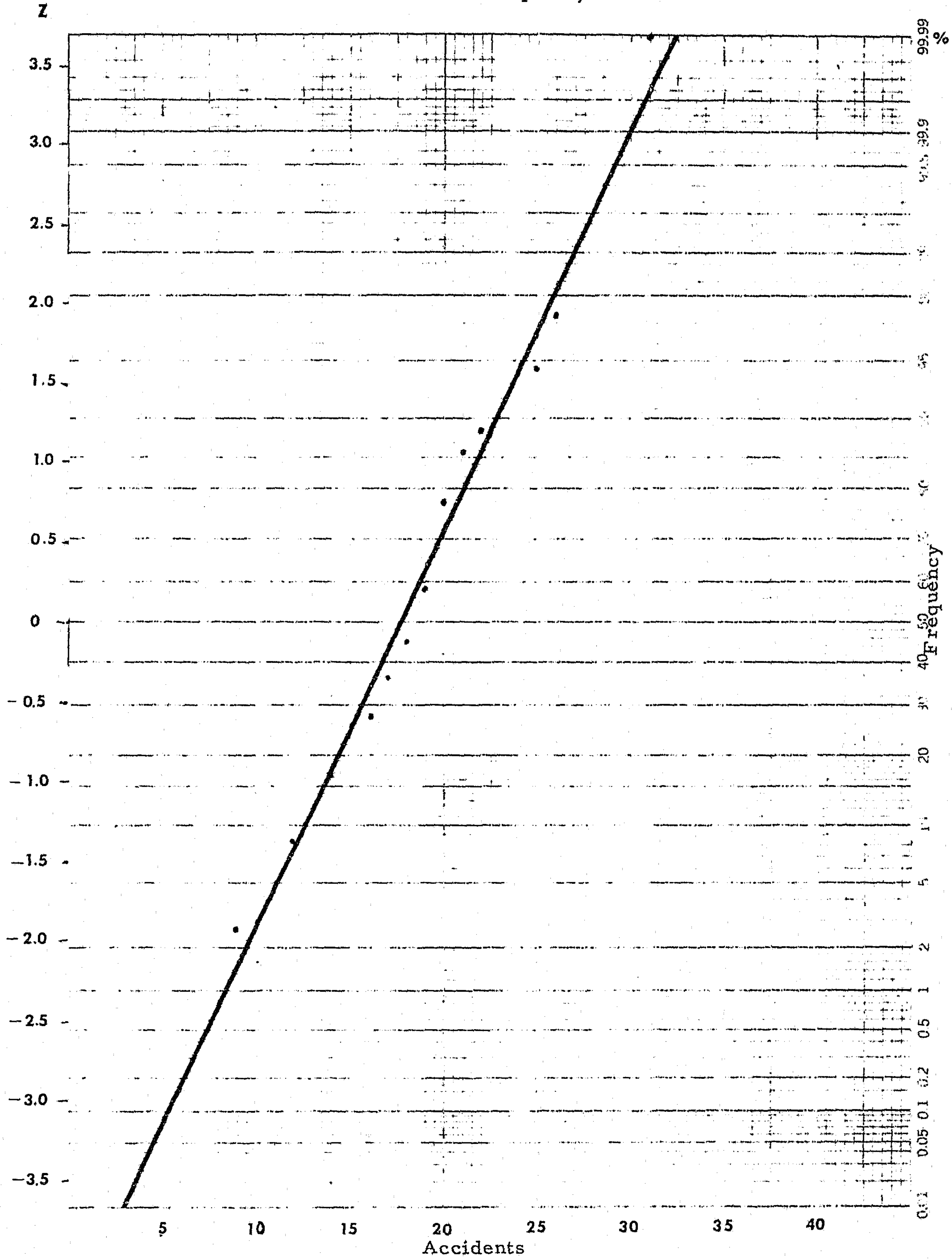


FIGURE II-2

efficient is extremely high showing a very linear relationship of the data. Furthermore, the standard error of the estimate was extremely low, less than 0.19. These various tests strongly support the assumption that the number of accidents which occur during one month are normally distributed.

It should be pointed out that testing the distribution of the STEP data is impractical because of the limited number of data points. Nevertheless, it is most reasonable to assume that the introduction of STEP operations would in the long run, have little if any effect on the fundamentally normal distribution of accidents per month.

The other assumption which is required for the Likelihood Ratio Technique is that the two samples come from populations having equal variances. This assumption is easily tested through the use of the F test for equality variances. This test was performed for each hypothesis to be tested in this evaluation. When the test indicated that the assumption of equal variances was unwarranted, the Likelihood Ratio Technique was not used. In its place the non-parametric Rank Order test was performed. The Rank Order test is a less powerful tool than the others, but it requires no assumptions about the data or its distribution.

EVALUATION RESULTS

Numerous specific statistical tests were performed on the available data. Each one was designed to test an hypothesis concerning a particular indicator that would tend to confirm the effectiveness of STEP.

Test 1: Total Accidents

As was stated above, this evaluation concentrated on a comparison of accidents occurring at STEP sites before and during STEP operations in Grand Forks County. The first indicator that was examined was total accidents occurring at the STEP sites. It was found that for the thirty-six months prior to STEP, the average number of accidents per month was 18.639. For the first 12 months of STEP the average was 15.5, a reduction of 16.89 percent. The average for all months from August 1972 through January of 1974 (when the STEP effort had completely shifted to Cass County) was 14.78, for a 20.7% reduction. These total figures do include seasonal influences which might account for some of the observed change. For that reason, the rest of the analysis was performed using only the twelve month figures. This approach is quite conservative and will in fact tend to understate the reductions which occurred.

The first test performed was used to determine whether the changes which occurred in the mean number of accidents per month after STEP operations began were significant. To accomplish this, the hypothesis that the mean number of monthly accidents under STEP was lower than during the baseline period was tested against the alternative that the mean was not lower (e.g. the same or higher).

As was described above, an F test for the equality of variances was performed first to determine if use of the Likelihood Ratio Technique

ALL STEP SITES

	69-70 # ACCS	69-70 # I+K	70-71 # ACCS	70-71 # I+K	71-72 # ACCS	71-72 # I+K	72-73 (STEP) # ACCS	72-73 (STEP) # I+K
Aug	20	11	20	18	20	23	20	6
Sept	20	13	18	26	19	7	17	19
Oct	16	12	20	9	20	16	14	16
Nov	19	6	21	14	22	5	12	6
Dec	19	9	12	9	26	18	24	6
Jan	18	10	16	24	9	3	15	9
Feb	25	19	14	4	17	10	21	9
Mar	31	14	20	11	17	6	11	3
April	12	9	21	19	19	11	11	11
May	14	6	14	5	18	8	18	9
June	16	8	21	7	16	12	8	8
July	25	17	17	6	19	10	14	5
				Total	671	415	186	107
				Mean	18.639	11.528	15.5	8.917
				Std. Dev.	4.189	5.782	4.7768	4.641

TABLE II-2

is justifiable. The variance of the baseline data was found to be 17.551 while the variance of the STEP data was determined to be 22.818. The ratio of these two variances is 1.300. From the table of F values it can be found that, given our sample sizes, the variances can be assumed <u>not equal</u> if F is greater than 2.05. Here, F is less than 2.05 so the variances can be assumed to be equal.

The "t" test was performed for the two samples with mean number of accidents per month for the baseline data of 18.639 and the STEP data of 15.5, yielding a t = 3.174 which indicates that we can be roughly 98% confident that the difference between the same data reflects a significantly lower number of accidents occurring during STEP than during the baseline period. We therefore accept the null hypothesis and conclude that STEP operations in Grand Forks County were accompanied by a significant reduction in accidents at STEP sites.

Test 2: Injury and Fatal Accidents

Because of the different accident reporting conventions used during STEP (all accidents, regardless of estimated damage) and the baseline period (only so called "reportable" accidents) it was felt that a comparison excluding property damage only accidents could provide a more accurate means of evaluating STEP.

During the baseline period there was an average of 6.472 injury and fatal accidents per month, while during STEP there were only 5.417 - a decrease of 16.3%. Again, including six more months of STEP data showed further decrease to 4.61 per month or a 28.76% reduction. Our statistical analysis using only the twelve months of data will therefore continue to be quite conservative.

Injury and Fatal Accidents

	69-70	70-71	71-72	72-73 (STEP)
Aug	5	9	9	4
Sept	6	13	6	9
Oct	8	8	7	12
Nov	4	9	4	4
Dec	5	3	11	4
Jan	8	6	2	6
Feb	9	10	6	4
Mar	8	6	5	3
April	4	10	5	5
May	5	4	6	7
June	5	4	6	3
July	7	5	5	4
		Total	233	65
		Mean	6.472	5.417
		Std. Dev.	2.402	2.712

TABLE II-3

Test 2 was set up to test the hypothesis that the mean number of fatal and injury accidents per month was significantly lower during STEP than during the baseline period. As before, the F test was performed, yielding an F ratio of 1.256. Again, this is smaller than 2.04 and we can assume that the two samples come from populations with equal variances.

The "t" test for this data yielded a "t" = 1.270. This value of t is not large enough to let us accept the hypothesis with a 90% confidence, but it is large enough to indicate a strong trend in that direction (greater than 85% confidence).

Similarly, a Rank Order test was performed on the same hypothesis. The "U" or Mann-Whitney test was utilized with slightly more positive results than were obtained with the "t" test. Here, the number of injury and fatal accidents occurring both during the baseline period and during STEP were written in ascending order and assigned ranks. A comparison was then made of the rank sums of the two populations. The one sided test that the baseline period was over represented in the higher ranks was performed. The statistic "U" was calculated to be 151.5 as compared to an expected value of 216. These figures, and the variance of "U" of 1,764 yielded a Z of - 1.535. This corresponds to a 93.7% confidence level that the decrease in injury and fatal accidents occurring during STEP was not due to chance.

On the basis of the strong trend affirmed by the "t" test, the significant results of the Mann-Whitney test, and the continued reduction in injury and fatal accidents beyond the twelve month period used, it is safe to conclude that there was a significant reduction in serious accidents at the STEP sites.

Test 3: Injuries and Fatalities

A good indicator of the seriousness of accidents is the number of injuries and fatalities associated with them. During the baseline period there was an average of 11.528 injuries and fatalities per month including 7.33 fatalities per year. During the first twelve months of STEP, this dropped to 8.917 injuries and fatalities per month (22.65% reduction) and only three fatalities. Including the following six months, the average fell to 8 injuries and fatalities per month (a 30.6% reduction) with only 1 additional fatality.

This test was made to determine the significance of the reduction in injuries and fatalities. The F test was performed first, yielding an F ratio of 1.113 which is less than the required 2.38, enabling us to assume equal variances and use the Likelihood Ratio Technique and the "t" test. The calculations revealed t = 1.385, which is significant at the 90% confidence level.

On the basis of this test, we can conclude that after STEP operations began in Grand Forks County, there was a statistically significant reduction in injuries and fatalities at STEP sites.

Test 4: Statewide Injuries and Fatalities

The next test was used to determine if the reduction in accidents and injuries observed at the STEP sites was associated with an overall reduction throughout the state. To accomplish this, the injuries and fatalities at the STEP sites were subtracted from the statewide data to give figures for the areas in the state without STEP. It was found that during the baseline period there were an average of 425.28 injuries and fatalities per month in the rest of the state, while during the first twelve month period of STEP this increased to 480.17, or 12.9%.

The F test yielded F ratio of 1.084 indicating the samples were drawn from populations with equal variances, allowing us to perform the "t" test. The "t" test yielded a "t" of 1.32 indicating a statistically significant increase with 90% confidence.

The results of this test are quite important. They indicate that the observed reductions in injuries and fatalities associated with STEP operations in Grand Forks County were not part of a statewide trend. Indeed, it was found that the significant reductions at the STEP sites occurred while there were significant increases in the rest of the state.

Test 5: STEP Injuries and Fatalities Compared to Statewide

The results of Test 4 led to an investigation of the ratios of STEP site injuries and fatalities to those occurring in the rest of the state during the same time period. A reduction in that ratio would be a good indicator of positive changes associated with STEP operations. Prior to STEP, the injuries and fatalities occurring at STEP sites accounted for an average of 2.868% of the monthly injuries and fatalities occurring in the rest of the state. During the first 12 months of STEP this dropped to an average of 1.906%; a 33.5% reduction.

To test the significance of this decrease it was necessary to use the Mann-Whitney test due to an F of 3.444, indicating the populations had significantly different variances. The monthly percentage figures were written in order and assigned ranks. The sum of the ranks of the baseline data and the sum of the ranks from the STEP period were

State vs. STEP Site Injuries (in %)

	69-70	70-71	71-72	72-73 (STEP)
Aug	2.011	2.917	5.913	0.971
Sept	2.334	4.522	1.857	3.499
Oct	1.917	1.335	4.278	2.286
Nov	1.161	2.627	1.441	1.008
Dec	1.772	1.931	4.986	1.105
Jan	2.208	7.362	1.345	2.542
Feb	5.026	1.521	3.650	2.866
Mar	3.590	4.803	1.786	1.136
April	2.158	5.864	5.023	2.784
May	1.058	1.370	2.156	1.837
June	1.553	2.096	2.024	1.706
July	3.131	1.558	2.967	1.134
		Total	103.251	22.874
		Mean	2.868%	1.906%
		Std. Dev.	1.615	0.8704

TABLE II-4

then calculated to test the hypothesis that the STEP data was over represented in the lower ranks. The statistic "U" was calculated to be 300 against an expected value of 216. These figures, and the variance of "U" of 1764 yielded a Z of 2.000. This difference is significant to the 97.7% level.

As a result of this test we can conclude, with greater than 97% confidence, that STEP activities in Grand Forks County were associated with a significant decrease in the ratio of STEP site injuries and fatalities to injuries and fatalities in the rest of the state. Perhaps more than any other, this test lends strong support to the contention that the observed reductions at the STEP sites were attributable to STEP operations.

Test 6: Economic Loss

As the cost of implementing a selective traffic enforcement program is quite high, it is pertinent to test for a reduction in the economic loss from accidents before and during such a program. The loss from each property damage accident was assigned a value of \$500.00, the economic loss from each injury was assigned a value of \$7,200.00, and the economic loss of each fatality was assigned a value of \$200,000.00.

During the three year base period, the average monthly economic loss from accidents at the STEP sites was \$204,491.67. During the first 12 months of STEP operation this was reduced to \$117,441.67, a 42.6% reduction. Including an additional six months of data reduced this further to an average of \$106,216.67 per month, or a 48.1% reduction.

The F test for the equality of variances yielded an F ratio of 3.13 indicating that the two populations have significantly different variances. While this is due entirely to the large reduction in fatalities during STEP, Economic Cost of Accidents (thousands of dollars)

	69-70	70-71	71-72	72-73 (STEP)
Aug	$276.5	$327.9	$556.7	$239.0
Sept	$97.1	$187.7	$249.7	$140.8
Oct	$281.2	$ 70.8	$829.9	$121.2
Nov	$ 49.7	$296.6	$237.8	$ 47.2
Dec	$ 69.8	$ 69.3	$137.1	$ 53.2
Jan	$461.6	$175.8	$217.9	$ 69.3
Feb	$139.8	$ 34.3	$ 77.5	$266.1
Mar	$106.8	$ 86.2	$ 49.2	$ 25.6
April	$261.6	$335.1	$279.0	$275.0
May	$ 47.7	$233.8	$ 63.6	$70.8
June	$255.9	$251.7	$284.8	$ 60.1
July	$131.4	$ 49.2	$ 79.0	$ 41.0
		Total	$7361.7	$1409.3
		Mean	$204.49	$117.44
		Std. Dev.	163.304	92.136

TABLE II-5

it still prevents the use of Likelihood Ratio Technique. The Mann-Whitney rank order test therefore was used to test the significance of this reduction. The monthly economic losses were arranged in ascending sequence and assigned ranks. From the sum of the ranks occupied by the STEP data, the statistic "U" was calculated to be 300 against an expected value of 216. (The fact that "U" was the same in Test 5 is merely coincidental) This difference corresponds to a Z of 2.0 and a 97.7% confidence level.

On the basis of the results of this test, we can conclude with 97.7% confidence that there was a significant reduction in the economic loss from accidents and injuries at the STEP sites during STEP operations.

Test 7: Net Cost of Accidents and STEP

This test was made to determine if the net economic cost of accidents and STEP was less than the economic loss due to accidents alone prior to STEP. The total first year cost of STEP was distributed equally among the first twelve months of operations and added to the economic loss of accidents during each of those months. STEP operations and support cost an average of $22,788.92 per month during the first year, bringing the average monthly cost of STEP and accidents to $140,230.58. This is 31.4% lower than the average monthly economic loss due to accidents during the previous three years.

The addition of an equal amount to each monthly figure does not alter the variances that were determined in Test 6, so we again must use a non-parametric test. The new monthly dollar figures were again put in ascending order and assigned ranks. The "U" or Mann-Whitney test was then performed. The statistic "U" was calculated to be 250 against an expected value of 216. This difference corresponds to a Z of .81 or a 78% confidence level.

The results of this test indicate that a significant reduction in net cost during STEP can not be claimed with adequate confidence. This does not in any way imply that the dollar loss without STEP was less than the total dollar cost during STEP. In fact there was a strong trend toward a net reduction in total cost. Based on the results of this test there is no reason to assume that STEP was not cost effective.

Test 8: Moving Averages

In an attempt to reflect accurately the continued downward trend of injuries and fatalities at the STEP sites beyond the initial twelve months of operations, the following procedure was employed. Beginning in August, 1969, 12 months of injuries and fatalities were totaled. The same thing was done for the twelve months beginning in September, 1969, October etc., continuing through the twelve month period ending July, 1972, the last month prior to STEP. This resulted in 25 numbers representing 12 months of injury and fatality data. The same process was repeated beginning with the first month of STEP (August, 1972) and continuing for nine 12 month periods ending May, 1974.

If there was no significant downward trend in accidents during STEP, the lowest twelve month periods would be randomly distributed among the 34 periods covered by the data. In fact, the greatest 12 months of injuries and fatalities during STEP was smaller than the smallest 12 month baseline period. Every 12 month period since the beginning of STEP was smaller than any 12 month period in the three years prior to STEP.

A Mann-Whitney rank order test was made of this data. The statistic "U" was computed to be 234 against an expected value of 112.5

and a variance of 656.25. This corresponds to a value of Z of 4.74 or greater than a 99.99% confidence that the results were not due to chance.

While this approach does not allow us to quantify the reductions, it is an overwhelmingly strong statement about the reduction in injuries and fatalities which occurred during STEP. There is virtually no possibility that the observed reductions in the 12 month periods of injuries and fatalities were due to sampling error or chance.

Site by Site Summary

Tests for reductions in accidents and injuries were also performed for the five STEP sites which received the vast majority of the enforcement manhours. These tests had varying results.

A01, which averaged over 730 manhours of enforcement effort per month, showed a 23.4% reduction in total accidents per month from 5.333 to 4.083. It also showed a 44.8% reduction in monthly injuries and fatalities, from 3.472 to 1.917. These reductions were tested for significance using the Mann-Whitney rank order test. It was found that the reduction in number of accidents was statistically significant to the 93.5% level. The reduction in injuries and fatalities on A01 was found to be significant to the 94.3% confidence level. As a result of this test we can conclude that STEP operations at site A01 were associated with a statistically significant reduction both in total accidents and in injuries and fatalities.

A02, which averaged slightly more than 86 manhours of enforcement effort per month showed 22.9% reduction in monthly accidents from .9722

AO1

	69-70 # ACCS	69-70 # I+K	70-71 # ACCS	70-71 # I+K	71-72 # ACCS	71-72 # I+K	72-73 (STEP) # ACCS	72-73 (STEP) # I+K
Aug	9	8	6	4	4	6	1	0
Sept	4	5	7	10	3	0	4	5
Oct	2	2	3	1	7	5	4	5
Nov	5	2	5	2	5	3	4	2
Dec	6	1	2	0	14	8	7	0
Jan	7	3	6	7	0	0	3	4
Feb	6	0	5	1	4	1	5	0
Mar	10	4	8	5	9	1	6	2
April	2	2	7	11	7	7	3	1
May	3	1	5	3	2	0	6	3
June	5	2	3	3	6	4	3	0
July	5	3	5	4	5	6	3	1
				Total	192	125	49	23
				Mean	5.333	3.472	4.083	1.917
				Std. Dev.	2.661	2.903	1.676	1.929

TABLE II-6

AO2

	69-70		70-71		71-72		72-73 (STEP)	
	# ACCS	# I+K	# ACCS	# I+K	# ACCS	# I+K	# ACCS	# I+K
Aug	0	0	1	0	2	3	0	0
Sept	0	0	2	7	1	0	1	0
Oct	1	0	1	1	2	3	1	1
Nov	0	0	3	3	3	0	0	0
Dec	2	0	2	6	1	0	3	0
Jan	1	2	0	0	1	1	0	0
Feb	0	0	1	0	0	0	1	0
Mar	0	0	2	1	1	2	1	0
April	5	7	1	3	0	0	0	0
May	2	1	0	0	0	0	1	1
June	1	0	1	0	1	2	0	0
July	0	2	1	0	1	0	1	1
				Total	35	42	9	3
				Mean	.972[2]	1,167	.75	.25
				Std. Dev.	1.502	1.978	.866	.452

TABLE II-7

to .75. Injuries and fatalities decreased from 1.167 per month to .25 per month for a 78.6% reduction. The "t" test was performed for the total accident figures because an F of 1.734 was small enough (less than 2.05) to support the assumption of equal variances. The "t" test failed to show that this difference was statistically significant due to the small value assumed by "t" (.484). Similarly, a rank order test of the reduction in injuries and fatalities was performed (F=19.15) with inconclusive results. The inability of these tests to verify these reductions is due to fact that of the 48 data points being evaluated for number of accidents, 16 of them were zero, and 21 of them were equal to 1. In the evaluation of injuries and fatalities, 31 were zero and 7 were 1. This kind of skewed distribution make rank order tests rather ineffective, and undermines the validity of the "t" test.

Nevertheless, it was felt that some test should be able to reflect the fact that the frequency of injuries declined from slightly more than one a month to one every four months. A paired sample sign test was therefore performed. In this test, the number of injuries and fatalities during each of the first twelve months of STEP was compared to the average for that month during the baseline period. Each time the STEP figure was lower, that month was given a minus sign; each time it was higher it was given a plus sign. Ties were not counted. If there was no true difference between the STEP months and the baseline period, the number of plus signs and the number of minus signs should be fairly close. It is possible, using the binomial distribution, to quantify the probability of getting any number of either sign by chance. In this case, there were 9 minus signs, 2 plus signs, and two ties. The chances of getting 9 or more minus signs, if the two populations were actually equal, is 3.28%. This means we can be 96.72% confident that there was indeed a significant reduction in injuries and fatalities at STEP site A02 when compared to the three previous years.

Location B01 which averaged about 134 manhours of enforcement per month showed virtually no change in total accidents between the baseline period and STEP. It also showed 56.7% increase in injuries and fatalities from 1.861 to 2.917 per month. To determine if this increase was significant, the "t" test was performed, based on a value of F of 1.54. The value of "t" was found to be 1.233 which is less than 1.303, the critical value for 90% significance. We conclude on the basis of these tests that there was no statistically significant change in either accidents or injuries at site B01.

Location C01, which averaged almost 370 enforcement hours per month, showed virtually no change in either accidents or injuries with accidents down 1.23% and injuries down 5.26%.

Location D01, which averaged more than 140 manhours of enforcement per month, showed a 20.85% decrease in accidents, from 2.0 per month to 1.583. On the Basis of F=1.564 indicating equal variances, a "t" test was performed. A value of "t" of 0.725 was determined, indicating that the reduction cannot be considered statistically significant. There was also a 27.78% decrease in injuries from 1.5 per month to 1.083. Based on a value of F of 1.564, a "t" test was performed. The results of this test, with "t" = 0.618 indicate that the reduction cannot be considered statistically significant.

The fact that the individual site evaluations failed to show stronger results is not surprising. It merely indicates that breaking the data down into its small constituent parts reduces the samples to such an extent that statistical tests are quite insensitive to even large changes. This in no way denies the consistently strong results that were obtained when the data from the combined STEP sites were evaluated.

B01

	69-70		70-71		71-72		72-73 (STEP)	
	# ACCS	# I+K	# ACCS	# I+K	# ACCS	# I+K	# ACCS	# I+K
Aug	0	0	2	1	6	2	3	4
Sept	0	0	3	3	2	1	5	10
Oct	6	7	3	2	3	1	6	1
Nov	2	1	3	3	7	0	1	2
Dec	2	3	2	0	1	1	6	3
Jan	4	1	3	10	1	0	1	0
Feb	1	0	1	0	1	1	1	3
Mar	4	5	2	2	1	1	1	0
April	1	0	3	1	5	2	3	7
May	1	0	6	1	3	0	2	0
June	3	3	5	2	2	5	2	3
July	8	8	1	0	3	0	3	2
			Total		101	67	34	35
			Mean		2.805	1.861	2.833	2.917
			Std. Dev.		1.983	2.416	1.899	2.999

TABLE II-9

C01

	69-70 # ACCS	69-70 # I+K	70-71 # ACCS	70-71 # I+K	71-72 # ACCS	71-72 # I+K	72-73 (STEP) # ACCS	72-73 (STEP) # I+K
Aug	1	2	5	5	3	4	3	1
Sept	1	1	2	1	7	3	5	4
Oct	2	0	8	2	3	0	7	4
Nov	4	0	5	3	5	2	4	1
Dec	3	1	6	3	6	3	6	3
Jan	2	1	4	4	5	2	7	3
Feb	5	4	4	2	10	6	10	4
Mar	7	1	6	3	5	1	1	0
April	1	0	7	2	6	2	2	1
May	2	2	2	1	6	4	6	3
June	4	1	5	2	4	0	1	0
July	3	3	6	1	6	4	1	0
Total					161	76	53	24
Mean					4.472	2.111	4.417	2.0
Std. Dev.					2.118	1.508	2.906	1.651

TABLE II-9

D01

	69-70		70-71		71-72		72-73 (STEP)	
	# ACCS	# I+K	# ACCS	# I+K	# ACCS	# I+K	# ACCS	# I+K
Aug	2	1	5	8	3	8	3	1
Sept	1	1	3	5	4	2	1	0
Oct	1	0	1	0	2	0	4	5
Nov	5	3	1	1	0	0	1	1
Dec	1	3	0	0	2	5	1	0
Jan	0	0	1	2	0	0	2	2
Feb	0	0	0	0	1	2	0	0
Mar	3	1	2	0	1	1	0	0
April	0	0	2	0	1	0	1	3
May	3	2	1	0	6	4	2	0
June	2	2	7	0	1	1	0	0
July	4	2	2	0	4	0	4	1
Total					72	54	19	13
Mean					2.0	1.5	1.583	1.083
Std. Dev.					1.805	2.145	1.443	1.564

TABLE II-10

CONCLUSION

The reduction of accidents and injuries was the prime objective of STEP operations in Grand Forks County North Dakota. Because total control of all the variables which influence accidents is impossible, absolute statements of cause and effect between STEP and measured reductions are not possible. Nevertheless, as a result of this evaluation, it is apparent that there were statistically significant reductions in accidents and injuries (including fatal injuries) during the period of STEP operations when compared to three previous years.

During STEP activities in Grand Forks County the following statistically significant changes occurred.

1. Accidents decreased 16.89%.
2. Injury and fatal accidents decreased 16.3%.
3. Injuries and fatalities decreased 22.6%.
4. Statewide injuries and fatalities increased 12.9%.
5. The ratio of injuries and fatalities at STEP sites to those in the rest of the State decreased 33.5%.
6. The economic loss of accidents and injuries at STEP sites decreased 42.6%.

Other pertinent findings indicate that the cost of STEP was at worst less than or equal to (probably less than) the reduction in economic loss due to accidents that occurred during STEP. Between the beginning of STEP and May 1974 no twelve month period had as many injuries and fatalities as the smallest twelve month period in the three years prior to STEP.

All the measures which STEP was designed to reduce showed statistically significant decreases during a period when those measures were increasing in the rest of the State. This does not prove absolutely that STEP caused those reductions. It does indicate a very high likelihood that STEP played a major role in reducing accidents and injuries. On the basis of the strong results found in this evaluation, the evaluators believe that STEP in Grand Forks County North Dakota was a successful program which played a major role in reducing accidents and injuries due to accidents.

SECTION III

RADAR SPEED CONTROL

BACKGROUND

This section covers the first quarter of STEP operations in Cass County, North Dakota, for the period September 1, 1973, through November 30, 1973. During this period a two month radar speed control countermeasure was performed on STEP location S01 (U.S. #81 South of Fargo).

U.S. #81 is a two lane trunk highway carrying a volume of 1,5000 ADT at milepost 55.24 to 10,000 at milepost 70.60, with cross traffic counts of 100 to 7,035 at various intersections throughout the 15.5 miles of highway between Fargo and the Cass County line. Most of this highway carried a posted speed limit of 65 mph with a 55 mph limit after 2200 hours during the period under consideration.

At the time this countermeasure was undertaken a nearby section of Interstate I-29 was scheduled to open November 1, 1973, and it was assumed that a substantial portion of U.S. #81 traffic would divert to I-29. It was decided to utilize this portion of U.S. #81 during the two months preceding the opening of I-29 to determine the relative effects of public information versus visible radar enforcement on speeding patterns. Historical data suggested that speed was a significant factor in a number of accidents on this highway.

COUNTERMEASURE DESCRIPTION

The radar speed control countermeasure on U.S. #81 was designed to utilize four officers for two months (September and October) with coverage during a seventeen hour period of each day.

They were utilized not only to enforce speeding but also to perform several periodic speed and volume surveys throughout the course of the operations. The objective of this countermeasure was to determine how a strong public information program coupled with intensive radar enforcement would effect speed distributions.

The countermeasure called for six distinct phases as outlined below:

Week of September 3 through September 9

During this period a week long radar speed and volume survey was conducted from unmarked vehicles at five locations along the 15.5 mile stretch of roadway. There was no public information regarding the operation and there was no speed enforcement during this week. During this seven day count 5,016 northbound and 5,401 southbound vehicles were checked between the hours of 0900 and 2200. Records were maintained by hour of day and day of week on the number of vehicles and their speeds.

Week of September 10 through September 16

At the conclusion of the first week of no public information and no enforcement an extensive public information campaign was launched in the local media announcing that radar speed enforcement would be undertaken. This campaign was conducted concurrently with a second week of speed and volume counts, but with still no enforcement. During this week 4,243 northbound and 4,063 southbound vehicles were checked.

September 17 through October 7

At the conclusion of the above second week-long survey, an intensive three week period of radar speed enforcement was applied along with continuing public information. Visible, marked vehicles were used. Following this three week period a third week-long survey was conducted as noted below.

Week of October 8 through October 14

During this week speed and volume counts were repeated with 4,452 northbound and 4,464 southbound vehicles recorded. This survey constituted the midpoint measurement prior to resuming the final two weeks of enforcement.

October 15 through October 24

During this period radar speed enforcement was again resumed.

Week of October 25 through October 31

During this last week of the countermeasure, and prior to relinquishing the location to routine patrol coverage, the STEP Task Force conducted the fourth and final week-long speed and volume count with 4,758 northbound and 5,187 southbound vehicles recorded.

At the conclusion of this exercise the number of vehicles clocked and their respective speed ranges by time of day, day of week and milepost location for each of the four surveys were recorded in a format suitable for analysis. That contingent of the STEP Task Force conducting this operation then begin an accident prevention and traffic enforcement program at another location in Cass County.

HISTORICAL DATA FOR U.S. #81

Prior to examining the results obtained during this two month effort, it will be useful to review a summary of the violations, accidents and speed-related factors occurring along this 15.5 mile stretch of highway in months preceding the STEP activity there.

Table III-1 summarizes accidents by time of day and day of week for the period September 1, 1972, through July 31, 1973. Table III-2 summarizes accidents for the same period by month and by type.

ACCIDENT DISTRIBUTION

U.S. # 81 Sept. /72 thru July/73

Time of Day	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	TOTAL
0001 - 0100	1				1			2
0101 - 0200	1		1					2
0201 - 0300	1							1
0301 - 0400								0
0401 - 0500							1	1
0501 - 0600								0
0601 - 0700								0
0701 - 0800								0
0801 - 0900								0
0901 - 1000						2		2
1001 - 1100			2			1		3
1101 - 1200		1			1			2
1201 - 1300						1	1	2
1301 - 1400				3		2	1	6
1401 - 1500		1	2	1		2	4	10
1501 - 1600	1		1	2		2	1	7
1601 - 1700		1				1	1	3
1701 - 1800			2		1	1	1	5
1801 - 1900		2		1	2	4	1	10
1901 - 2000	1	1	2	1		2		7
2001 - 2100	2		1	1	2	2		8
2101 - 2200				1	2		1	4
2201 - 2300	1	1	1			2		5
2301 - 2400			1					1
TOTAL	8	7	13	10	9	22	12	81

TABLE III-1

ACCIDENT DISTRIBUTION BY

MONTH AND TYPE

U. S. # 81 Sept./72 thru July/73

MONTH	TOTAL	DAMAGE	INJURY	FATAL	# INJ.	# KILLED
Sept./72	5	5				
Oct./72	9	8	1		2	
Nov./72	8	8				
Dec./72	13	12	1		1	
Jan./73	10	7	3		6	
Feb./73	3	3				
Mar./73	8	8				
Apr./73	9	5	4		3	
May/73	6	6				
June/73	8	6	2		3	
July/73	2	2				
TOTAL	81	70	11		15	

TABLE III-2

In Table III-3 these accidents are presented by milepost location and accident type. In addition, the range of reported speed of the vehicles involved in the accidents are tabulated as well as the number of accidents at each location which were cited, and if speed or alcohol violations were cited. These figures indicate that more than half of all accidents occurred in the vicinity of milepost 70, with 70% of all accident-related citations issued there, and 70% of all accident-related speeding infractions cited there.

In Table III-4 the violation distribution for each month of the year preceding STEP activities at this location are shown. Speeding accounted for 70% of all cited violations at this location.

ACCIDENT DISTRIBUTION BY MILEPOST AND SPEED RELATED FACTORS

U. S. # 81 — Sept./72 thru July/73

MILEPOST LOCATION	ACCIDENT TYPE P/D	ACCIDENT TYPE INJ.	VEHICLE SPEED 0-20	VEHICLE SPEED 21-40	VEHICLE SPEED 41-50	VEHICLE SPEED 51-60	VEHICLE SPEED 60+	VEHICLE SPEED UNK.	NBR. CITED	CITED FOR SPEED	CITED FOR ALCO.
56.01 - .99	1		1								
57.01 - .99											
58.01 - .99											
59.01 - .99	1					1					
60.01 - .99	1	1				2			1	1	
61.01 - .99	1	1		1	1				2		
62.01 - .99											
63.01 - .99											
64.01 - .99	2	1	1		2				2	1	
65.01 - .99	2		1		1				1	1	
66.01 - .99	2							2	1		
67.01 - .99	2	1		1	1	1			1		
68.01 - .99		1			1				1		1
69.01 - .99	8			2	1	1		4	6	4	
70.01 - .99	45	6	16	22				18	43	16	1
TOTAL	70	11	19	26	7	5		24	58	23	2

TABLE III-3

VIOLATION TYPE BY MONTH

U.S. # 81 — Sept./72 thru Aug./73

VIOLATION	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	TOTAL
SPEED	20	11	11	2	7	22	6	5	10	4	0	7	105
DWI	0	1	0	1	1	0	0	0	1	1	0	1	6
OPEN CONTAINER	1	0	0	0	0	1	0	0	2	0	0	1	5
RIGHT OF WAY	0	1	0	0	0	0	0	0	0	0	0	0	1
IMPROPER TURN	0	0	0	0	0	0	0	0	0	0	0	0	0
STOP SIGN	0	0	0	0	0	0	0	0	0	0	0	1	1
IMPROPER PASSING	0	0	0	0	0	1	1	0	1	1	0	0	4
FOLLOWING TO CLOSE	0	0	0	0	0	0	0	1	1	0	0	0	2
OTHER HAZARDOUS	0	1	1	0	0	0	1	2	2	0	0	1	8
NON-HAZARDOUS	0	0	0	0	0	0	0	0	5	0	0	0	5
DRIVER LICENSE	3	1	1	0	0	2	0	2	2	0	1	0	12
TOTAL	24	15	13	3	8	26	8	10	24	6	1	11	149

TABLE III-4

OPERATIONAL RESULTS ON U.S. # 81

During the initial survey, and prior to any enforcement or public announcements, unmarked vehicles recorded the following speed distribution for the 10,417 vehicles checked during the period September 3 through September 9.

SPEED IN MPH

	Less than 55	55-59	60-64	65-69	70-74	75-79	80-84	85+
%	23.19	21.89	26.77	18.50	6.64	2.23	.52	.26

At the conclusion of the above survey, intensive local media coverage stressed the upcoming radar speed control campaign and the survey was then repeated and 8,306 vehicles were checked the week of September 10 with the following results.

SPEED IN MPH

	Less than 55	55-59	60-64	65-69	70-74	75-79	80-84	85+
%	29.08	24.32	28.59	13.99	3.06	.73	.24	0

Following this, three weeks of radar coverage in marked vehicles was applied and the survey repeated for another week with 8,916 vehicles recorded. The following distribution was observed.

SPEED IN MPH

	Less than 55	55-59	60-64	65-69	70-74	75-79	80-84	85+
%	35.04	25.31	24.71	13.19	1.53	.13	.12	0

Following this, radar enforcement was resumed until October 25 when the final survey was conducted with 9,945 vehicles recorded.

SPEED IN MPH

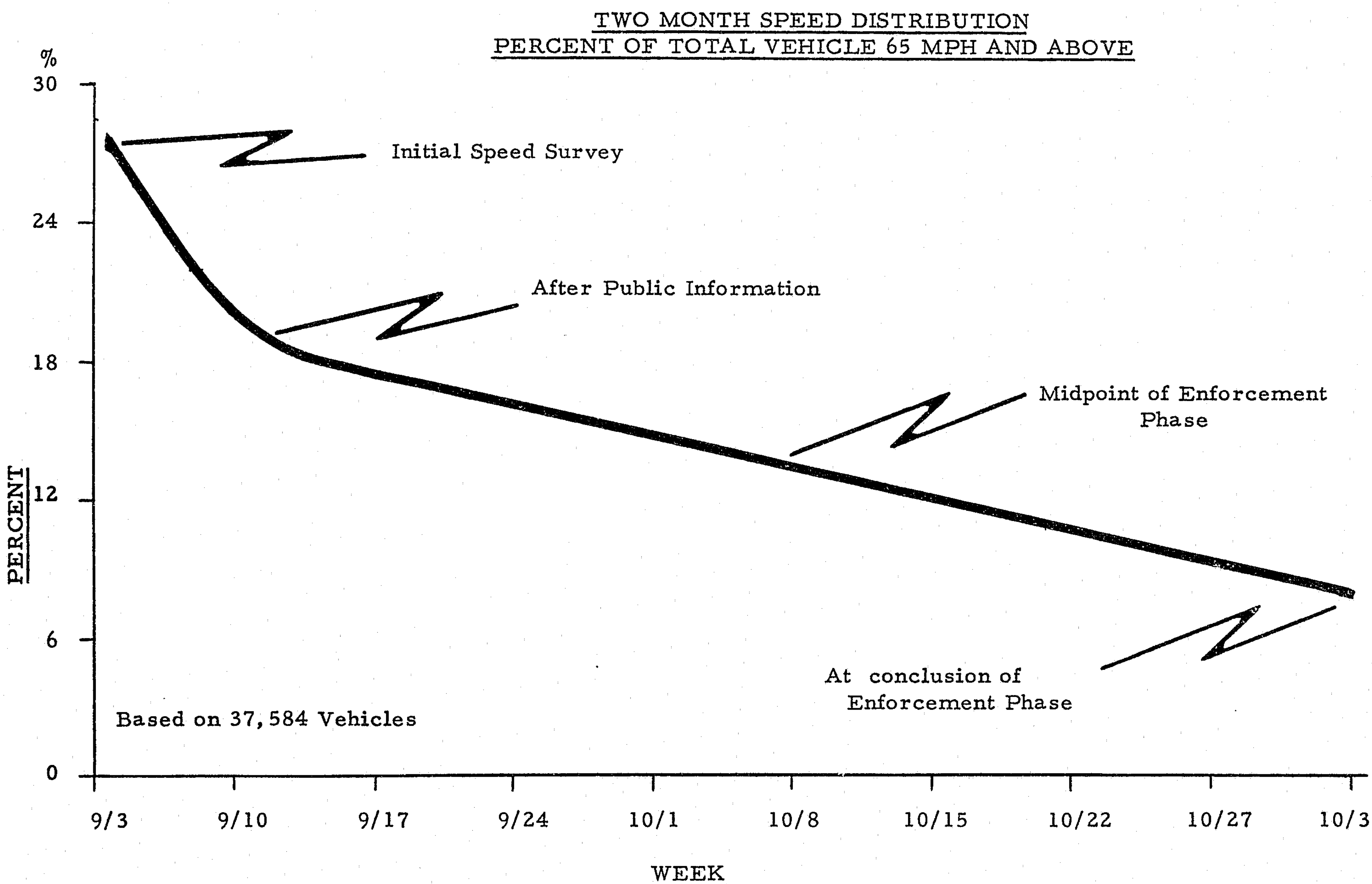
	Less than 55	55-59	60-64	65-69	70-74	75-79	80-84	85+
%	41.82	22.32	25.43	8.18	1.85	.38	0	.02

A comparison of these four distributions reveals a significant change in driver behavior with respect to vehicle speed. Altogether, there was an 18% reduction in the number of vehicles at speeds of 65 mph or above. Figure III-1 depicts a fitted curve of percentage reduction in this speed range over the two months of STEP operations on U.S. # 81.

Figure III-2 summarizes the results of the four surveys under three ranges of recorded speed: 0-64 mph, 65-74 mph and 75 mph or above. As noted there, public information above resulted in a 10% increase in those drivers observed in compliance with the 65 mph posted limit, with corresponding reductions in the other two speed ranges. Following three weeks of radar enforcement an additional 3% increase in drivers in compliance was observed. By October 31, nearly another 5% increase in drivers in compliance was observed.

Altogether during the two month operation, 18% more drivers were observing the posted speed limit at the conclusion of the program than were initially. The ratio of drivers in the 65-74 mph range was reduced by more than 50% and those in excess of 75 mph were reduced to a negligible figure (less than one half of one percent).

A three month comparison for violations cited is presented in Table III-5. As would be expected, speeding violations increased rapidly in September and October and begin to decline during November when routine



TWO MONTH SPEED DISTRIBUTION
PERCENT OF TOTAL VEHICLE 65 MPH AND ABOVE
%
30
24
18
12
6
0
PERCENT
Initial Speed Survey
After Public Information
Midpoint of Enforcement Phase
At conclusion of Enforcement Phase
Based on 37,584 Vehicles
9/3
9/10
9/17
9/24
10/1
10/8
10/15
10/22
10/27
10/31
WEEK

FIGURE III-1

SPEED DISTRIBUTIONS OF FOUR SURVEYS ON U.S. # 81

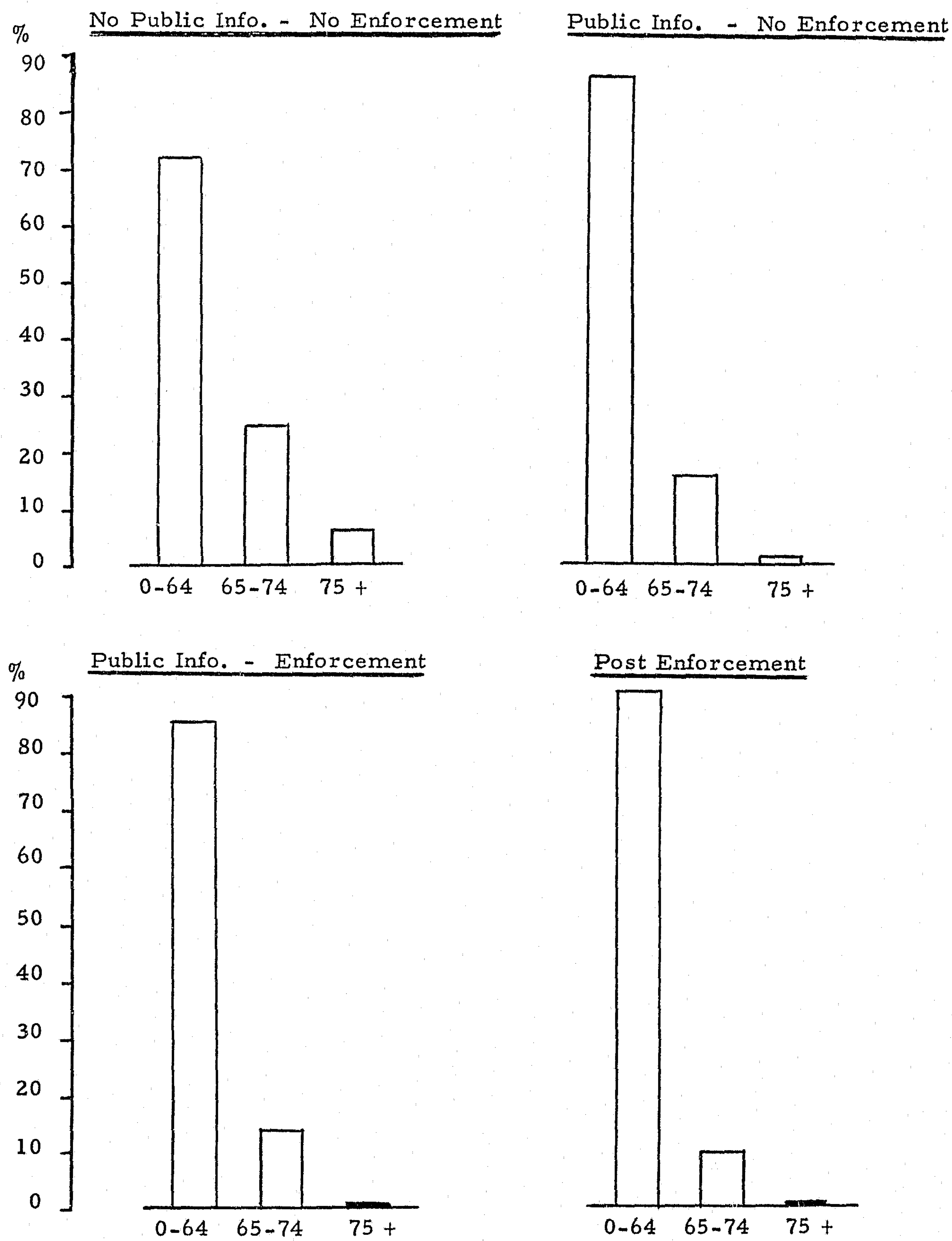


FIGURE III-2

patrol coverage was resumed. It should also be noted that November, 1973 figures may not be particularly relevant for comparison purposes since it is assumed that the opening of I-29 diverted a significant portion of U.S. #81 traffic.

THREE MONTH COMPARATIVE VIOLATION SUMMARY

U. S. # 81	72	73		72	73	Sept.	72	73	Oct. -72/73	
VIOLATION	Sep.	Sep.		Oct.	Oct.		Nov.	Nov.		Incr.
SPEED	20	36		11	84		11	4		83
DWI	0	1		1	2		0	0		2
OPEN CONTAINER	1	0		0	4		0	0		3
RIGHT OF WAY	0	0		1	0		0	0		0
IMPROPER TURN	0	0		0	0		0	0		0
STOP SIGN	0	0		0	1		0	3		4
IMPROPER PASSING	0	0		0	0		0	2		2
FOLLOWING TO CLOSE	0	0		0	0		0	0		0
OTHER HAZARDOUS	0	0		1	0		1	2		0
NON-HAZARDOUS	0	0		0	0		0	0		0
DRIVER LICENSE	3	0		1	3		1	2		0
TOTAL	24	37		15	94		13	13		

TABLE III-5

CONCLUSIONS AND RECOMMENDATIONS

A number of observations suggested by the results of this operation may be made. However, it is not certain to what extent such observations can be generalized to fit other locations. Certainly the size of the samples recorded in the four surveys (in excess of 37,000 vehicles) should substantiate the impacts observed at this one location as being highly relevant and statistically significant.

It is particularly interesting to note that over half of the impact on observed changes in driver speeds resulted solely from public information and with no influence from actual enforcement or even the presence of marked patrol vehicles.

This may suggest that selective deployment of radar units for short duration at various locations, if preceded by public information, could achieve the same effect as considerably larger deployment of units without intensive public information coverage. The implication, of course, being an increased utilization of radar units, increased cost/benefit and improved resource allocation.

SECTION IV

CASS COUNTY

BACKGROUND AND INTRODUCTION

This section presents a review and evaluation of the effectiveness of the Selective Traffic Enforcement Program (STEP) in Cass County, North Dakota, for the period September 1973 to November 1974. Insofar as the main objective of STEP was the reduction in the number and severity of traffic accidents, the measurement of effectiveness was based on changes in accidents during enforcement. Vitally important also was the use of changes in the number of injuries, which represents the severity of the accidents recorded as an indicator of enforcement effectiveness. The number of fatalities was not used as an indicator due to the small number during STEP operations.

The evaluation of an enforcement program designed to reduce traffic accidents is complex. It requires the control of all outside influences for results to be completely dependable. Some of the factors are measurable, such as seasonal trends, traffic volumes, speed distributions and the number of citations. The usual approach of evaluation is a comparative analysis of accident frequencies during enforcement to historical accident trends prior to enforcement. The assumption is made that the factors influencing accidents remain constant and any changes in accident trends can be attributed to the enforcement program. The measure of effectiveness depends on the magnitude of the change.

The usual evaluative approach, such as that used in the pre-energy crisis evaluation of Grand Forks County, was not appropriate for the evaluation of STEP operations in Cass County. The time period of STEP was unique in that enforcement was accompanied by a nationwide energy crisis. The shortage of fuel made before and after comparisons to determine the impact of enforcement, meaningless. A complete differentiation between the impact of the energy crisis and the impact of enforcement was not possible, so any changes in accident trends from prior periods could not be attributed to enforcement alone.

National Energy Crisis

Nationally, there was a marked decrease in the number and severity of traffic accidents in 1974. This can be attributed to a combination of several factors that influence highway safety. Reductions in speed, traffic volume and shift in travel patterns all contributed to the reduction, but no single factor can be shown to be dominant.

The imposition of a 55 mph speed limit has not been proven to be the lifesaver it was claimed to have been. Fatal accidents were down almost as much on city streets not affected by 55 mph speed limits as they were on high speed roads. Fatal accidents, on roads with less than 55 mph limits, were down 75% as much as those on roads with previously posted speeds of 55 mph and over. The trend seemed to be a reduction of extreme speeds, with a corresponding increase in numbers driving in a uniform pace. In 1974, the number of vehicles within a 10 mph pace increased 20%. In general, speeds have not slowed down to 55 mph; instead, the majority (70%) are found driving in a range 55-65 mph. Very few speeds of 70-80 mph were found in 1974 in contrast to 1973.

An interesting phenomenon was that pedestrian deaths, which usually occur in urban areas (65%) and are unlikely to be affected by speed limit changes, revealed a substantial decrease. The first seven months of 1974 pedestrian deaths were down 24.7% from the same period in 1973. In rural areas the drop was 23% and in urban areas the drop was 26%.

Travel volumes also declined in 1974 when compared to the same period in 1973. The first eight months declined almost 4% from the same period of the previous year. On main rural roads, the decline was even greater, approximately 4.6%. A measure of long distance passenger travel is the traffic volume on rural Interstate highways serving major corridors. In early 1974, the traffic volumes decreased anywhere from 20% to 40% on these Interstates, when compared to 1973. The greatest portion of this drop was found to be on weekends. Travel on weekends was down approximately 50% more than that on weekdays.

An explanation of the decrease in number and severity of traffic accidents is a difficult task to perform. The role of the reduced speed limits is not obvious. Even though accidents fell during the same time period, factors such as traffic volumes and patterns, and attitudes, have changed also. For this reason, the isolation of any single factor as being primarily responsible for overall accident reductions is highly questionable.

Cass County

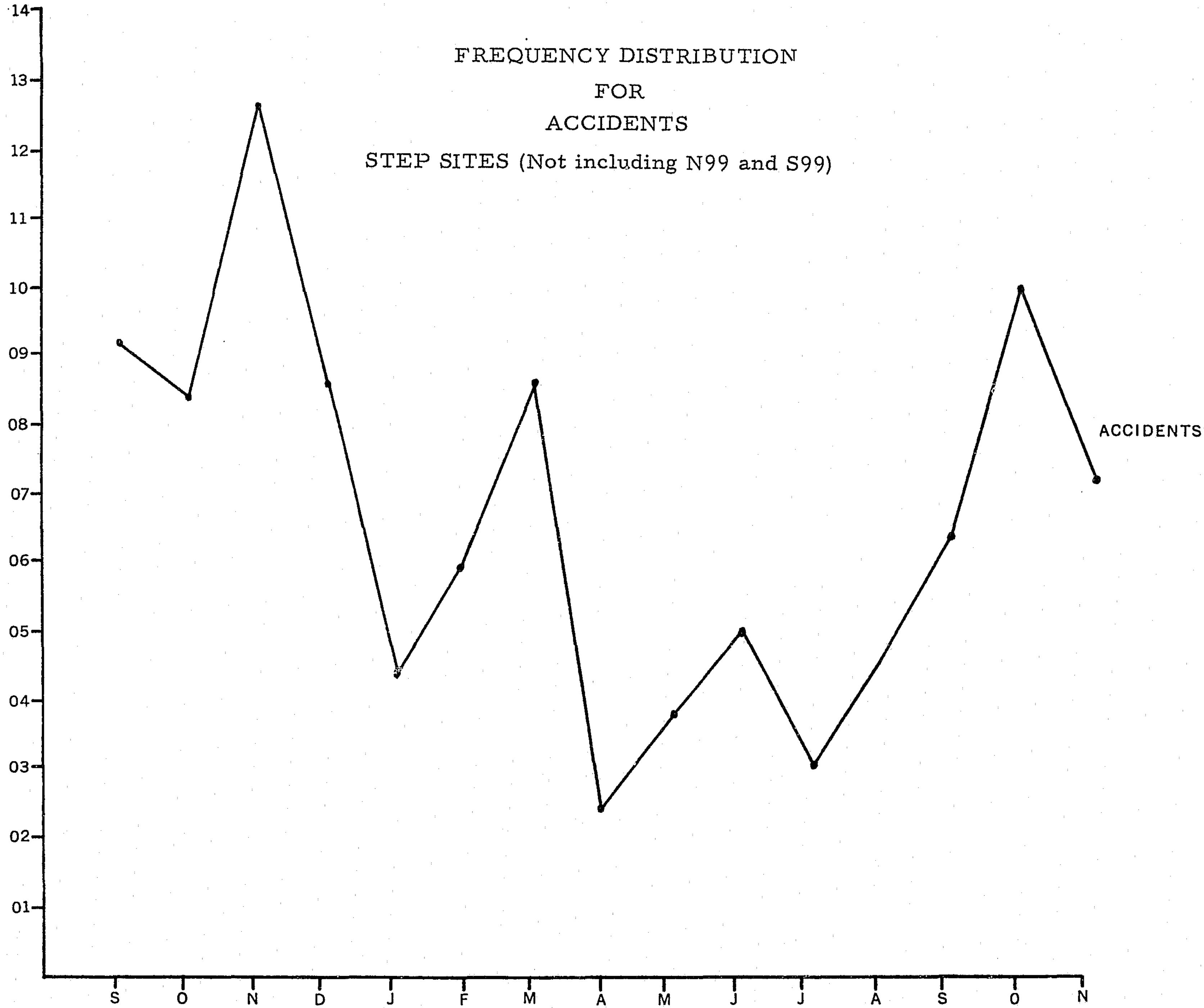
Because the influence of the energy crisis on traffic accidents in Cass County could not be separated from the influence of STEP for a before and after comparison, it was necessary to examine the data from a different perspective.

It was found that traffic indicators in the entire State of North Dakota, as well as in Cass County, display consistent seasonal patterns. In a monthly index of traffic accidents for North Dakota, computed for calendar years 1969-1973, March through August had the six smallest indices (Table IV-1). The patterns were similar for Cass County data during STEP. Periods of mild weather were accompanied by fewer accidents than periods of inclement weather (Graph IV-1).

NORTH DAKOTA
TOTAL ACCIDENTS
1969 - 1973

MONTH	1969	1970	1971	1972	1973
January	2,815	2,186	2,497	1,009	1,242
February	2,057	1,739	1,920	1,719	1,273
March	2,043	1,762	1,499	1,672	858
April	1,371	1,506	1,367	887	1,052
May	1,504	1,590	1,435	1,303	1,150
June	1,490	1,581	1,541	1,546	1,203
July	1,548	1,641	1,487	909	1,442
August	1,519	1,695	1,561	1,510	1,442
September	1,620	1,844	1,645	1,565	1,568
October	2,043	2,110	1,858	1,893	1,324
November	1,764	2,303	1,682	1,817	1,301
December	2,487	2,479	2,221	2,243	1,325
TOTAL	22,261	22,438	20,240	18,289	15,190

TABLE IV-1


FREQUENCY DISTRIBUTION
FOR
ACCIDENTS
STEP SITES (Not including N99 and S99)
ACCIDENTS
14
13
12
11
10
09
08
07
06
05
04
03
02
01
S
O
N
D
J
F
M
A
M
J
J
A
S
O
N

GRAPH IV-1

Traffic volumes revealed seasonal trends contrary to those for accidents. During Spring and Summer, Average Daily Traffic (ADT) and Vehicles Miles were substantially higher than that of Fall and Winter. This seasonal pattern was maintained regardless of the change in actual volume. ADT's, expressed as a percentage of the total for Cass County, declined an average of 4.4% during the months of September 1973 to November 1974 when compared to the previous year, but still maintained the identical seasonal patterns (Graph IV-2) In contrast, periods of high accident frequencies were accompanied with relatively low traffic volumes, revealing the impact of the seasonal influence on traffic accidents. The seasonal traffic patterns that existed prior to the energy crisis remained in Cass County and North Dakota after the shortage of fuel set in. This reflects that any energy crisis influence was distributed over the entire STEP period and did not influence month to month variations.

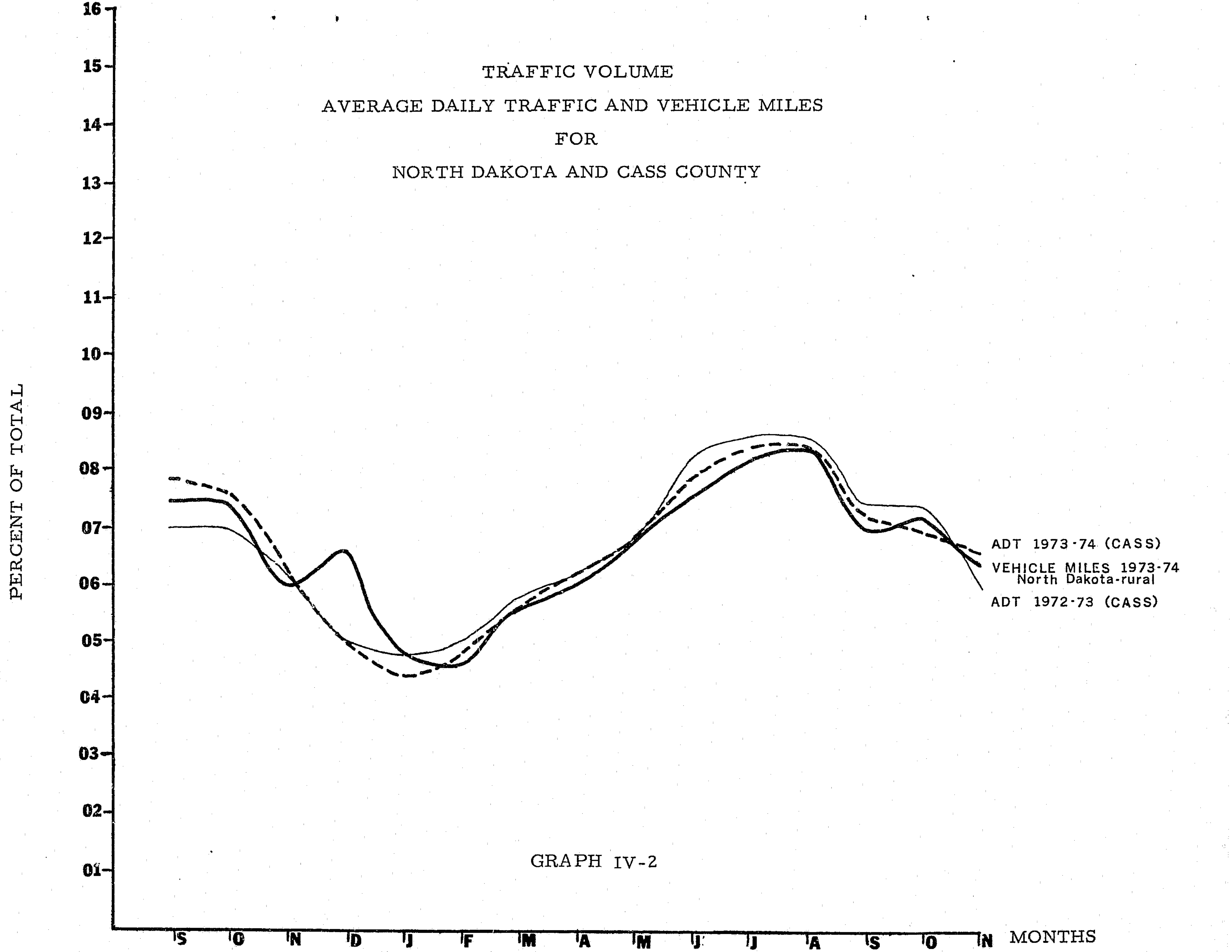
The basis of the earlier evaluation in Grand Forks County was comparison of baseline accident data with accident data during STEP. Enforcement effectiveness was measured by changes in accident frequencies during STEP with historical patterns in the County. However, due to the energy crisis and reduced speed limits, the Cass County evaluation differed substantially. The primary strategy was to analyze all significant changes in accidents and injuries during STEP operations with the corresponding allocations of manpower. Effectiveness was determined by measuring how closely changes in allocation of enforcement compared with changes in accident frequencies. Once a relationship was established, the validity of the relationship was tested.

TRAFFIC VOLUME

AVERAGE DAILY TRAFFIC AND VEHICLE MILES

FOR

NORTH DAKOTA AND CASS COUNTY



GRAPH IV-2

EVALUATION METHODOLOGY

The methodology used was designed to examine trends in the movements of STEP data parameters. The objective was to analyze all significant changes in accidents and injuries with the corresponding allocations of STEP manpower. The measurement of effectiveness was dependent on how closely changes in allocation of manpower compared with changes in accident frequencies. Once the relationship was established, the validity of the theoretical assumptions behind the relationship was tested.

A moving average was calculated for both total accidents and manhours during the STEP program. This was designed to reveal any movement tendencies without being severely handicapped by sharp fluctuations. Once a relationship was established, correlational analysis was used to reveal the strength of association between manhours and accidents. Both parametric and non-parametric tests were employed. The non-parametric test was used in case the samples could not be considered of interval scale and from a normal population. Partial correlations were performed to test for a spurious relationship between manhours and accidents. By holding constant the effect of other variables, the validity of the assumptions behind the manhour and accident relationship could be tested.

Data collected from the County was separated and analyzed for each highway under the enforcement plan. Emphasis was placed on the highways actively patrolled by the task force. Areas N99 and S99 were excluded from a majority of the calculations, due to the minimal enforcement on them during the reporting period.

There were four types of enforcement countermeasures:

1) marked vehicle in stationary environment (PO1),

2) marked vehicle in moving observation (PO3),

3) patrol and citations for hazardous moving violations (P11) and

4) radar speed detection (P12).

Countermeasure, PO3, "marked vehicle in moving observation", represented 90% of the average monthly manhours total.

Total accidents, property damage accidents, injury accidents and the number of injuries were isolated for comparison with enforcement allocations. Fatal accidents included in the total accident were not analyzed as a group, due to the small number during STEP.

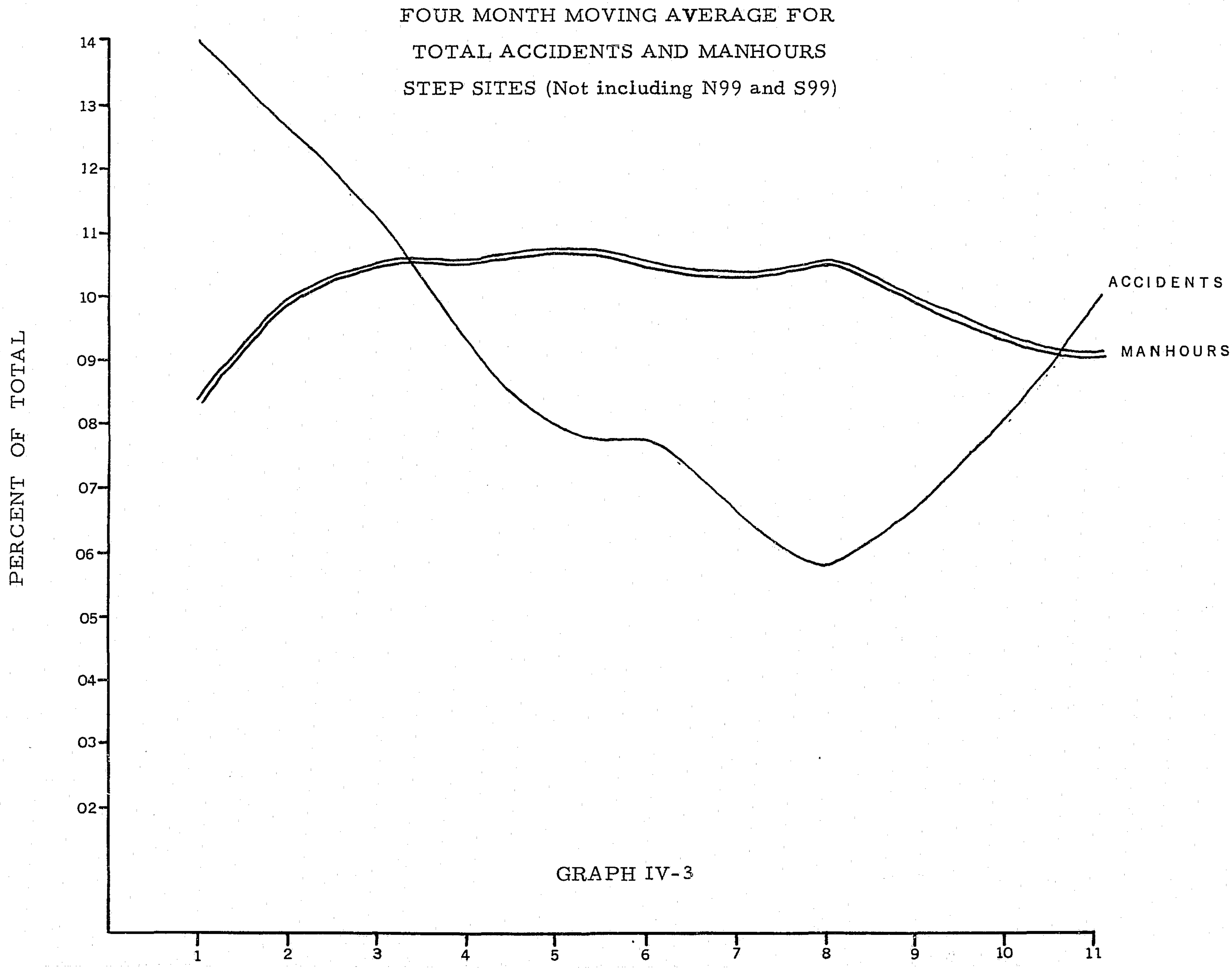
STEP evaluation was performed separately for each site. However, the totals from the combined sites are more meaningful, due to the relatively small number of accidents at each site.

EVALUATION RESULTS

Correlation Analysis

The four month moving average of total accidents declined sharply over the first eight periods, followed by an increase for the last three periods (Graph IV-3). When expressed as a percentage of the total, the moving average for accidents declined from a high of 14% of the total, to a low of 6% of the total in the eighth period. From this point, the moving average rose steadily to above 10% of the total in the last period. The same calculation for manhours showed a tendency to increase substantially and remain stable for the first eight periods and decline for the remainder. When expressed as a percentage of the total, the shift seems insignificant, but actually represents a substantial change in manhours. At the point where manhours decline, the total accident average began to rise. The decline in manhours was due to a shift to the grouped highways (N99 and S99), which were not included in the calculations. Little significant statistical inference can be drawn from the moving average other than to reveal movement tendencies.

The moving average tests revealed a tendency for total accidents and manpower volume to be inversely related. Because of this, the evaluation process was expanded to measure the strength of association between accidents and manhours through the use of correlation analysis. Parametric, non-parametric and partial correlations were performed to examine the relationships of the variables under different assumptions. Constraints, such as the energy crisis, reduced speed limits and seasonal influences and were interjected into the basic approach in an attempt to test the reliability of the results. Care was taken to prevent conclusions being drawn from invalid assumptions.


FOUR MONTH MOVING AVERAGE FOR
TOTAL ACCIDENTS AND MANHOURS
STEP SITES (Not including N99 and S99)
PERCENT OF TOTAL
14
13
12
11
10
09
08
07
06
05
04
03
02
ACCIDENTS
MANHOURS
1
2
3
4
5
6
7
8
9
10
11

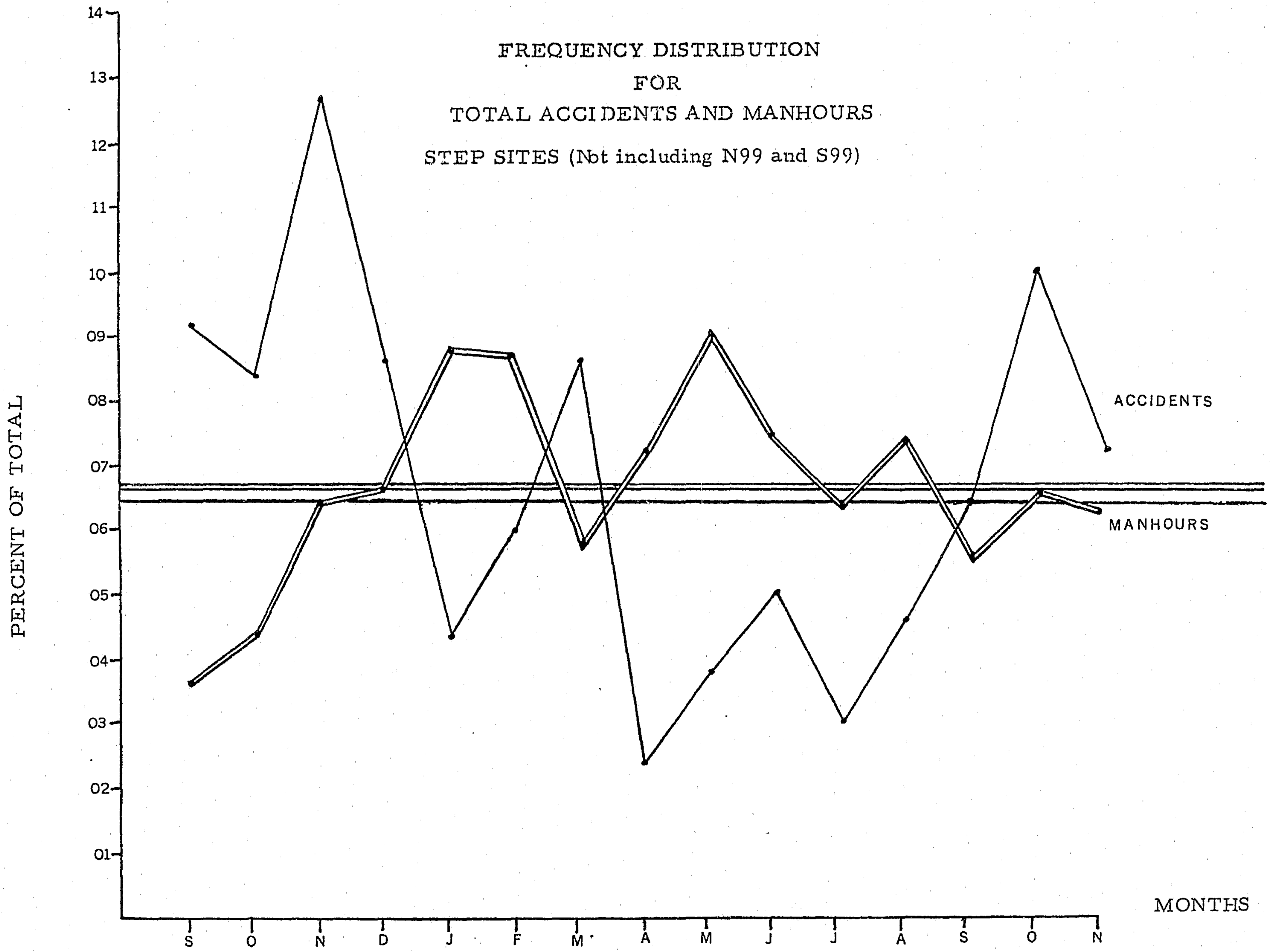
GRAPH IV-3

A correlational analysis was used (Pearson product-moment correlation) to reveal the strength of association between manhours and accidents. The result was a strong inverse relationship, expressed by a correlation coefficient of -.5313. This figure was supported by a 98% significance level. Property damage and personal injury accidents also displayed a strong inverse relationship with manhours. This analysis that a significant trend existed for accidents to be high when manhours were low, and for accidents to be low when manhours were high. In only two of the fifteen months not falling on the median did accidents and manpower lie on the same side of their respective medians (Graph IV-4). In October, 1974, accidents were above the accident median when manhours were marginally above manhour median. July, 1974, recorded accidents below the accident median when manhours were below the manhours median.

The number of injuries also expressed a negative correlation with manhours, with a correlation coefficient of -.4062. August and October were the only months that recorded an injury total above the injury median when the manhours were also above the manhour median (Graph IV-5). However, July and March displayed injury totals below their median when enforcement was below its corresponding median.

As would be expected, injuries correlated positively with accidents and maintained the same seasonal pattern. The only discrepancies were found in March and November. March, 1973, recorded a total accident count twice that of injuries, when expressed as a percentage of the total. In November, 1974, accidents were approximately 7% of their total, while injuries were almost 11% of their total (Graphs IV-4 and IV-5).

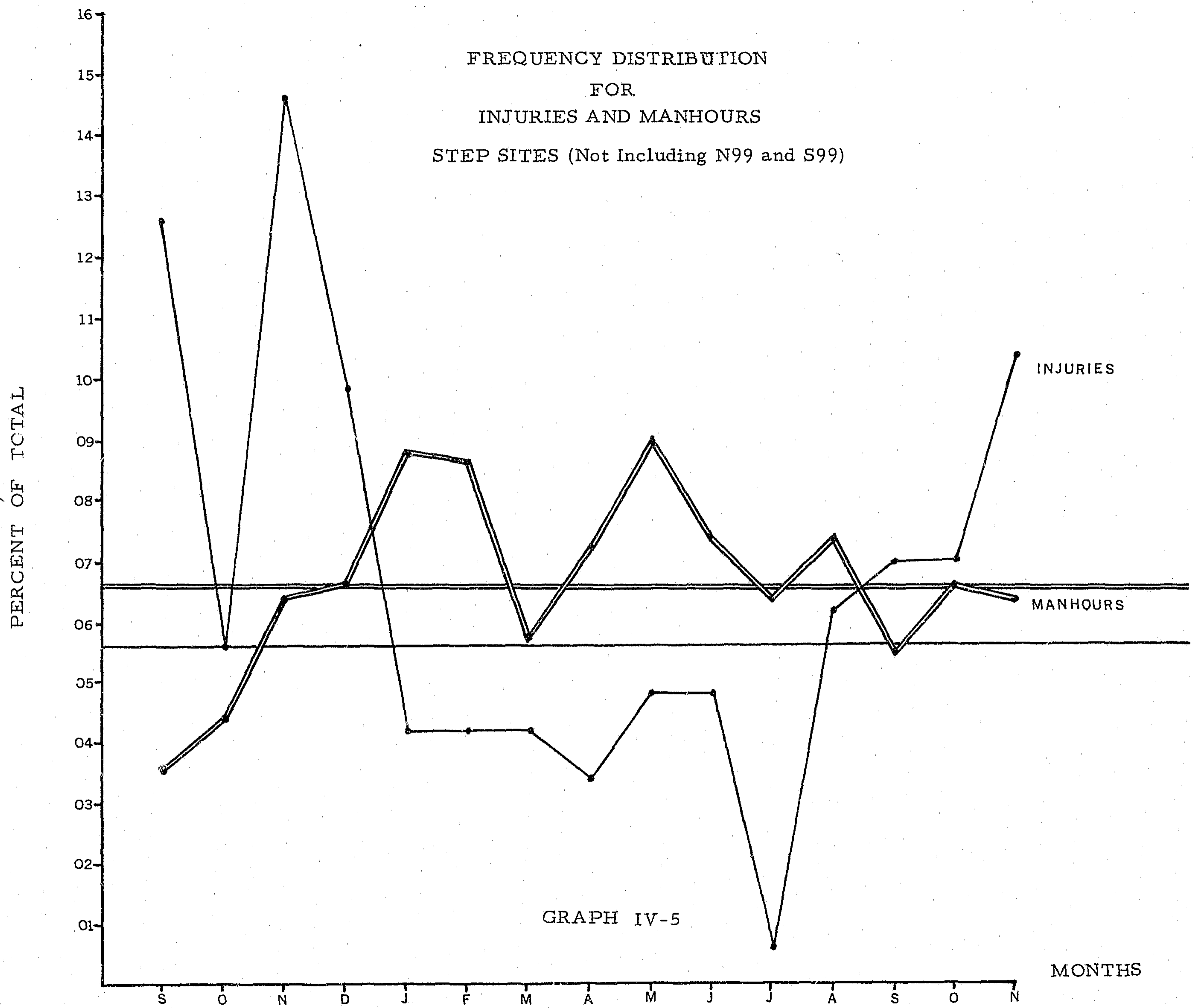
Of the countermeasures that make up total manhours, a vehicle in moving observation provided the strongest negative correlation with accidents.

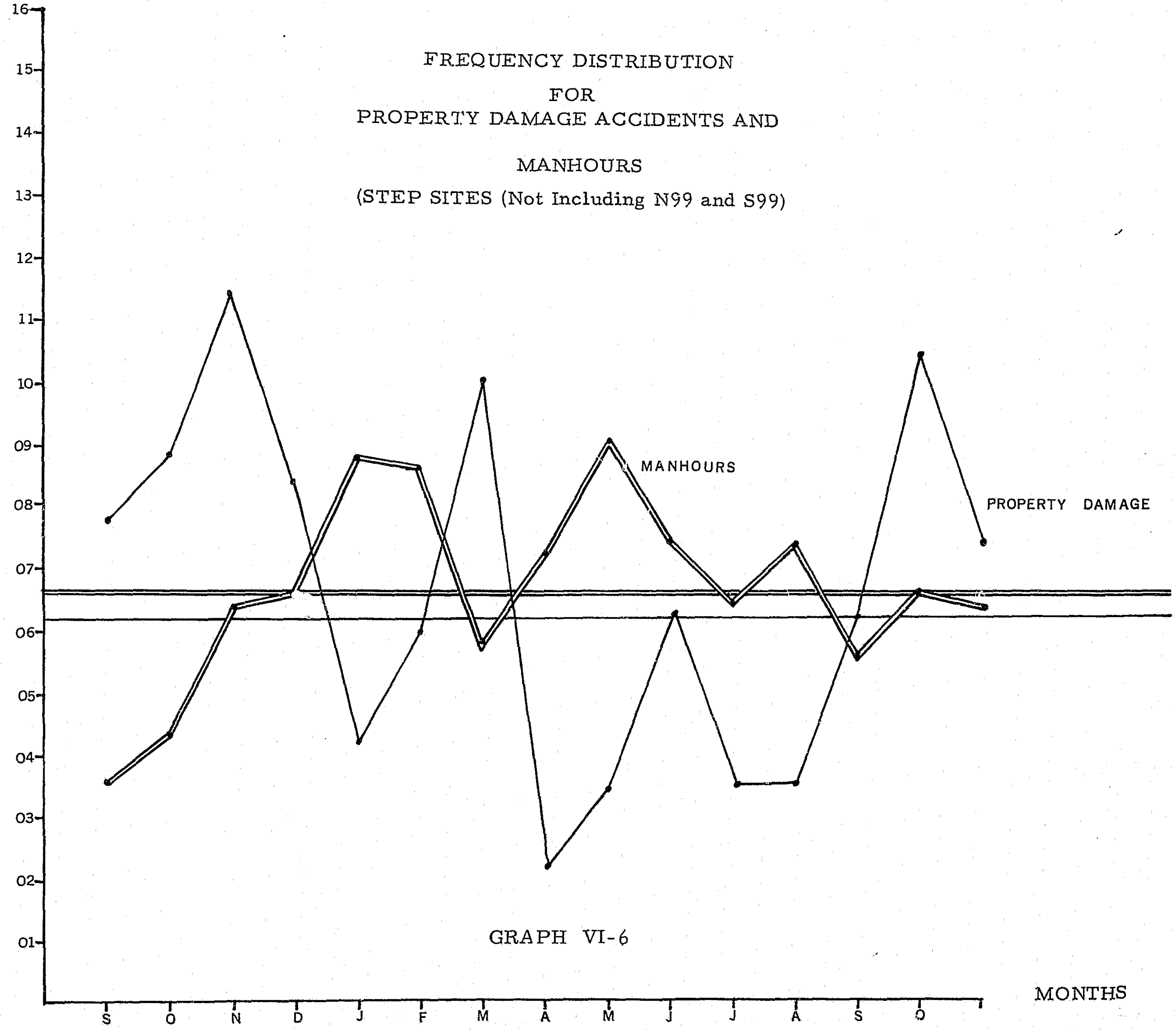

FREQUENCY DISTRIBUTION
FOR
TOTAL ACCIDENTS AND MANHOURS
STEP SITES (Not including N99 and S99)
PERCENT OF TOTAL
14
13
12
11
10
09
08
07
06
05
04
03
02
01
ACCIDENTS
MANHOURS
MONTHS
S
O
N
D
J
F
M
A
M
J
J
A
S
O
N

GRAPH IV-4

CONTINUED

1 OF 3


FREQUENCY DISTRIBUTION
FOR
INJURIES AND MANHOURS
STEP SITES (Not Including N99 and S99)
PERCENT OF TOTAL
16
15
14
13
12
11
10
09
08
07
06
05
04
03
02
01
INJURIES
MANHOURS
GRAPH IV-5
MONTHS
S
O
N
D
J
F
M
A
M
J
J
A
S
O
N


FREQUENCY DISTRIBUTION
FOR
PROPERTY DAMAGE ACCIDENTS AND
MANHOURS
(STEP SITES (Not Including N99 and S99)
PERCENT OF TOTAL
16
15
14
13
12
11
10
09
08
07
06
05
04
03
02
01
MANHOURS
PROPERTY DAMAGE
MONTHS
S
O
N
D
J
F
M
A
M
J
J
A
S
O

GRAPH VI-6

Notably, manhours revealed a stronger negative correlation with accidents than did citations. The correlation coefficient between citations and accidents was calculated at -.2869 with a significance level of 85%. Based on this, it would appear that visible patrol had a greater impact on accident frequency than citations.

Of the individual STEP sites, SO3 had the strongest negative correlation between accidents and manhours, with a coefficient of -.5191, at a significance level of 97%. SO3 was alloted 5,490 manhours, which represents 31% of the total STEP enforcement, and the largest total of any of the individual sites (Table IV-2).

STEP site NO2 had the highest accident average, with a mean of 8.9 accidents per month, but still showed an inverse relationship with manhours. A coefficient of -.3924 was calculated, supported by a significance level of better than 92%. Like SO3, NO2 was assigned a large portion of the total STEP enforcement (Table IV-2).

The Pearson correlations require that samples be of interval scale and from a normal population. To guard against invalid assumptions, the Spearman Rank-order, non-parametric, correlation method was employed. The Spearman method enables relationships to be discovered without any assumptions about the data or its distribution. If the assumptions made in the parametric test were invalid, the coefficient from the non-parametric test should be substantially different. The coefficient for manhours and accidents was computed at -.5791, representing a strong negative association. These non-parametric tests confirmed the results obtained in the preceding analysis.

A partial correlation was performed for accidents and manhours while removing for the seasonal fluctuations of accidents. A monthly

MANPOWER DISTRIBUTION

(MANHOURS)

BY

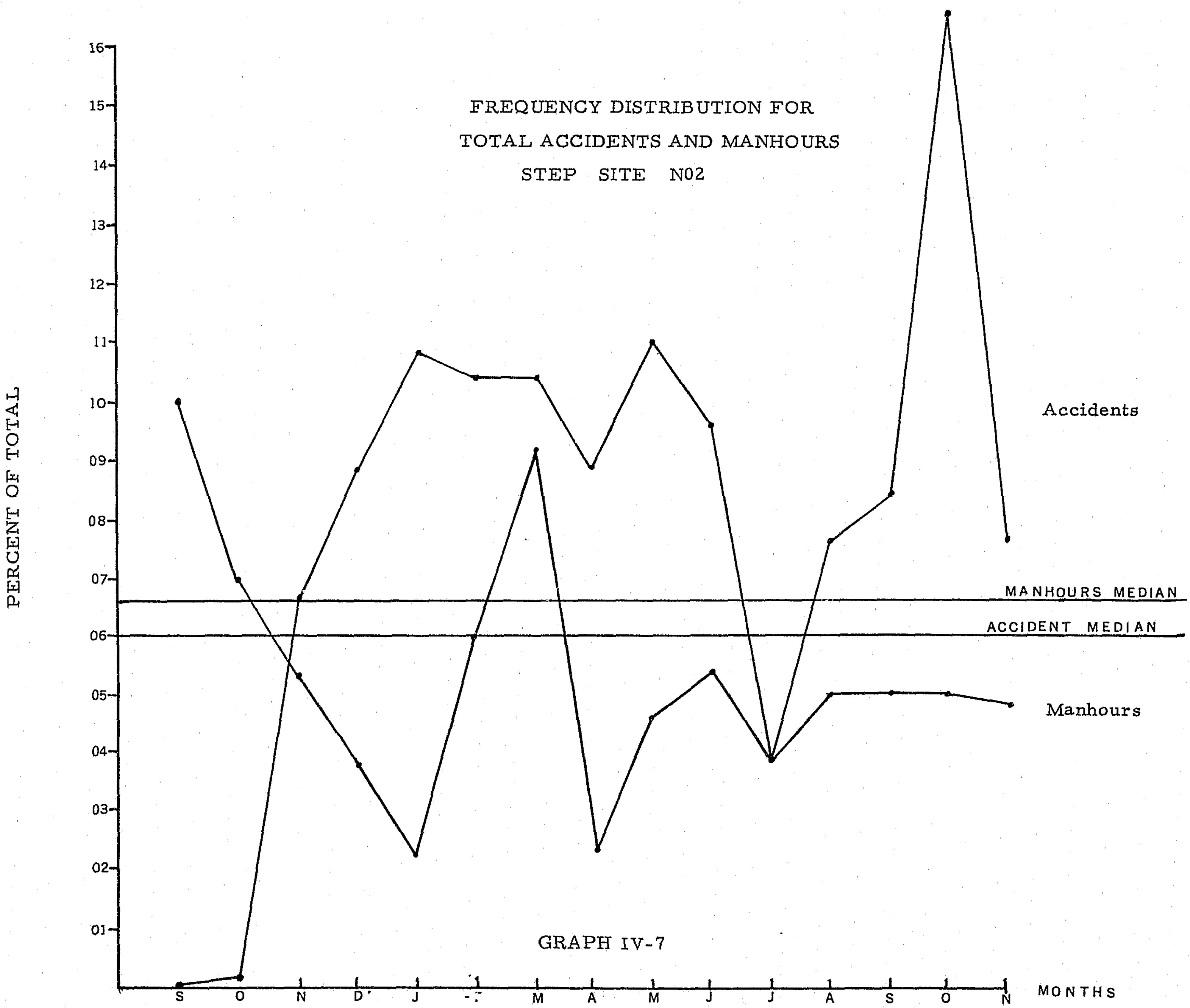
MONTH AND LOCATION

MONTH	N01	N02	N99	S01	S02	S03	S04	S05	S99	TOTALS
SEPT. 1973	53	0	0	436	0	147	0	0	0	636
OCT. 1973	103	5	39	464	0	199	0	2	0	812
NOV. 1973	316	331	3	101	32	355	0	3	0	1141
DEC. 1973	322	443	1	32	67	293	0	1	0	1159
JAN. 1974	368	543	1	60	78	496	0	0	0	1546
FEB. 1974	443	521	2	16	52	473	0	0	0	1507
MAR. 1974	459	529	1	17	25	0	0	0	1	1032
APR. 1974	369	443	2	18	49	391	0	0	3	1275
MAY 1974	472	556	2	16	33	505	0	0	0	1584
JUNE 1974	339	482	10	22	63	399	0	0	10	1325
JULY 1974	348	188	10	57	98	457	0	0	0	1158
AUG. 1974	335	254	14	52	96	549	10	13	148	1471
SEPT. 1974	286	257	14	27	51	355	0	6	294	1290
OCT. 1974	372	252	11	34	68	440	0	0	323	1500
NOV. 1974	330	244	12	37	84	431	0	0	383	1500
TOTALS	4915	5048	122	1389	796	5490	10	25	1162	18957

TABLE IV-2

index, computed from North Dakota accident data for the previous five years, was employed. The State index proved reliable in that it varied directly with Cass County accidents during STEP. The correlation coefficient was calculated at .5910, supported by a 98% significance level. When the seasonal index was held constant, the negative correlation between accidents and manhours increased from -.5313 to -.5643. The change, although small, displayed that the inverse relationship between accidents manhours remained strong when the seasonal variation in Cass County was extracted. When the seasonal index was correlated with Cass County accidents during STEP, holding manhours constant, the coefficient increased from .5910 to .6183, at a 99% significance level. As the impact of manhours was removed, the relationship between accidents and seasons strengthened. When manhours were interjected into the relationship between accidents and seasons, the coefficient declined. The correlation of manhours on accidents was independent of seasonal variations.

If a spurious relationship existed between accidents and enforcement due to reduced speed limits, it would have been revealed on highways not affected by limit changes. Highway segment NO2 had posted speed limits of less than 55 mph before and during the energy crisis, and the highest accident total of the STEP sites. Yet, the inverse relationship between accidents and manhours remained intact. A coefficient of -.3924 was calculated for this highway which was alloted 20% of the total enforcement. This is not to assume that speeds remained the same, only that any change that the energy crisis had on accidents was not due to posted limit changes. March represented the only month where both accidents and manhours were above their espective medians (Graph IV-7).


FREQUENCY DISTRIBUTION FOR
TOTAL ACCIDENTS AND MANHOURS
STEP SITE N02
PERCENT OF TOTAL
16
15
14
13
12
11
10
09
08
07
06
05
04
03
02
01
Accidents
MANHOURS MEDIAN
ACCIDENT MEDIAN
Manhours
S
O
N
D
J
M
A
M
J
J
A
S
O
N
MONTHS

GRAPH IV-7

ACCIDENT DISTRIBUTION
BY
MONTH AND LOCATION

MONTH	N01	N02	N99	S01	S02	S03	S04	S05	S99	Total
SEPT. 1973	0	13	0	8	3	9	0	1	0	34
OCT. 1973	3	10	1	6	2	6	0	4	0	32
NOV. 1973	9	6	7	6	5	16	1	4	4	58
DEC. 1973	5	5	9	6	5	9	0	2	2	43
JAN. 1974	2	5	9	0	1	6	1	0	2	26
FEB. 1974	2	9	6	2	3	6	0	0	4	32
MAR. 1974	1	12	8	2	4	12	0	1	2	42
APR. 1974	1	3	5	0	2	2	0	1	6	20
MAY 1974	2	6	9	1	1	3	1	0	3	26
JUNE 1974	7	7	7	0	2	2	0	1	5	31
JULY 1974	2	5	6	1	1	2	0	0	5	22
AUG. 1974	2	10	14	1	0	1	1	2	7	38
SEPT. 1974	4	11	17	1	0	6	0	2	6	47
OCT. 1974	3	22	13	0	3	5	3	1	15	65
NOV. 1974	1	10	4	1	2	12	0	1	13	44
TOTAL	44	134	115	35	34	97	7	20	74	560

TABLE IV-3

CONCLUSION

The intent of the Selective Traffic Enforcement Program in Cass County, North Dakota, was to reduce the number and severity of traffic accidents. Extreme care was taken to enable statistically supported conclusions to be drawn. However, it should be noted that this evaluation process was severely constrained by factors of the energy crisis. Accidents in the nation declined considerably in 1974, but the direct effect of the energy crisis could not be definitively measured.

The basis of the evaluation process in Cass County was a comparison of accident trends with allocations of manpower. Accident frequencies during STEP could not be compared to historical accident frequencies in the County, due to the energy crisis and reduced speed limits. Nevertheless, the results of the analysis reveal strong evidence that STEP positively influenced the number and severity of traffic accidents.

Correlational and graphical analysis disclosed a definite tendency for accidents to decline when manpower increased, and increase when enforcement declined.

The results of this study would contradict any contention that manhours and accidents were spuriously related. When the impact of citations was eliminated, the manhour and accident relationship was altered minimally. The removal of seasonal influences did not alter their inverse relationship. The measurable factors of the energy crisis revealed insignificant influence on the basic profile of traffic accidents during STEP operations as compared to the period prior to the energy crisis. Highway segment NO2, not affected by speed limit reductions, revealed the same strong negative correlation between accidents and manpower. The seasonal pattern of accidents and traffic volume was not altered by the energy factors. The seasonal index for North Dakota, prior to the energy crisis, was a good predictor of the seasonal accident pattern for Cass County during STEP. Average Daily Traffic declined an average of 4.4% from September 1973 to November 1974, but continued to hold its seasonal pattern. Any reduction in the total number of traffic accidents, resulting from reduced traffic volume due to the energy crisis, would have no impact on the relationship between manhours and number of accidents. The relationship between accidents and manhours would still exist.

The significance level of the manhour and accident relationship was 98%. This tends to deny any assumption of coincidence. Graphic representations for manhours and accidents support these conclusions. Shifts in the data were dramatic, and yet closely proportional.

In summary, even though the results of the evaluation do not imply cause and effect, they disclose a strong likelihood that the frequency and severity of traffic accidents were reduced as a result of STEP operations.

SECTION V

PRE-ARREST BREATH TESTER

INTRODUCTION AND SUMMARY

Drivers operating under the influence of alcohol continue to be a major highway safety problem in this country. In an effort to combat this, the State of North Dakota has sponsored the use and evaluation of the alcohol pre-arrest screening device (ALERT) as an aid in the detection and apprehension of drivers operating while intoxicated (DWI). The report to follow is a final evaluation of the ALERT in the State of North Dakota for the period January 1, 1974, through September 30, 1974.

The ALERT, a portable breath alcohol test device, allows a police officer to screen drivers suspected of being under the influence of alcohol. The intention is to remove the subjective judgment of the officer in cases where outward appearance and physical performance make detection difficult. The ALERT test can be used only to guide the officer in a determination of whether an arrest should be made. After an arrest is made, an evidentiary test must be performed to determine the actual BAC level of the offender.

For the study, the ALERT was calibrated to register a failure at a blood alcohol concentration (BAC) level of .11% or higher, a warning between BAC levels .06% and .10% and a pass at a BAC level of less than .06%.

The 78 North Dakota Police Officers were separated into experimental and control groups and evaluated for their performance during the study. Sixty seven of the officers were issued the device for half of the nine month period and were evaluated for their performance with and without the device. The remaining 11 officers were given the device for the entire nine month period and were evaluated on this basis.

The effectiveness of the ALERT was dependent on its ability to aid the officers in the detection and apprehension of two distinct types of DWI offenders: the offender with a BAC at or near the legal limit of .10% and the offender with a higher BAC but displaying few visible signs. The effectiveness was measured by higher apprehensions, lower average BAC levels of the drivers arrested for DWI, desired shifts in the DWI arrest distributions, and the operational reliability of the equipment.

Change in DWI Arrest Level

The 67 Highway Patrol Officers made 780 DWI arrests in the 12 months (1973) just prior to the experiment. During the nine months of the study, the same officers made 969 DWI arrests. When separated into experimental and control groups, officers with the device made 529 arrests and the officers without the device made 440 arrests. The monthly per-man average arrest level for the officers with the device was 19.8% higher than that of the same officers without the device. This difference was found to be statistically significant at a confidence level of greater than 95%.

Change in Average BAC Levels

The analysis of baseline and experimental data reflected several significant changes in the average BAC level of the DWI arrests.

When compared to 1973, lower average BAC levels occurred during both the experimental and control periods, with the shifts being more dramatic during the periods of device usage. The average BAC level of the arrests made during the study declined by 7% from the pre-experimental average (.1915 to .1781).

The average BAC level of the DWI arrests were significantly lower for the periods when the officers were issued the ALERT. The average BAC levels of the experimental groups (with ALERT), from January - September, was .1744, while the average BAC level of the control groups (without ALERT) was .1827. With the large sample sizes, the difference is significant at a confidence level above 99%.

Change in the DWI Arrest Distribution

The DWI arrest distribution for the officers participating in the study was found to be considerably different from the 1973 distribution. This was primarily due to a shift at the low BAC levels. During the study, 63.5% of the arrests occurred between BAC levels .05 - .19. This represents a 17.6% increase over the results of the baseline period.

The results of the tests performed on the data revealed the arrest distribution for the officers with the ALERT to be considerably different from the distribution for the officers without the device. This difference was due to a change at the low BAC levels. For the officers issued the ALERT, 32% of the arrests occurred between BAC levels .05 - .14. This represents a 33% increase over the results of the officers without use of the device.

Accuracy of Test Results

The accuracy of the test results was evaluated by the number of screening tests that recorded a failure when the evidentiary test revealed a BAC level below the calibration point for a failure. Tests of this kind were of considerable importance because they could result in the arrest of a non-intoxicated driver. Of the total tests administered, 14% were false failures. Of these, 11 had an evidentiary BAC reading of less than .08, and 51 had an evidentiary BAC reading between .08 - .10. Due to the time lag between the screening and evidentiary tests, it was assumed that a certain undefined percentage of the 51 tests, with an evidentiary BAC level between .08 - .10, were associated with accurate ALERT readings when the tests were administered. The number of false warnings and passes were not evaluated because the majority of the tests recording a pass or warning were not followed up by evidentiary tests.

Operational Reliability

Operational reliability was evaluated by the number of device malfunctions and the length of time a device was out of service due to malfunction. From January - September there were 31 recorded device malfunctions. Of the 31 malfunctions, 22 (or 71%) were registered by nine officers and 15 (or 48%) by six devices. This represents slightly over one reported device malfunction per man year of experimental use.

Of the types of malfunctions reported, incorrect calibration was the most frequent. All of the other malfunctions did not show any re-occurring trends, or were not adequately explained by the officer. Several officers reported that the device was not working, but gave no explanation of the nature of the malfunction.

The length of out-of-service time due to a malfunction was considerably long in certain cases. Five officers reported extended periods (more than one month) without the use of the device. Two of the officers reported three months of consecutive out-of-service time as a result of a malfunction.

Conclusion

The results of this evaluation indicate that the ALERT program in North Dakota successfully met its stated objectives. A significant majority of the statistical tests performed support the concept of using screening breath testers in the enforcement of drinking and driving laws. The reliability of the equipment was judged adequate for a demonstration project of this nature.

EXPERIMENTAL DESIGN

A preliminary analysis of the historical performance of the North Dakota Highway Patrol officers was conducted to enable the selection of two similar test groups. The selection criteria were uniform officer performance and geographical coverage of the eight patrol districts. To do this, the number of DWI arrests for each officer were plotted on a graph, by average BAC level, and separated by the intersection of the group averages (GRAPH V-1 & TABLE V-1).This placed each officer in one of four groups:

(1) Those officers whose number of DWI arrests was below the Patrol average and whose BAC level was above the Patrol average.

(2) Those officers whose number of DWI arrests was below the Patrol average and whose average BAC level was below the Patrol average.

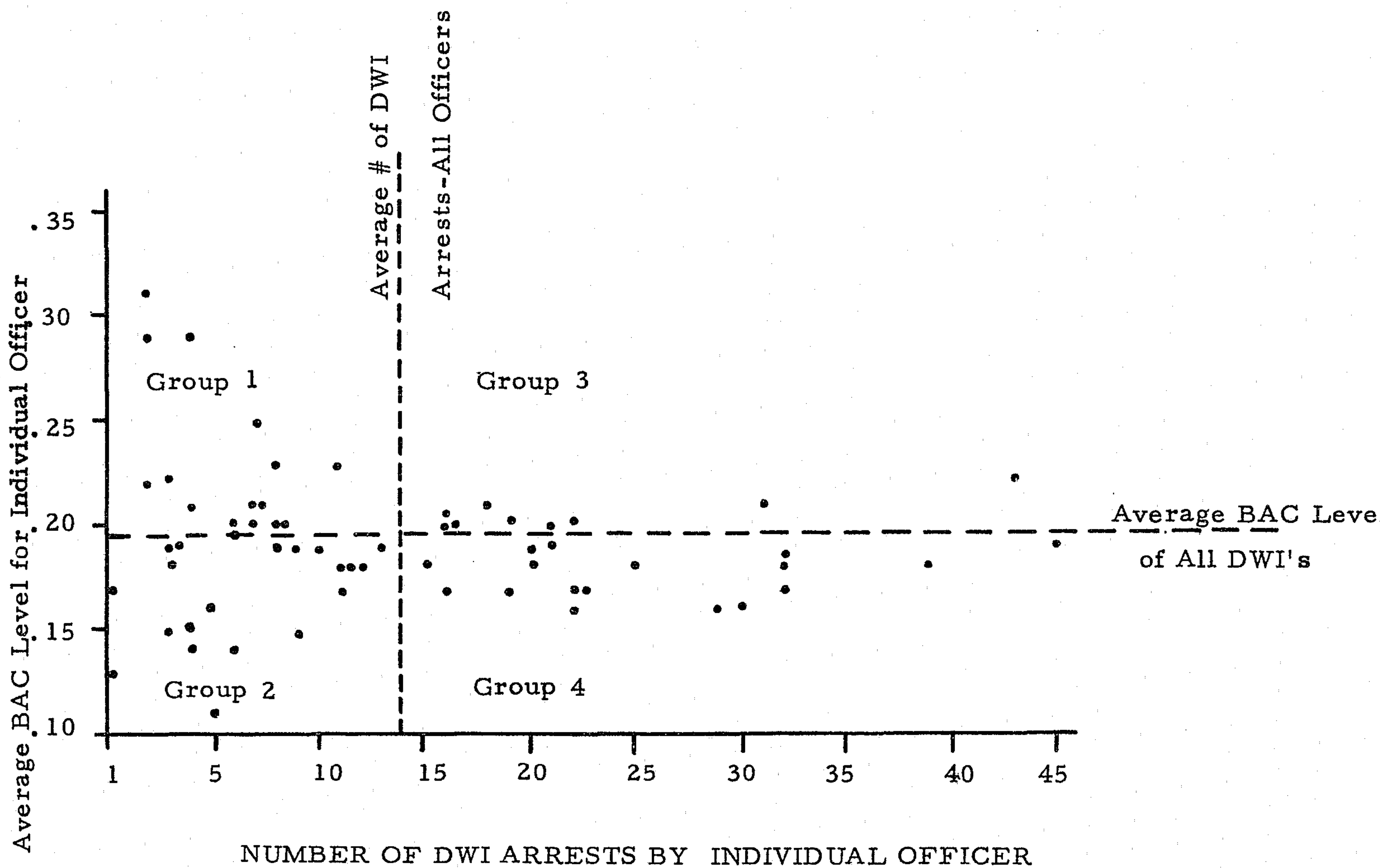
(3) Those officers whose number of DWI arrests was above the Patrol average and whose average BAC level was above the Patrol average.

(4) Those officers whose number of DWI arrests was above the Patrol average and whose average BAC level was below the Patrol average.

Then, half of each of the four groups were selected on the basis of stratified random sample, and combined with half of the officers with no DWI arrests in 1972. This comprised the two similar test groups (A and B).

NUMBER OF ARRESTS VERSUS AVERAGE BAC LEVEL

FOR EACH PATROL OFFICER FOR 1972



GRAPH V-1

Group	Officer ID	Patrol District	# DWI
(1)	261	II	2
	283	III	7
	248	IV	11
	211	IV	6
	223	V	8
	244	V	8
	286	VI	4
	237	VI	3
	243	VI	7
	250	VI	8
	255	VI	2
	234	VII	7
	240	VII	2
	256	VII	7
	266	VIII	4
(2)	245	I	11
	222	I	1
	247	II	10
	282	II	11
	227	II	9
	253	III	3
	224	III	3
	231	III	5
	222	IV	5
	264	IV	8
	228	VI	9
	257	VI	12
	216	VI	11
	287	VII	4
	265	VII	6
	269	VII	13
	226	VII	3
	260	VII	1
	219	VIII	4
	210	VIII	3
(3)	230	I	16
	254	I	43
	235	II	31
	252	II	18
	214	III	21

TABLE V-1

Group	Officer ID	Patrol District	# DWI
(3) Cont'd.	242	III	16
	246	IV	19
	251	IV	16
	285	V	16
	236	V	22
(4)	281	I	15
	215	II	22
	249	II	21
	213	II	22
	232	IV	20
	258	IV	45
	284	IV	32
	220	V	32
	238	V	39
	239	V	19
	262	V	25
	269	VI	30
	233	VII	20
	263	VII	17
	288	VIII	32
	225	VIII	22
	241	VIII	29

TABLE V-1 (cont'd)

Of the 78 officers that participated in the experiment, 67 were from the Highway Patrol and 11 were from the Selective Traffic Enforcement Program. Of the Highway Patrol officers 34 were assigned to Group A and 33 to Group B. Group A was issued the ALERT for the first half (January - May 18th) and made up the first half experimental group. Group B was issued the ALERT for the second half (May 19th - September) and made up the second half experimental group. The 11 STEP officers were issued the ALERT for the entire nine months and were evaluated separately.

Subsequent to the assignment of the Highway Patrol officers into Group A and Group B, historical data for calendar year 1973 revealed a difference in the DWI arrest distributions, by BAC level, for the two groups of officers. The officers in Group B recorded a larger percent of their total DWI arrests between BAC levels of .05-.19 and a smaller percent of their total between BAC levels of .20 or more, than Group A did for 1973 (GRAPH II). This may have been due to any one of several outside influences or the way in which the officers were selected. The inclusion of 5 officers without any DWI arrests in 1972 may have accounted for part of the difference in the 1973 data. It was not possible to isolate all the influences on the average BAC level for the groups, but the significance of the difference had to be determined. If the two groups were significantly different prior to the experiment, the difference would have to be taken into consideration before any inter-group comparisons could be made from the experimental data.

A chi-square (x^2) test was used to determine the significance of the difference over the entire distributions. The DWI arrest frequencies were grouped in seven BAC classes, and expected frequencies were computed for each class (TABLE V-2). A minimum confidence level of 90% was chosen to test the hypothesis (H_0) that the two groups were the same. A chi-square of 4.7157 was calculated from the sample of 778 observations (TABLE V-2). From a chi-square table, the value that corresponds to the 90% confidence level, and six degrees of freedom, was $x^2.90 = 2.204$. The decision rule to test the hypothesis that the two groups were the same was:

Accept H_0
if $x^2 \leq x^2.90$;

Reject H_0
if $x^2 > x^2.90$.

On this basis, the hypothesis that the two groups of officers were the same, for 1973 DWI data, was rejected because x^2 (4.7157) was greater than $x^2.90$ (2.204).

1973 DATA

(BEFORE DEVICE ISSUANCE)

	GROUP A		GROUP B	
(BAC)	OBSERVED FREQUENCY	EXPECTED FREQUENCY	OBSERVED FREQUENCY	EXPECTED FREQUENCY
.05 - .09	10	11.57	14	12.43
.10 - .14	72	80.01	94	85.99
.15 - .19	109	112.79	125	121.21
.20 - .24	113	107.49	110	115.51
.25 - .29	47	42.42	41	45.58
.30 - .34	16	13.98	13	15.02
.35 or More	8	6.75	6	7.25

Chi Square (x^2) = 4.7157

TABLE V-2

The mean BAC level for the DWI arrests made by Group A for 1973 was .1962. The mean BAC level for the DWI arrests made by Group B for 1973 was .1870. Using standard techniques to test the difference between the two means it was found that the difference was statistically significant. The large sample size of 780 observations justified the use of the Central Limit Theorem and standard statistical techniques. A $z = 2.11$ was calculated, which represents a confidence level of greater than 95% that the observed difference was not due to chance.

The significant difference in the performance of the two groups of officers prior to the study caused the evaluation methodology to be altered from the original plan. Any inter-group comparisons would have to take into consideration the difference between the groups prior to the experiment. A difference factor (δ) was included in the basic mathematical formulae to balance the groups for comparison. Because the accuracy of this factor could not be substantiated, intra-group and combined group comparisons were given more consideration in the final conclusions. These tests were not affected by the difference between the groups. Inter-group comparisons were used only to support the basic trends revealed by the other tests.

EVALUATION METHODOLOGY

The basis of statistical evaluation of the ALERT was the comparison of apprehension frequencies and their average BAC levels for the experimental, control and baseline groups. The effectiveness of the ALERT was dependent on its ability to detect DWI offenders whose outward appearance and physical performance made detection difficult. Increased apprehensions and lower average BAC levels were measurements of the ALERT's effectiveness.

Historical data was collected and used for the selection of the test groups, and as a reference of officer performance prior to the experiment. Baseline data for 1972 was used to assign the 67 Highway Patrol officers into their respective groups. Baseline data for 1973 was used to determine the effect of the experiment on the officers' performance and measure the difference in the officers detection ability prior to the experiment. The use of two separate years of baseline data, instead of the combination of the two years, may seem unusual. However, the original operational plan was to use only the 1972 data to select the test groups. It was after the group assignment that an examination of the 1973 data revealed a difference in the groups. Through the use of baseline data, a difference factor (δ) was created to balance the groups for comparison. The difference factor was recalculated for the experimental data to determine if the difference remained the same during the experiment.

Several different techniques were used in evaluating the data so a complete picture could be drawn. It is important to note that the evaluation methodology did not require assumptions about the distributions.

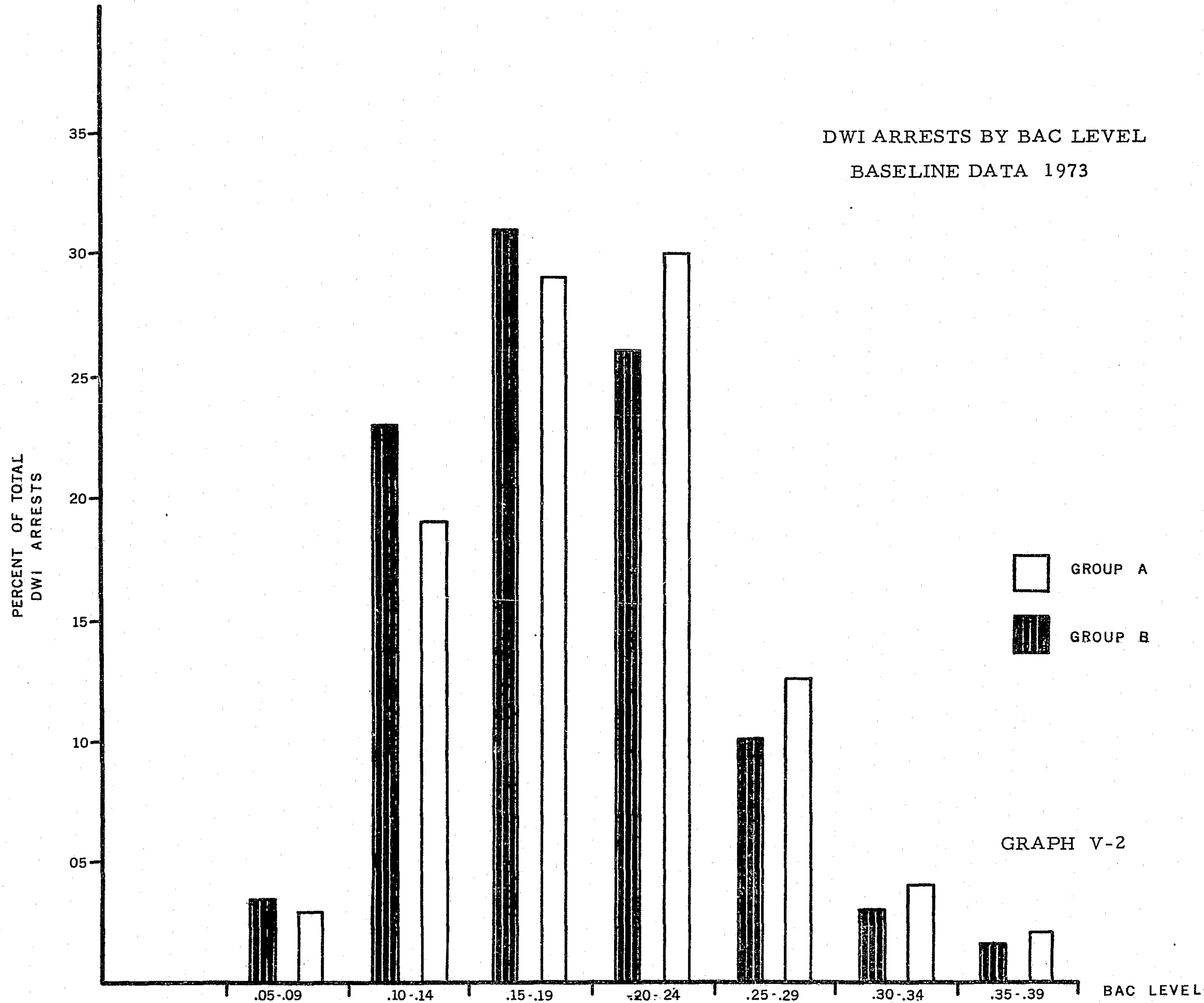
The large sample sizes justified the use of the Central Limit Theorem and various tests that require a normal distribution.

Standard statistical averaging techniques were used to compare BAC levels of the drivers apprehended during the experiment. The mean BAC levels of the DWI's were calculated and compared for the test period. Variations between the means were analyzed for their significance, and confidence levels were attached to the observed differences. A technique for testing the difference between two means was employed so the significance of the differences could be determined. For intra-group and combined-group comparisons, which were not affected by the pre-experimental difference in the officers, the basic formula was $z = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$. For inter-group comparisons, the formula was expanded to include a difference correction factor, small delta (δ), calculated from the 1973 data by taking the difference between the means (.1962 - .1870 = .0092). It was inserted in the numerator to balance the groups during calculation. The formula was $z = \frac{\bar{X}_1 - \bar{X}_2 - \delta}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$.

In addition to average BAC level comparisons, tests were performed to identify at what BAC level the variations occurred. The chi-square technique, which tests for independence between groups of data, was used to determine if the test groups had different DWI arrest distributions. The DWI arrests were grouped into classes by BAC level, and expected frequencies were calculated for each class. For all tests, a tolerable error of .10 was chosen to evaluate the test results. This corresponds to a confidence level of 90% that the results were not due to chance. Any test that passed this criterion was stated at the highest appropriate confidence level.

The breakdown by BAC level allowed chi-square to be computed for low and high BAC levels. Chi-squares were calculated for the

DWI ARRESTS BY BAC LEVEL
BASELINE DATA 1973



GRAPH V-2

six BAC levels (.05 - .09), (.10 - .14), (.15 - .19), (.20 - .24), (.25 - .29), (.30 or more) and for combinations of low and high BAC levels (.05 - .14 and .15 or more). This enabled more specific conclusions to be drawn about the distributions. Variations in the distributions, occurring predominantly at certain BAC levels, could be identified. The use of the chi-square technique enabled two important premises to be tested. First, chi-square is used to test for independence between two groups of data. Thus, a significantly large chi-square would infer that the two groups of data were different, and a small chi-square would infer they were the same. Second, because of the arrangement of the data by BAC level and ALERT usage, the effect of the ALERT on the BAC distributions of the offenders could be tested. A significantly large chi-square would infer that the ALERT had an effect on the BAC level, and a small chi-square would infer no effect on the BAC level. The size of chi-square is dependent on the difference between the data and the number of data groups (degrees of freedom). As the number of BAC classes increased, a larger chi-square was needed to satisfy the 90% confidence level. For the baseline comparison the chi-square was used only to determine if the two groups of officers were the same. For the experimental comparisons, the chi-square tests were used to determine if the ALERT had an effect on the BAC level of the DWI's.

The operational reliability of the ALERT was evaluated on the basis of the accuracy of the screening test results and the frequency of ALERT malfunctions. The accuracy of the results was based on the number of drivers who failed the screening tests but passed the evidentiary test. The number of device malfunctions were analyzed for recurring types of malfunctions and the length of their maintenance time. The effect of extreme temperatures on the machine performance was also considered.

Graphic representations were used to support the results of the other tests and reveal any trends that were not already evident.

ALERT USAGE

From January - September a total of 630 ALERT screening tests were administered. Of this total, 439 were failures, 131 were warnings and 60 were passes (TABLE V-3). The number of tests that registered a failure represented approximately 70% of the total tests administered.

During the first half of the experiment (January 1 - May 18) 395 screening tests, or 62.7% of total tests were registered. The number of failures was 62.4% of the nine month total. During the second half (May 19 - September 30) 235 tests were administered. This represents a decline of 160 tests, or 40.5% of the total tests given during the study. The number of failures in the second half was down 39.8% of the first half figure. This reduction was not due to an increase in the tests registering a warning or a pass. The number of warnings for the second half was down 38.3% from the first half, and the number of passes was down 50% of the previous period.

The percentage of failures to total tests given remained relatively constant for each month of the nine month study. The percentage of failures was 69.4% of the total tests from January - May, and 70.2% from May - September. The only two periods that deviated from the trends were the second half of May (19-31), with 62%, and the month of August, with 80.4%.

The number of tests that could not be administered due to device malfunction, refusal of the driver, or inability of the driver to complete the test remained relatively constant for both halves. From January through September 46 screening tests could not be administered. These were divided evenly (23) between the two halves. Device malfunctions made up 31 of the 46 tests, with 16 occurring in the first half and 15 in the second

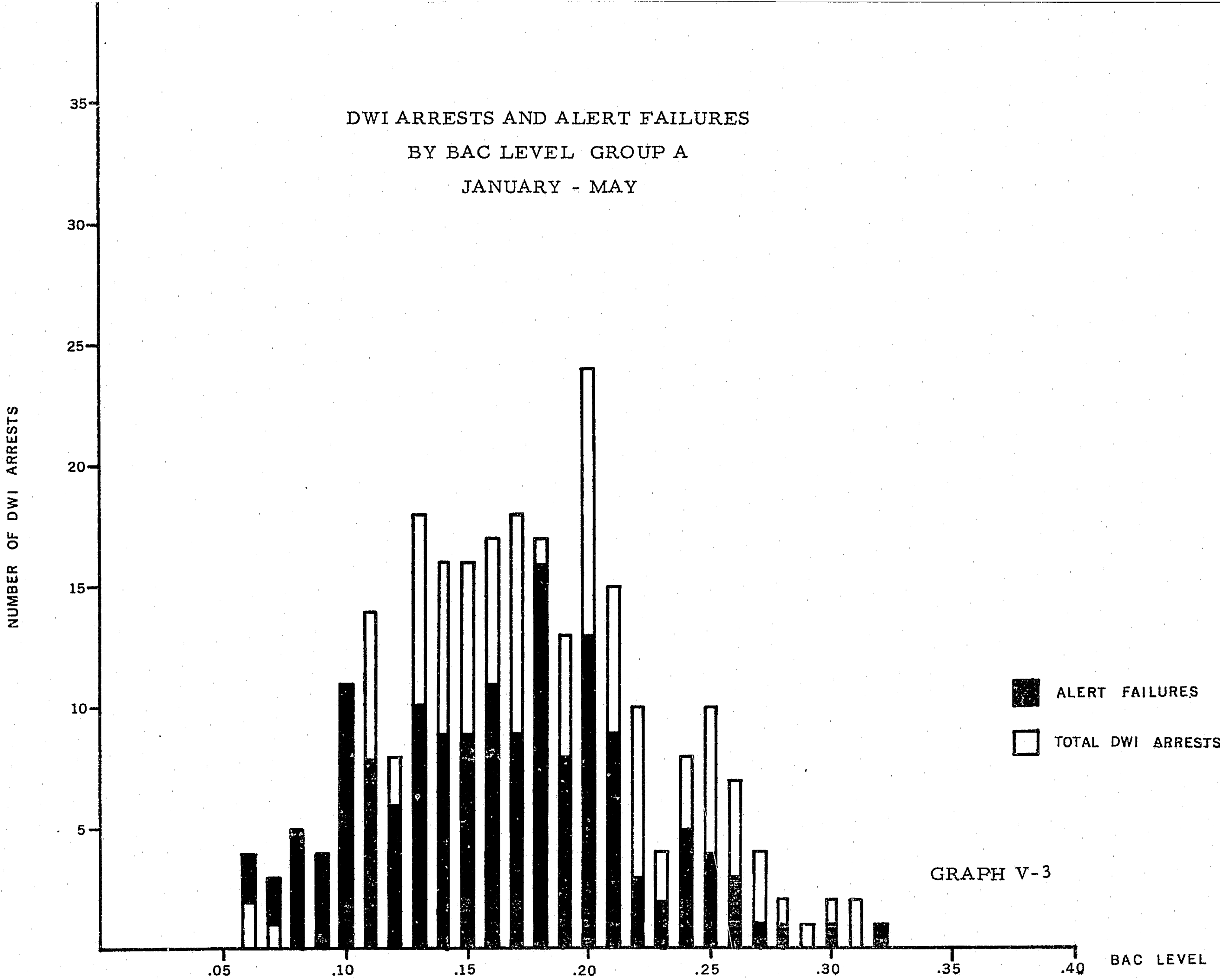
MONTH	PASSED	ALERT TEST RESULTS WARNED	FAILED	UNABLE	REFUSED	DEVICE MAL-FUNCTION	MONTHLY TOTALS	% OF FAIL-URES TO TOTAL TESTS	DWI ARRESTS (W/O STEP)	STEP
JANUARY	9	18	59	2	2	6	96	68.60	41	30
FEBRUARY	12	12	66	1	1	1	93	73.33	41	38
MARCH	7	24	65	1	0	2	99	67.71	73	24
APRIL	6	14	33	0	0	5	58	62.26	53	24
MAY (18th)	6	13	51	0	0	2	72	72.86	42	23
TOTALS	40	81	274	4	3	16	418	69.37	250	143
MAY (19-31)	4	7	18	1	0	4	34	62.07	24	17
JUNE	6	16	46	0	1	5	74	67.65	63	19
JULY	6	14	35	0	2	0	57	63.64	73	13
AUGUST	3	7	41	2	0	2	55	80.39	55	30
SEPTEMBER	1	6	25	2	0	4	38	78.13	64	34
TOTALS	20	50	165	5	3	15	258	70.21	279	113

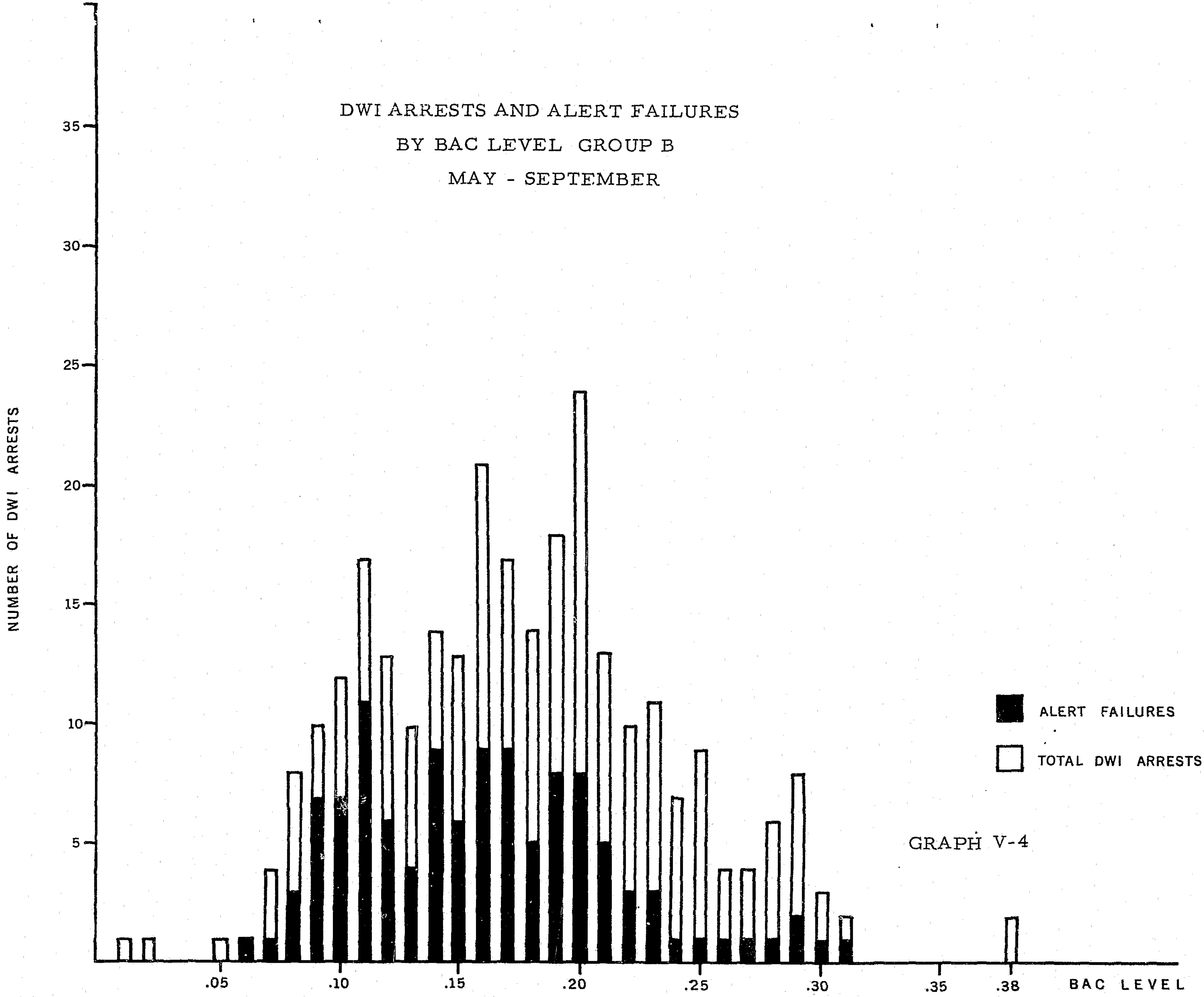
TABLE V-3

half. The number of driver refusals and inabilities remained constant for both halves, with seven in the first half and eight in the second half.

The percentage of ALERT failures to the number of DWI arrests was quite different for the two halves of the study. During the first half, 401 DWI arrests were made by the officers issued the ALERT. This is compared to 274 ALERT failures recorded for the same period. The number of ALERT failures represents 68.3% of the total number of DWI arrests (GRAPH V-3). During the second half, 384 DWI arrests were made by the officers with the ALERT. Only 165 ALERT failures were recorded for that period. The number of ALERT failures represents 43% of the total arrests (GRAPH V-4). The number of arrests for the officers issued the device declined by 4.2% while the number of ALERT failures declined by 39.8%.

The distribution of ALERT screening tests by the hour of the day is represented by the number of DWI arrests for the officers issued the device (GRAPH V-5 & V-6). The dark columns illustrate the arrests for the officers with the device, and the light columns illustrate the arrests for the officers without the device. The basic shapes of the two histograms are similar for the two time periods, with the majority of arrests made between the hours of 9 P.M. and 3 A.M. The trend was the same for both halves of the study, regardless of the issuance of the device. This enabled comparison of the results for both time periods.


DWI ARRESTS AND ALERT FAILURES
BY BAC LEVEL GROUP A
JANUARY - MAY
NUMBER OF DWI ARRESTS
35
30
25
20
15
10
5
.05
.10
.15
.20
.25
.30
.35
.40
BAC LEVEL
ALERT FAILURES
TOTAL DWI ARRESTS
GRAPH V-3

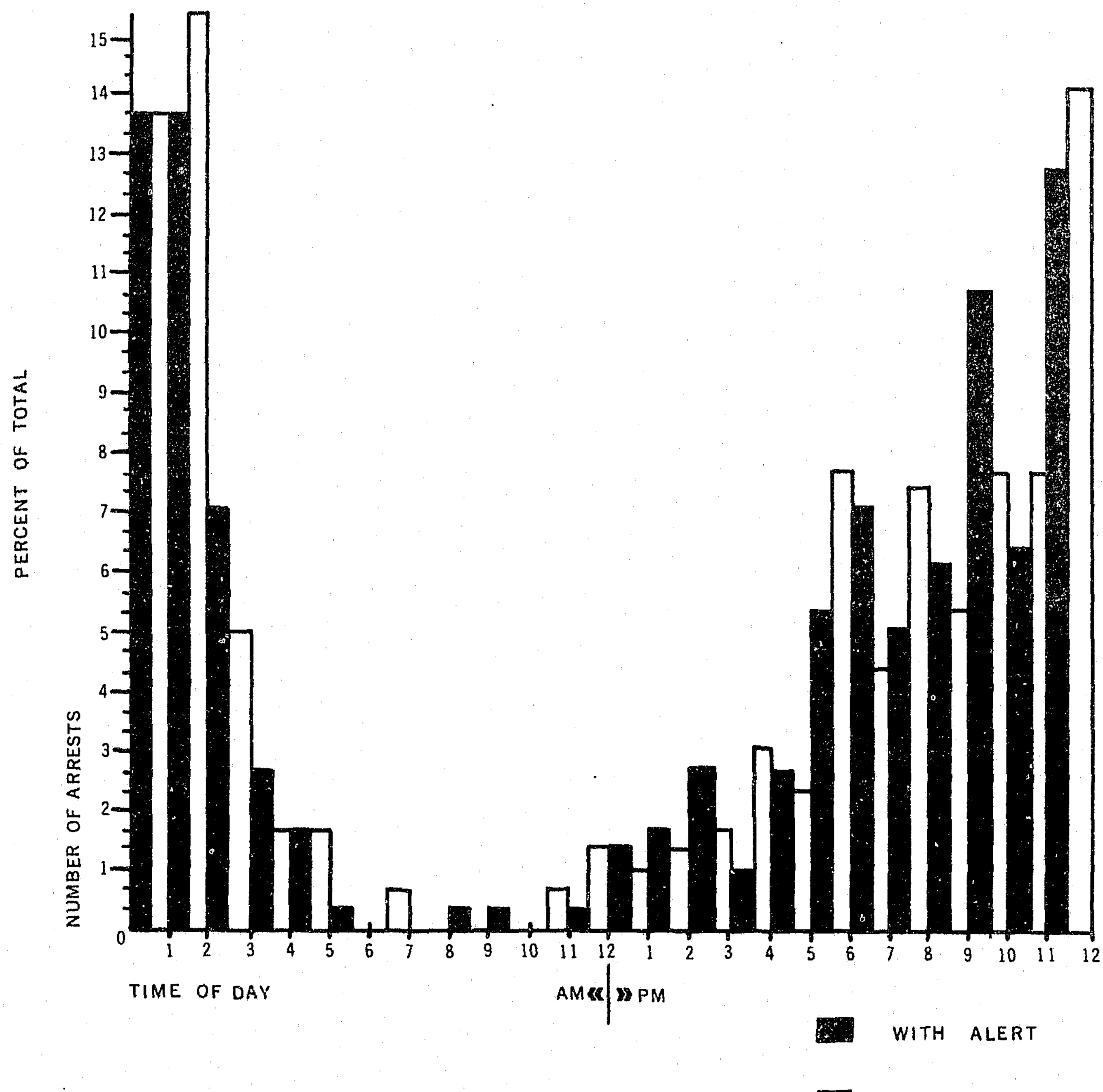


DWI ARRESTS AND ALERT FAILURES
BY BAC LEVEL GROUP B
MAY - SEPTEMBER
NUMBER OF DWI ARRESTS
35
30
25
20
15
10
5
.05
.10
.15
.20
.25
.30
.35
.38
BAC LEVEL
ALERT FAILURES
TOTAL DWI ARRESTS

GRAPH V-4

DWI ARRESTS BY TIME OF DAY

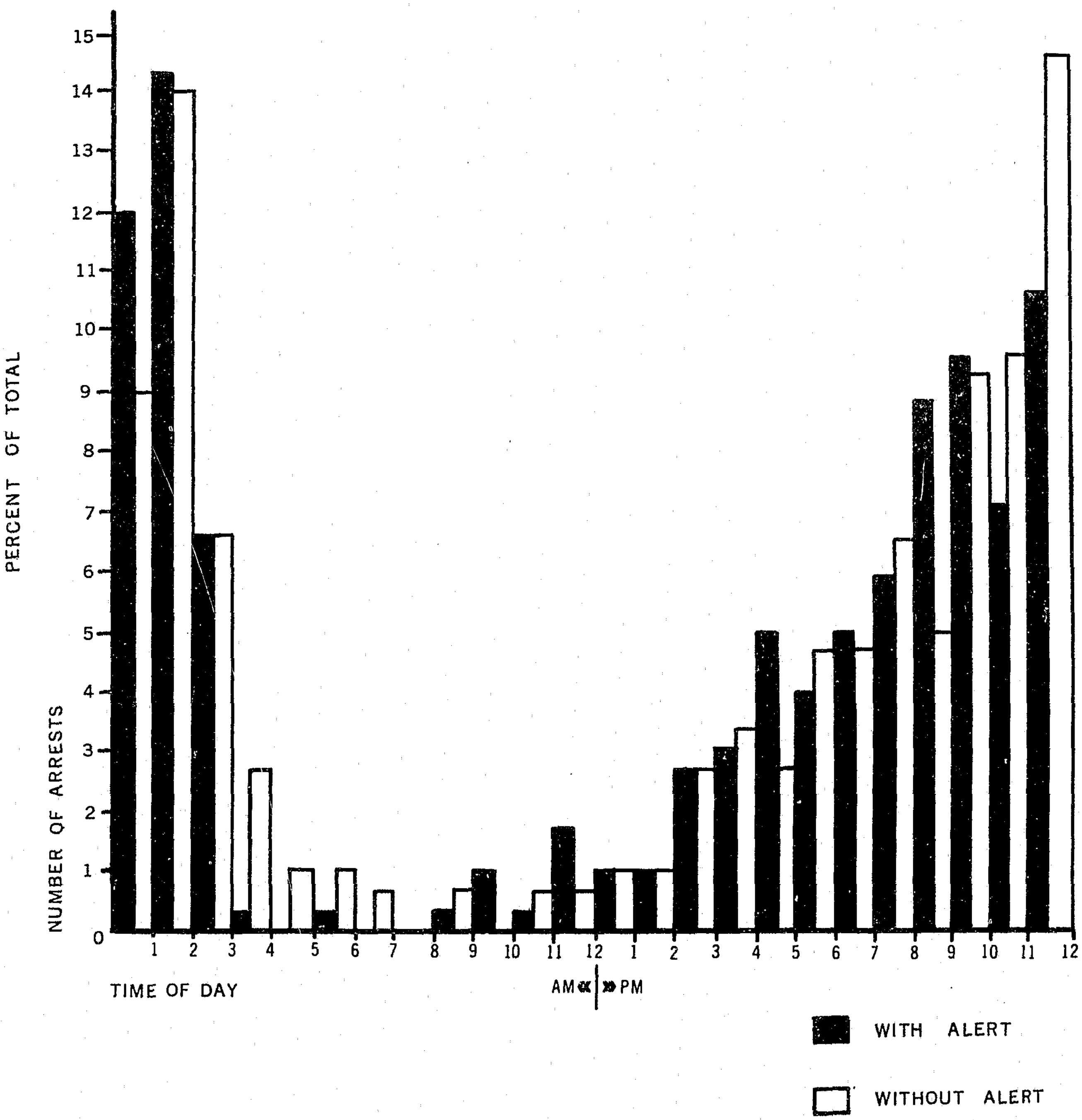
GROUP A



GRAPH V-5

DWI ARRESTS BY TIME OF DAY

GROUP B



GRAPH V-6

INTRA-GROUP COMPARISONS

Group A

During the first four and a half months (January 1 through May 18) the officers in Group A, who were issued the ALERT, recorded 250 DWI arrests. The mean BAC level for the 250 arrests was $\bar{x} = .1744$. At the mid-point of the experiment, the device was transferred to the officers in Group B for the remaining four and a half months. From May 19 through September 30, the officers in Group A recorded 240 DWI arrests without use of the device. The mean BAC level of the 240 arrests was a higher average of $\bar{x} = .1881$. A standard statistical test for a difference between the two means was performed and it was found that the mean BAC level was significantly lower during the period when the device was used. The test revealed a $z = 2.91$, which represents a confidence level of greater than 99% that the difference between the means was not due to chance alone.

In addition to the test for a difference between the means, a chi-square (x^2) test for independence was used to determine whether the ALERT had an effect on the BAC level of the DWI arrests made by Group A. On this basis the following hypotheses were formulated:

H_0: The ALERT had no effect on the BAC level of the DWI arrests (the distributions are the same).

H_1: The ALERT had an effect on the BAC level of the DWI arrests (the distributions are different).

The DWI arrest frequencies were separated into six classes by BAC level, and expected frequencies were calculated for each BAC class (TABLE V-4). The result was a chi-square (x^2) = 10.63. A confidence level of 90% was chosen to test the hypotheses. From a table of chi-square areas, and five degrees of freedom, it was found that $x^2.10 = 9.236$. With a decision rule of:

Accept H_0
if $x^2 \leq x^2.10$;

Reject H_0
if $x^2 > x^2.10$;

the hypothesis that the ALERT had no effect on the average BAC level of the DWI arrests made by Group A, was rejected because x^2 (10.63) was greater than $x^2.10$ (9.236). With the large sample size of 490 observations the chances of making an error was kept to a minimum.

GROUP A

	(with ALERT) January - May		(without ALERT) May - September	
(BAC)	OBSERVED FREQUENCY	EXPECTED FREQUENCY	OBSERVED FREQUENCY	EXPECTED FREQUENCY
.05-.09	12	7.64	3	7.36
.10-.14	67	57.64	46	55.46
.15-.19	81	89.10	94	85.90
.20-.24	61	64.15	65	61.85
.24-.29	24	25.46	26	24.54
.30 or more	5	6.11	7	5.89

Chi-Square (x^2) = 10.63

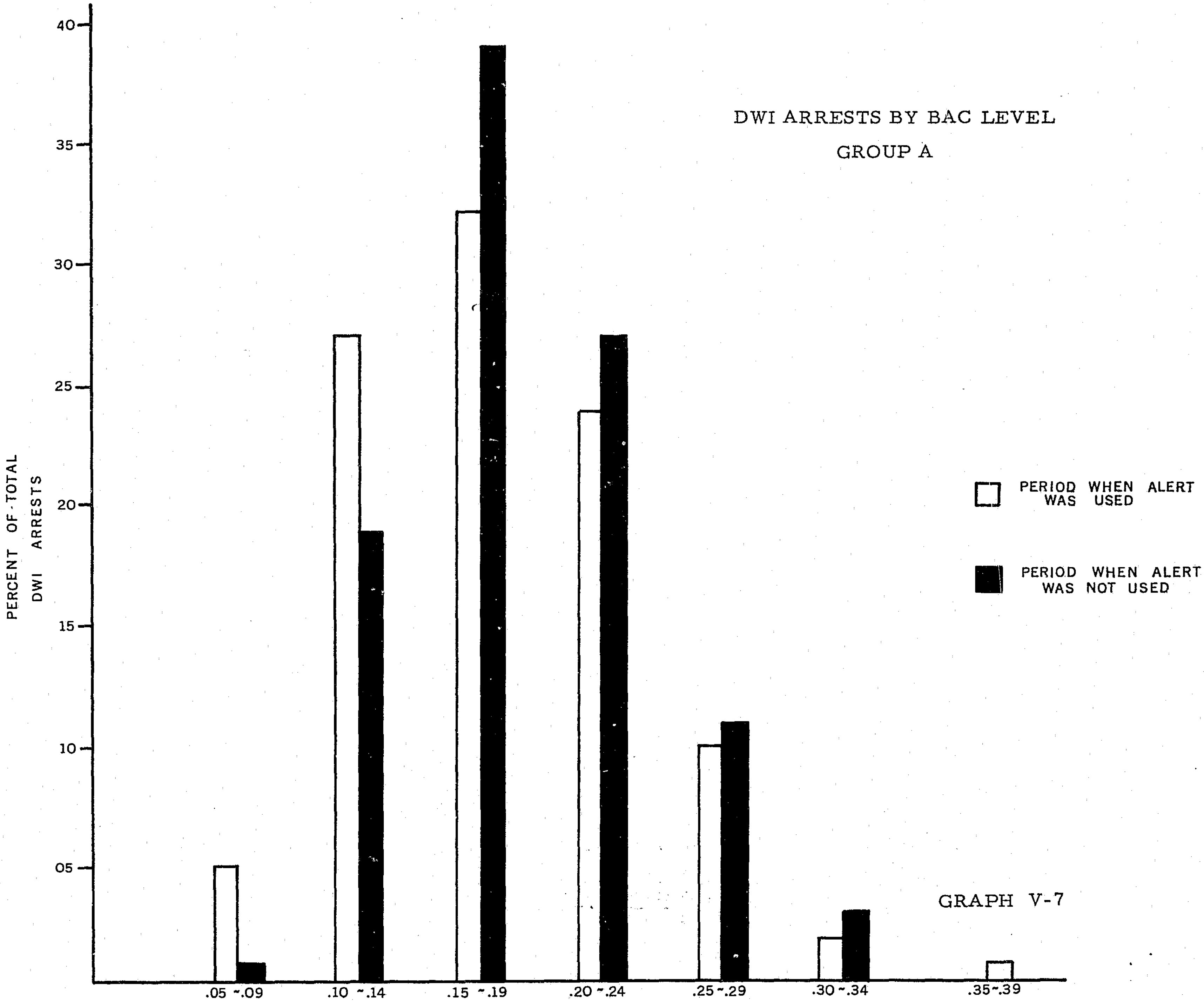
TABLE V-4

The results of the chi-square test revealed the two distributions of data to be different over the six BAC classes. The test was also made at BAC levels of .05 - .14 and .15 or more to reveal whether the observed differences occurred predominantly at low BAC levels. A chi-square of 2.40 was calculated for BAC levels .05 - .14 from a sample of 128 observations. From the chi-square table the value that corresponds to the 90% confidence level and one degree of freedom was found to be $x^2.90 = 2.706$. The probability that the difference between the two distributions was due to chance was slightly greater than 10%. A chi-square of $x^2 = .30$ was calculated for BAC levels .15 or more from a sample of 363 observations. This corresponds to greater than 95% confidence that the two groups of data were the same at BAC levels .15 or more. Even though the confidence level of the test for BAC levels .05 - .14 was below 90%, the majority of difference between the two groups of data, over their entire distributions, can be attributed to a difference at the low BAC levels. A larger percentage of the total DWI arrests were made at the low BAC levels for the period of device usage. Of the total arrests 32% were between BAC levels .05 - .14 (GRAPH V-7). After the device was taken away the percentage of arrests at that level declined to 20%. The relative difference between the two periods at the low levels was balanced by a shift, in the opposite direction, at the middle levels.

Group B

For the first four and a half months (January - May 18) the officers in Group B made 200 DWI arrests without the use of the ALERT. The mean BAC level for the 200 arrests was $\bar{x} = .1761$. At the experimental mid-point the officers in Group B were issued the ALERT for the remaining four and a half months (May 19 - September 30). During this period they recorded 279 DWI arrests with a mean BAC level of $x = .1743$. The test for a difference between the two means revealed a $z = .3498$. The confidence level represented by this figure was only 63.7%. The probability that the difference between the two means occurred by chance alone was greater than 36%.

The chi-square test was used to detect any difference in the distributions of the data, for officers in Group B, between the two periods. The DWI arrest frequencies were separated into six classes by BAC level, and expected frequencies were calculated for each BAC class (TABLE V-5). As in the test of Group A, a significance level of .90 (90% confidence level)



DWI ARRESTS BY BAC LEVEL
GROUP A
PERCENT OF TOTAL DWI ARRESTS
40
35
30
25
20
15
10
05
PERIOD WHEN ALERT WAS USED
PERIOD WHEN ALERT WAS NOT USED
.05 -.09
.10 -.14
.15 -.19
.20 -.24
.25 -.29
.30 -.34
.35-.39

GRAPH V-7

was chosen to test the hypotheses. The result was a $x^2 = 9.15$. With a decision rule of:

$$\text{Accept } H_0 \text{ if } x^2 \leq x^2_{.10};$$

$$\text{Reject } H_0 \text{ if } x2 > x^2_{.10};$$

the null hypothesis that the ALERT had no effect on the average BAC level of the DWI arrests made by Group B was accepted because x^2 (9.15) was less than $x^2_{.10}$ (9.236).

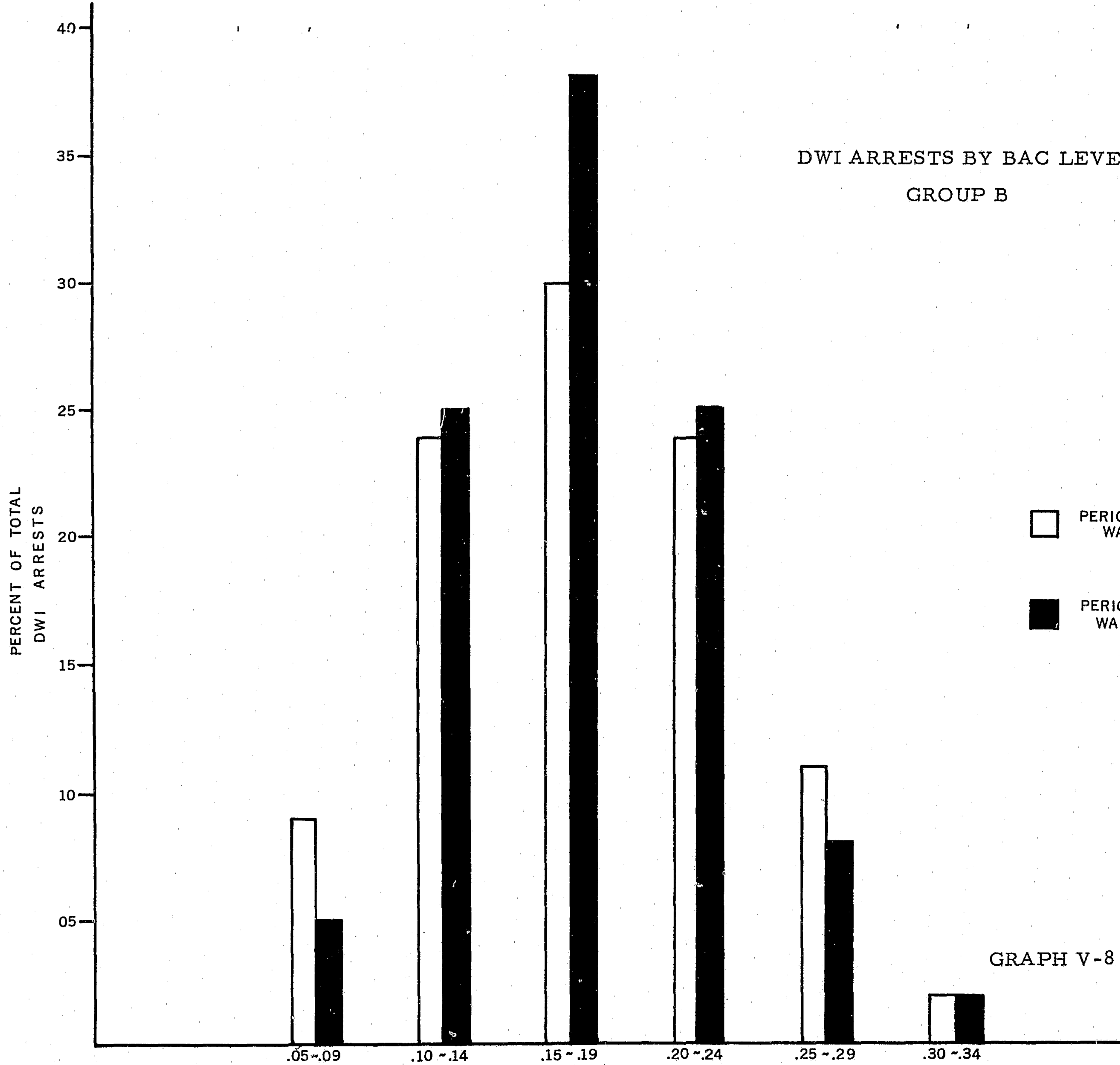
GROUP B

	(without ALERT) January - May		(with ALERT) May - September	
(BAC)	OBSERVED FREQUENCY	EXPECTED FREQUENCY	OBSERVED FREQUENCY	EXPECTED FREQUENCY
.05-.09	7	13.03	24	17.97
.10-.14	50	48.74	66	67.26
.15-.19	75	66.39	83	91.61
.20-.24	50	48.32	65	66.68
.25-.29	15	19.33	31	26.67
.30 or more	3	4.20	7	5.80

Chi-Square (x^2) = 9.15

TABLE V-5

The total number of DWI arrests were separated and analyzed in BAC classes .05 - .14 and .15 or more to test if the difference in the data was a result of a difference at low or high BAC levels. A chi-square of 4.34 was computed for BAC levels .05 - .14 from a sample of 147 observations. This value represented a confidence level of greater than 95% that the two groups of data were different at BAC levels .05 - .14. This was repeated for BAC levels .15 or more and the result was a chi-square of 3.98. This value represented a confidence level of less than 80% that the two groups were different at BAC levels .15 or more. Significantly, the chi-square value for the entire distributions revealed a confidence level of less than 90% that the two groups of data were


DWI ARRESTS BY BAC LEVEL
GROUP B
PERCENT OF TOTAL DWI ARRESTS
40
35
30
25
20
15
10
05
.05 -.09
.10 -.14
.15 -.19
.20 -.24
.25 -.29
.30 -.34
PERIOD WHEN ALERT WAS USED
PERIOD WHEN ALERT WAS NOT USED
GRAPH V-8

different. Nevertheless, there was a greater than 95% confidence that the groups of data were different at BAC levels of .05 - .14.

STEP Officers

Due to the lack of baseline data for the STEP officers, it could not be determined if their basic performance characteristics were comparable with the Highway Patrol officers. For this reason, the STEP officers were evaluated separately for their performance during the study. They were issued the ALERT for the entire nine months and were evaluated on the basis of trends in their performance during that period.

From January 1 through September 30 the 11 STEP officers registered 256 DWI arrests with average BAC level of .1688. This represented the lowest average BAC level of all the officers participating in the experiment. Of the 256 arrests, 34.8% fell in the BAC range of .05 - .14 and 70.3% in the range of .05 - .19 (GRAPH V-10). The ALERT was used for 121 or 47% of the total arrests.

The results for the nine month period are somewhat misleading. The number of arrests were substantially higher for the first four and a half months, and the average BAC level substantially lower. For the first half of the study the STEP officers made 143 of their 256 DWI arrests with an average BAC level of .1610. For the second half 113 arrests were made with an average BAC level of .1786. Of the 143 first half arrests 74 or 52% were made using the ALERT. Of the 113 second half arrests 47 or 42% were made with the device.

The change in their performance during the second half could have been due to any one, or a combination of several factors. Their device utilization declined by more than 19% during the second half. This could have been attributed to increase in device malfunctions or a decline in officer interest for the device. It was not possible to clearly identify why the change occurred, due to the numerous influences that could have caused the change. On this basis, the evaluation could only point out that the change did occur.

COMBINED GROUP COMPARISONS

January - September

During the nine month experimental period the 67 North Dakota Highway Patrol officers arrested 529 DWI offenders, while issued the ALERT screening device. The average BAC level for the 529 arrests was $\bar{x} = .1744$. When they did not have the device, the same 67 officers arrested 440 DWI offenders. The average BAC level for the 440 DWI arrests was $\bar{x} = .1827$. Using the standard technique to test for a difference between two means, it was found that the officers recorded a significantly lower average BAC level during periods when issued the ALERT. A $z = 2.37$ was computed from 969 observations, collected from January 1974 through September 1974. The confidence level for the test was greater than 99%. The probability that the difference between the means occurred by chance alone was less than 1%.

The chi-square (x^2) technique was used to test for a difference in the distributions of the two groups of data, for the period January - September. A contingency table was constructed and the DWI arrests were grouped in six classes by BAC level (TABLE V-6).

From this table a chi-square (x^2) test was performed to test for independence between the experimental data and the control data. The reason for using this test was to see if the ALERT had any effect on the BAC level for DWI arrests. It was not possible to isolate all influences on the BAC level for DWI arrest, but the results of the test were still reliable in drawing conclusion about the groups of data. Even if the ALERT was not the only factor that influenced the results during the experiment, it can be assumed that it played a major role. The combination of the data for all 67 officers, in this test, eliminated any inter-group comparisons. Both groups of officers were considered part of the experimental and control groups. On this basis the following hypotheses were formed

H_0: the ALERT had no effect on the BAC level of the DWI arrests.

H_1: the ALERT had an effect on the BAC level of the DWI arrests.

GROUP A & B

	(with ALERT) January - September		(without ALERT) January - September	
(BAC)	OBSERVED FREQUENCY	EXPECTED FREQUENCY	OBSERVED FREQUENCY	EXPECTED FREQUENCY
.05-.09	36	25.02	10	20.98
.10-.14	133	124.56	96	104.44
.15-.19	164	181.14	169	151.86
.20-.24	126	131.09	115	109.91
.25-.29	55	52.22	41	43.78
.30 or more	12	11.97	10	10.03

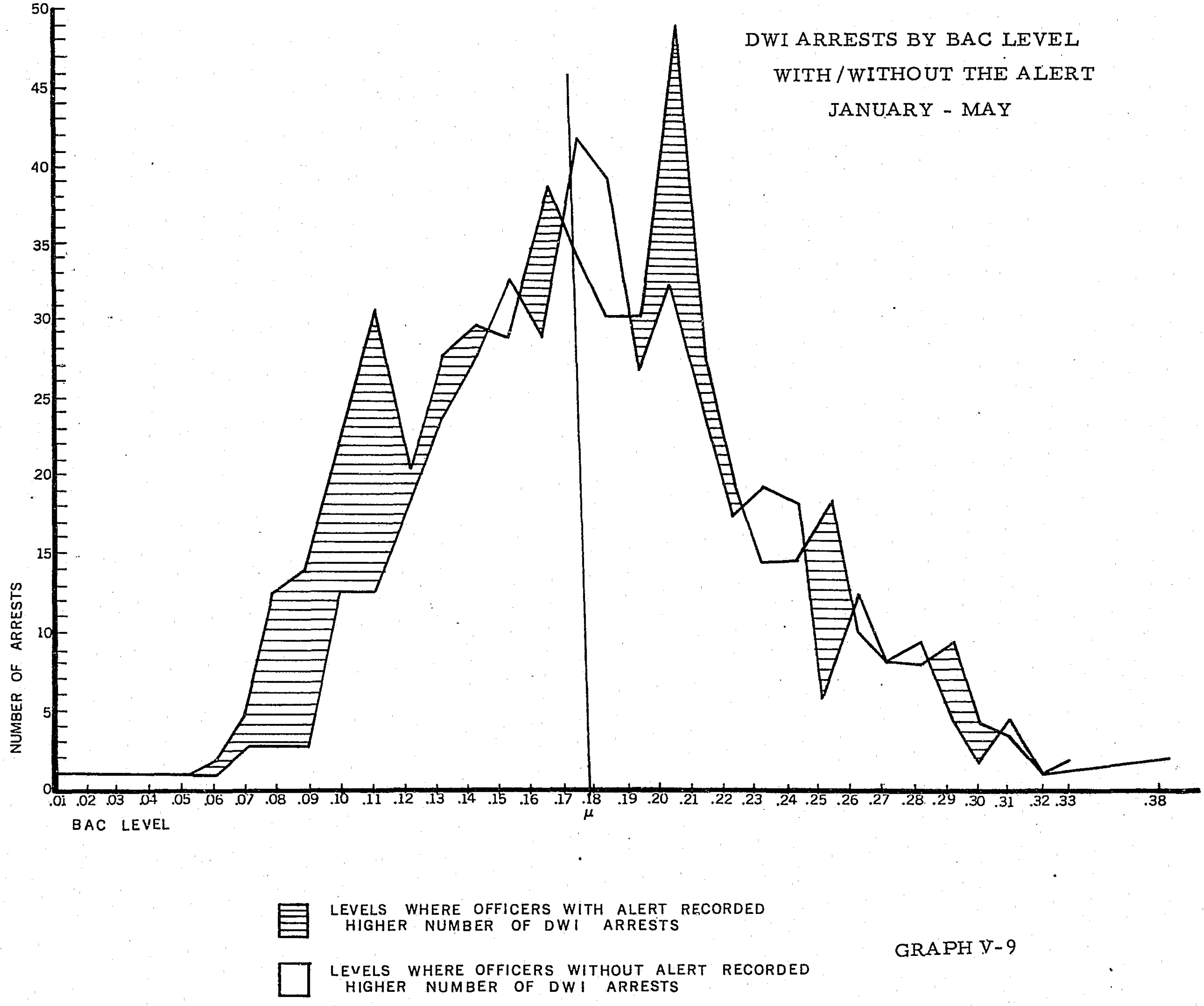
Chi-Square (x^2) = 16.14

TABLE V-6

A chi-square (x^2) of 16.14 was calculated from a sample of 969 observations. From a chi-square table the value that corresponds to the 99% confidence was found to be $x^2_{.01} = 15.086$. The null hypothesis that the ALERT had no effect was rejected with a 99% confidence level because $x^2 > x^2_{.01}$

The results from the chi-square test revealed that the two distributions of data were different over the six BAC classes. To determine if the difference between the two groups of data occurred at low or high BAC levels, the data was divided into DWI arrests with BAC levels .05 - .14 and .15 or more. A chi-square of 6.58 was calculated for the groups at BAC levels .05 - .14 from 275 observations. From the chi-square table the value that corresponds to the 98% confidence level and one degree of freedom was found to be x^2 .02 = 5.412. This means that for the data tested, there was a significant difference between the groups with and without the ALERT at BAC levels .05 - .14 (greater than 98% confidence level). The same test was performed on the data from BAC levels .15 or more. The result was a chi-square of 2.09 from almost 700 observations. The confidence level that corresponds to this value with three degrees of freedom was less than 50%. This means that for total number of DWI arrests for the 67 Highway Patrol Officers, from January through September, the significant difference arrived at was primarily due to the difference at low BAC levels.

The difference between the arrest distributions is clearly illustrated when expressed graphically. The distribution of arrests by the officers with the ALERT included a higher concentration of arrests to the left of the mean (below) than the distribution of arrests by the officers without the device (GRAPH V-9). The higher number of arrests at the low BAC levels was not due to a reduction of arrests at the high BAC levels. The number of arrests to the right of the mean (above) was randomly higher and lower for both distributions. This is a good indication that the ALERT achieved the desired objectives, in that, it increased the detection of borderline cases without sacrificing the other cases.


DWI ARRESTS BY BAC LEVEL
WITH/WITHOUT THE ALERT
JANUARY - MAY
NUMBER OF ARRESTS
0
5
10
15
20
25
30
35
40
45
50
.01 .02 .03 .04 .05 .06 .07 .08 .09 .10 .11 .12 .13 .14 .15 .16 .17 .18 .19 .20 .21 .22 .23 .24 .25 .26 .27 .28 .29 .30 .31 .32 .33 .38
μ
BAC LEVEL
LEVELS WHERE OFFICERS WITH ALERT RECORDED HIGHER NUMBER OF DWI ARRESTS
LEVELS WHERE OFFICERS WITHOUT ALERT RECORDED HIGHER NUMBER OF DWI ARRESTS

GRAPH V-9

INTER-GROUP COMPARISONS

As stated in the evaluation methodology there was a significant difference between the two groups of officers prior to the study. The officers in Group B recorded a significantly lower average BAC level during 1973, than the officers in Group A. Rather than excluding inter-group comparisons, the basic formula for testing the difference between means was expanded to include a difference factor (δ) that would remove the variation during calculation. While this appraisal is considered valid, the accuracy of the factor could not be exactly determined. For this reason inter-group comparisons were used only to support the other findings.

January - May

For the period January 1 - May 18, the officers in Group A (with ALERT) registered 250 DWI arrests with a mean BAC level of .1744. The officers in Group B (without ALERT) registered 200 DWI arrests with a mean BAC level of .1761. A test of the difference between these two means, without taking into consideration the pre-experimental difference between two groups of officers, would have revealed the average BAC level of the two groups to be similar. However, with the inclusion of the difference factor, the officers in Group A were found to have a significantly lower average BAC level than the officers in Group B. The test revealed a $z = 2.23$, which represents a confidence level of greater than 98% that the difference between the means was not due to chance alone.

May - September

For the period May 19 - September 30, Group B was issued the ALERT and recorded 279 DWI arrests. The mean BAC level of the offenders was calculated at .1743. Group A, the control group for the second half of the experiment, recorded 240 DWI arrests. The mean BAC level was computed at .1881. A test of the difference between these two means, without taking into consideration the basic difference between the two groups of officers, would have revealed the average BAC level for Group B to be significantly lower than Group A. However, when the difference (δ) in the groups of officers was included in the Z test, the result was a z = .9240. The confidence that Group B had lower average BAC level than Group A was less than 85%

<u>January - September</u>

The difference between the performance of Group A and Group B prior to the experiment was still evident during the experiment. Group A registered 490 DWI arrests between January and September. The average BAC level of the offenders was .1811. Group B made 479 DWI arrests between the same period. The average BAC level of the offenders was .1750. Both groups were issued the device for one period and were without it for the other. The test of the difference between the two means revealed the two average BAC levels to be significantly different over the nine months. A z = 1.724 was the result, which represents a confidence level of greater than 95% that the observed difference was not due to chance. The direction of the difference between the means was the same for the experimental period as it was for the pre-experimental period. The DWI arrests made by Group B had a significantly lower average BAC level than the DWI arrests by Group A. Although the difference between averages was not as large as the pre-experimental difference, it is still noteworthy that the difference maintained the same direction.

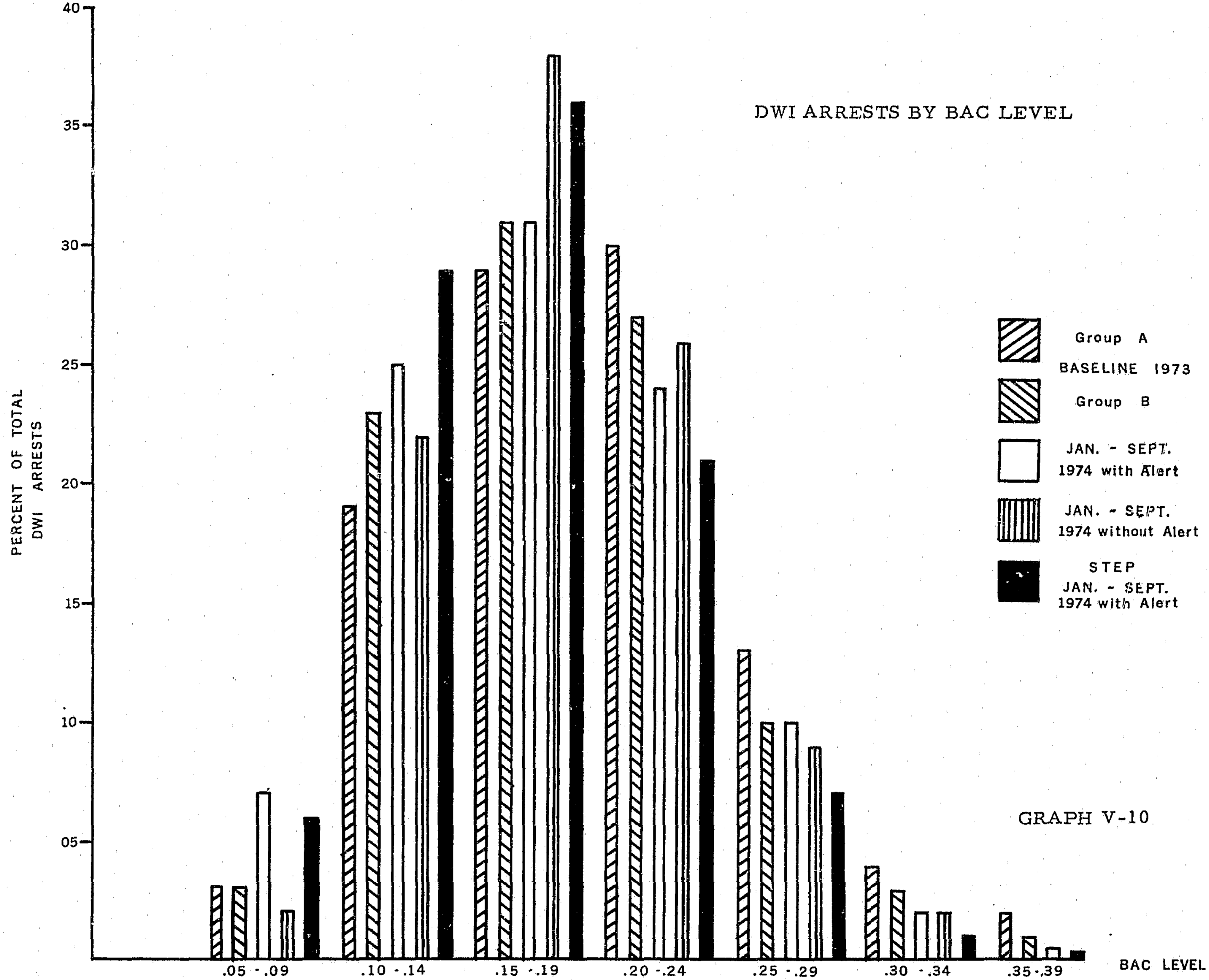
HISTORICAL VS. EXPERIMENTAL PERFORMANCE

The analysis of baseline and experimental data reflected several significant changes in the officers performance between the two periods. This seems due in part to the experimental conditions as well as issuance of the ALERT device. An increased number of DWI arrests and lower average BAC levels occurred during both the experimental and control periods, when compared to the 1973 baseline data. The shifts were more dramatic during the experimental periods, but there still was a substantial difference in the performance of the control officers.

The 67 Highway Patrol officers made 780 DWI arrests in the 12 months of 1973. Yet in the nine month study, the same officers made 969 arrests. The average BAC level of their arrests declined by 7% from .1915 - .1781. Of their total arrests, 63.5% occurred at BAC levels .05 - .19 (GRAPH V-10). This is compared to 54% for the baseline period. These figures include both when the officers were part of the experimental and control groups.

The officers in Group A made 376 arrests during 1973. During the experiment they made a total of 490 arrests. The average BAC level of their arrests declined by 7.7% from .1962 to .1811. Of their 490 arrests 61.5% occurred at BAC levels .05 - .19. Of the 376 baseline arrests 50.8% occurred at those BAC levels.

The officers in Group B made 404 arrests during 1973. During the experiment they made 479 arrests. The average BAC level of their arrests declined by 6.4% from .1870 - .1751. Of their 479 arrests, 65% occurred at BAC levels .05 - .19. Of the 404 baseline arrests 57.7% occurred at those BAC levels.


DWI ARRESTS BY BAC LEVEL
PERCENT OF TOTAL DWI ARRESTS
40
35
30
25
20
15
10
05
.05 -.09
.10 -.14
.15 -.19
.20 -.24
.25 -.29
.30 -.34
.35-.39
BAC LEVEL
Group A
BASELINE 1973
Group B
JAN. - SEPT. 1974 with Alert
JAN. - SEPT. 1974 without Alert
STEP JAN. - SEPT. 1974 with Alert

GRAPH V-10

Of the 969 DWI arrests made during the study, 529 were made by officers with the ALERT and 440 were made by officers without the device. On a per-man basis the average monthly arrest level for the officers with the ALERT was 1.51. This compares to 1.26 for the same officers without the device. A test of the difference between these two means revealed the per-man average arrest level of the officers with the ALERT to be significantly higher than that of the same officers without the ALERT. A $z = 1.86$ was computed which represents a difference between the means significant at a confidence level of greater than 95%.

The use of the ALERT and the experimental conditions appear to be responsible for the changes in the officers performance. The measurements of effectiveness established in the evaluation methodology were achieved, with and without the device, when compared to their past performance. However, it is reasonable to assume that the use of the ALERT played a substantial role in the shifts in officer performance. The more dramatic changes occurred when the device was used.

EQUIPMENT RELIABILITY

An important part of the evaluation was the device's operational reliability. This was based on the accuracy of the test results and the number of device malfunctions.

The accuracy of the test results was based on the number of ALERT tests that registered a false failure. A false failure was any test that registered a failure when the evidentiary test revealed a BAC level of less than or equal to .10. The ALERT was calibrated to register a failure at a BAC of .11 or higher. Tests of this kind were of considerable importance because they could result in the arrest of a non-intoxicated driver.

Of the 630 ALERT tests administered from January through September, 439 tests were failures. Of the 439 failures, 62 tests or 14.12% were false failures. Of the false failures, 11 had an evidentiary BAC reading of less than .08, and 51 had an evidentiary BAC reading between .08 - .10 (TABLE V-7).

ALERT Failures with BAC Below .11

	January - May		May - September	
BAC	Highway Patrol	STEP	Highway Patrol	STEP
.05	0	1	0	0
.06	4	0	1	0
.07	3	1	1	0
.08	5	5	3	0
.09	4	3	7	2
.10	11	3	7	1
	27	13	19	3

TABLE V-7

A false failure with an evidentiary BAC level between .08 - .10 was not necessarily indicative of an inaccurate reading by the device. A borderline failure, with a BAC level of approximately .11 could have an evidentiary BAC reading below .11 due to the time lag between the screening and evidentiary tests. The exact amount of alcohol wear-off depended on the length of the time lag and the driver's metabolism. Nevertheless, it is reasonable to assume that a certain undefined percentage of the 51 tests, with an evidentiary BAC level between .08 - .10, were associated with accurate ALERT readings when the tests were administered.

Another measure of accuracy of the test results was the number of false warnings and passes. A false warning or pass was a screening test that did not register a failure when the driver's BAC level was above .10. However, these tests were not available because the majority of ALERT tests recording a pass or a warning were not followed up by evidentiary tests.

The number of device malfunctions and the length of maintenance time were not always identifiable on the ALERT log sheets. This limits any conclusions about the operational reliability of the device, based on the number of ALERT malfunctions. For the purpose of this evaluation, one malfunction was recorded for each mention of a device malfunction by the officer. A monthly log sheet with no screening tests and a recorded malfunction was treated as one malfunction.

There were 31 recorded device malfunctions during the nine month of the study. Of these, 16 were recorded during the first half and 15 during the second half. The total represented 4.9% of the 630 tests administered. Many of the malfunctions were recorded by the same officers or for the same devices. From this it was inferred that a certain portion of faulty devices made up a significant part of the total malfunctions. Nine officers registered 22 of the 31 (or 71%) device malfunctions. Six devices made up half of the nine month total. Of those, one device was responsible for four malfunctions, one for three, and four for two each. Of the types of malfunctions reported, incorrect calibration was the most frequent. The effect of extreme temperatures on the device performance did not appear significant. The majority of the screening tests were given inside the patrol car and not affected by temperature. Of the tests given outside the car, only one officer reported difficulty in device operation; that was a slow warm-up in the extreme cold. None of the tests given outside revealed an inaccurate reading by the device.

The reliability of the equipment was judged adequate for a demonstration project of this nature.

CONCLUSION

The primary objective in the use of the Borg-Warner ALERT was to increase the arrest rate of drivers violating the DWI statutes in the State of North Dakota by aiding the officers in the identification of offenders who might otherwise go undetected. The effectiveness of the device was measured by higher apprehensions, lower average BAC levels of the drivers arrested for DWI, desired shifts in the DWI arrest distributions, and the operational reliability of the equipment. It was not possible to isolate all outside influences on DWI arrests; however, extreme care was taken to enable statistically supported conclusions to be drawn.

The basis of the evaluation process was the comparison of DWI arrest frequencies and their average BAC levels for the experimental and control group officers. The 78 North Dakota Patrol Officers were evaluated on an intra-group, inter-group, combined-group, and a past performance basis. The results of the analysis reveal strong evidence that the ALERT successfully aided the officers in the detection of DWI offenders and strongly influenced a change in the DWI arrest distribution. Statistical and graphical analysis disclosed a definite tendency for arrests frequencies to increase and average BAC levels to decline when the ALERT was issued. A certain amount of the change can be attributed to the experiment itself, however, the changes were more dramatic for the officers issued the device.

An increase in the total number of DWI arrests was an indication the devices were effectively serving the purpose for which they were developed. The 67 Highway Patrol Officers made 24% more DWI arrests during the nine month study than during 12 months prior to the study. They registered 17% more arrests during periods when issued the device than during periods when not issued the device. During the nine months, the officers with the device always made more arrests than the officers without the device.

During the period of the evaluation it was found that the average BAC level of drivers arrested by officers issued the ALERT was .1744, as opposed to .1827 for the officers without the ALERT. This difference was found to be statistically significant to a confidence level of greater than 99%. The lower average BAC level of drivers charged with DWI by officers using the ALERT indicated that the device was aiding the officers make more arrests at the lower BAC levels.

The distribution of DWI arrests by the officers with the ALERT included a higher concentration of arrests below the average BAC level and a relatively equal concentration of arrests above the average BAC level, when compared to the distribution of arrests by the officers without the device. The results of chi-square test revealed the distribution of arrests by the officers with the ALERT to be significantly different (greater than 99% confidence level) from the distribution of arrests by the officers without the device. The difference between the distributions was found to be significant to the 98% confidence level for BAC levels .05 - .14 while significant to less than the 50% confidence level between BAC levels .15 or more. The difference arrived at was primarily due to a difference at low BAC levels. This indicated the ALERT achieved the desired objectives; it increased the detection of borderline cases without sacrificing the other cases.

In summary, the Borg-Warner ALERT was effective in meeting the objectives established for this evaluation. Use of the ALERT was accompanied by a significant increase in the number of DWI arrests and a significant reduction in the average BAC level of the drivers arrested. Furthermore, shifts in the distribution of arrests revealed significantly higher arrest rates at the low BAC levels.

SECTION VI

SPEED ENFORCEMENT STUDY

INTRODUCTION AND BACKGROUND

This section presents a review and evaluation of the effectiveness of different levels of manpower allocations in the enforcement of a 55 mile per hour (MPH) speed limit. For a period of 18 weeks, March 3, 1975, to July 4, 1975, varied combinations of manpower were utilized on two selected four-lane highways segments in an effort to identify the optimal combination of manpower needed to enforce a 55 MPH speed limit. In that traffic accidents were a major concern of the Selective Traffic Enforcement Program (STEP) in North Dakota, their reduction was a secondary objective of the speed enforcement plan. The effectiveness of the speed enforcement program was measured by changes in key parameters of the vehicle speed distribution during enforcement. The evaluation was designed to identify any change in the central tendency, the dispersion, or the extremes of the speed distribution during different levels of enforcement.

The evaluation of an enforcement program of this nature is complex. It requires the control of all outside influences for the results to be completely reliable. Some factors are measurable, such as seasonal trends, traffic volumes and weather conditions. They can be used in the evaluation to identify their effect on the parameters being measured. For factors that cannot be measured, the assumption is made that their influence remains randomly distributed throughout the entire program.

Inclement weather conditions created a considerable problem in the evaluation of this speed enforcement program. Of the 122 days in the four month period (March through June), 52 days contained measurable precipitation. The month of June contained the highest precipitation level with 9.40 inches. The other three months, March, April and May contained 1.48, 3.24 and 1.45 inches of precipitation, respectively. The month of March had six days of at least one inch of snowfall. June recorded 8.54 inches of rainfall in a twelve day period beginning June 19th.

Traffic volumes did not pose a problem for the evaluation. The average daily traffic volume for both highways was 1136.26 vehicles. This represents on the average 142 vehicles per hour for the 8 hour enforcement period. With vehicles traveling at an average daily speed of 58.40 MPH this represents a distance of 2170 feet between each vehicle. The average daily traffic volumes on both highways increased from March through June. This agrees with previous studies of traffic volumes in North Dakota. The average daily peak traffic volume (hour) for both highways was 164.73 vehicles. With vehicles traveling at an average daily peak hour speed of 57.74 MPH, the distance between each vehicle was 1850 feet.

OPERATION METHODOLOGY

Two segments of four-lane divided highway in Cass County were patrolled by the Selective Traffic Enforcement Program task force during a weekday eight hour shift (11 A.M. to 7 P.M.). The segments were located on I-29 North of Fargo (milepost 65.254 to 92.138) and I-94 West of Route 18 (milepost 331.222 to 307.738.)

The enforcement countermeasure employed was a marked vehicle in moving observation (P03). The patrol units were dispatched at specific equal time intervals and traveled the entire distance of the target highways in both directions. The patrol unit allocation was based upon all combinations of zero, two and four patrol units on the two selected highway segments for the 18 week duration (Table I). Under this allocation plan, four officers were active at all times on I-29 and/or I-94. A fifth officer in an unmarked vehicle was employed to patrol either location when no visible countermeasure was in force. The officers not on line patrol on the selected highways were active in the remainder of Cass County, employing area patrol and other selected countermeasures.

TABLE I

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Week
4	0	0	0	2	0	4	2	0	2	2	2	4	4	0	4	2	4	I 29
0	4	4	4	2	4	0	2	4	2	2	2	0	0	4	0	2	0	I 94

The STEP vehicles patrolling the northbound segment of I-29 and the eastbound segment of I-94 traveled at a speed of 50 MPH. The STEP vehicles patrolling the southbound segment of I-29 and the westbound segment of I-94 traveled at a speed of 55 MPH.

Vehicles detected traveling between 60 and 64 MPH were stopped and issued written warnings. Vehicles detected traveling at 65 MPH or greater were stopped and issued written citations.

In the initial operation plan, four Traffic Data Recorders (TDR) were to be utilized to measure and record vehicle speed data at specified fixed intervals along both highways. They were to be placed on the medians at locations dividing the two target highways into six approximately equal increments. On I-29 the TDR's were to be located at mileposts 74 and 83. On I-94 they were to be located at mileposts 323 and 315. However, due to the unavailability of four recorders, only one recorder was used on each highway. These were located at milepost 74 on I-29 and 323 and on I-94. A third unit was used for replacement parts in case of machine malfunctions. Both locations were on open highway, away from interchanges, rest areas, or inclines which might influence vehicle speeds.

Each recorder was used to measure and record vehicles speeds, traffic volumes, peak periods and various speed parameters for all lanes in both directions of travel. No external power source was needed, so the availability of a power supply was not a consideration. The recorders were self contained and operated with rechargeable batteries. They were equipped with insulation to allow operations in zero degree weather. When temperatures were expected to fall below zero degrees, the equipment was brought inside.

Vehicle data was recorded on magnetic tape cassettes by the TDR's. The cassettes were collected by the North Dakota Highway Patrol and forwarded to another subcontractor to be converted into a workable format for analysis.

In addition to the speed data collected by the TDR's, weekly accident data was collected for the target highway segments.

EVALUATION METHODOLOGY

This evaluation was designed to examine trends in the movements of the vehicle speed distribution parameters with corresponding allocation of STEP manpower. Effectiveness was measured by how closely changes in the vehicle speed distribution compared to changes in allocations of manpower. A secondary measurement of effectiveness was a reduction in traffic accidents attributed to the enforcement of the 55 MPH speed limit. Once a relationship between enforcement and the speed parameters was established, the validity of the theoretical assumptions behind the relationship was tested.

The evaluation methodology incorporates both longitudinal and baseline comparison analyses. Longitudinal analysis was used to examine the vehicle speed distribution for changes under periods of varied enforcement. Vehicle speeds were isolated for comparisons with manpower levels on the target highways in an attempt to identify the optimal manpower level. The mean and median speeds, the standard deviation of the vehicle speeds and the 15th, 85th and 95th speed percentiles were calculated for the eight hour enforcement periods and the peak volume hour. Other parameters of interest were the percentage of vehicles exceeding the speed limit by 10 MPH or more, and the speed range (MPH) between the 5th and 95th percentiles. The objective of the enforcement plan was to reduce the number of vehicles exceeding the speed limit by 10 MPH and more without shifting the entire distribution downward. As extreme speeds were reduced, the percentage of vehicles in a 10 MPH pace should in crease and the speed range between the 5th and 95th percentiles should decline. In using this approach, three basic characteristics of the distributions were examined: the central tendency, the dispersion or variability, and the extremes.

Baseline comparisons were used to evaluate any change in traffic accidents during the speed enforcement program. Three years of baseline data, for a similar time period (March through June), was collected and compared to the traffic accident frequencies during the speed enforcement program.

Daily weather data was collected to enable the comparison of vehicle speed parameters to changes in the weather conditions. The precipitation volume (inches) of rainfall and snowfall, and the amount of snow or ice (inches) on the ground at 6 A.M. was used to identify changes in the speed data due to inclement weather conditions.

Once a general trend was identified between manpower and the speed distribution, computerized correlational analysis was used to test the strength of the relationship. Both parametric and non-parametric tests were employed. The non-parametric test was used in case the samples could not be considered of interval scale and normally distributed. Partial correlations were performed to test for a spurious relationship between manpower levels and vehicles speeds. By holding constant the effect of other variables, such as traffic volumes and weather conditions, the true influence of enforcement could be determined. One measure of effectiveness of enforcement was an inverse relationship between speed parameters and manpower volume.

EVALUATION CONSTRAINTS

In the initial operation plan, 90 days were allocated for the speed enforcement program. The manpower schedule was designed so all combinations of zero, two and four units of visible enforcement could be compared to changes in the speed distribution parameters. The allocation of 18 weeks for the study was to enable the speed distribution to be analyzed under different weather conditions and traffic volumes as well as enforcement levels. Days in which speeds could not be measured due to inclement weather conditions would then be excluded in the evaluation process. However, of the 90 days allocated, less than one-third were available for evaluation. Lack of adequate substitute traffic data recorders, heavy snowfalls in March and flood level rainfalls in June helped contribute to the small volume of data.

Twenty seven days of data were available for analysis from Interstate 94. Of these, nine days were from periods of no visible enforcement, 10 days from periods of two units of visible enforcement and 8 days from periods of four units of enforcement. Subtracting out days with measurable precipitation reduced the total days available on I-94 to 18. Of these, seven were from periods of zero and two units of enforcement and four from periods of four units of enforcement.

Twenty two days of data were available for analysis from Interstate 29. Of these, six days were from periods of no enforcement, 11 days from periods of two units of enforcement and five days from periods of four units of enforcement. Subtracting out days with measurable precipitation reduced the total days available on I-29 to 13. Of these, four days were from periods of no enforcement, six days from periods of two units of enforcement and only three days from periods of four units of enforcement.

Traffic volumes were of sufficient size to give an adequate representation of the speed distribution for any given day. However, the small number of days of data and the gaps in the data prevented any evaluation of long range exposure of enforcement or the varied levels of enforcement with change in the speed parameters. The evaluation process was limited to identifying trends in the movements of the speed parameters with the three allocations of enforcement. Combinations of the enforcement allocations were virtually eliminated.

There was a discrepancy between the traffic volumes recorded and the traffic volumes used in the calculations of the speed parameters by the traffic data recorders on I-29. If one of the two sensors was not functioning properly, a vehicle crossing the sensors was counted but a valid speed was not measured. The average daily traffic volume was almost three times the size of the traffic volume used in the computations on I-29. On I-94 the volumes recorded and the volumes used were almost identical.

In addition to the discrepancy between the recorded and used traffic volumes, the average daily speed (mean) for all northbound vehicles during periods of no enforcement on I-29 was 44.47 MPH. This compares to average daily speed (mean) of 57.65 MPH for all southbound vehicles during periods of no enforcement on I-29. The relatively low average daily speed and the discrepancy in the recorded traffic volumes causes suspicion as to the accuracy and comparability of the data collected on I-29.

Several of these constraints may have been alleviated if the original plan had been adhered to. In the original operation plan, two traffic data recorders were to be used on each highway and a fifth was to be used as a substitute. However, only three recorders were available, limiting the collection of data to one location on each highway. In the original plan, the cassettes containing the data were to be collected and submitted weekly for transformation into a workable format. The data was then to be sent to the evaluators for analysis. Due to delays in a subcontract for data reduction, the data was not furnished to the evaluators until after the operations in North Dakota were completed. It was only at that time that it was discovered that valid data was available for less than one third of the experiment. By then it was too late to alleviate the situation.

EXPERIMENTAL RESULTS

The evaluation was designed to examine the parameters of the vehicle speed distribution under various weather conditions, traffic volumes and enforcement allocations. The central tendency of the speed distribution, which represents the speed values the observations tend to cluster around, was measured by the average speed (mean). The dispersion or variability among the speed observations was measured by the standard deviation of the vehicle speeds, the speed range (in mph) between the 5th and 95th percentiles, and the percentage of vehicles in a 10 MPH pace. In addition to the basic parameters, measures of the speed distribution extremes were analyzed. These were represented by the 15th, 85th and 95th percentile speeds, and the percentage of vehicles exceeding the speed limit by 10 MPH or more.

Interstate # 94

1) Measure of Central Tendency

The measure of central tendency of the vehicle speed distribution was the average daily speed (mean). The westbound vehicles were traveling at an average daily speed of 59.40 MPH (Table VI-2). During periods of no visible enforcement the expected value for average daily speed was 60.50 MPH. With two and four units of visible enforcement, patrolling at 55 MPH, the expected values were 59.46 and 58.10 MPH, respectively. Parametric correlation analysis revealed a slight trend for an inverse relationship between enforcement and average daily speed. The correlation coefficient was -.2382. However, the test was supported by a confidence level of only 88%. When holding constant for precipitation the result was similar. A partial coefficient of -.2340 was calculated with a confidence level below 90%.

INTERSTATE # 94

		No Enforcement	2 Units of Enforcement	4 Units of Enforcement	All Levels of Enforcement
Average Daily Speed	(West)	60.50 mph	59.46 mph	58.10 mph	59.40 mph
	(East)	61.91 mph	62.51 mph	56.80 mph	60.62 mph
Standard Deviation	(West)	7.98 mph	7.67 mph	6.70 mph	7.48 mph
	(East)	8.52 mph	7.14 mph	7.06 mph	7.58 mph
Speed Range (5th to 95th Percentiles)	(West)	24.21 mph	20.54 mph	21.44 mph	22.09 mph
	(East)	22.12 mph	21.36 mph	22.05 mph	22.82 mph
10 mph Pace	(West)	57.22 %	61.67 %	61.12 %	59.96 %
	(East)	60.11 %	61.40 %	57.37 %	59.78 %
15th % Speed	(West)	53.89 mph	54.74 mph	51.88 mph	53.57 mph
	(East)	56.18 mph	56.45 mph	49.88 mph	54.41 mph
85th % Speed	(West)	67.48 mph	66.97 mph	64.54 mph	66.40 mph
	(East)	68.84 mph	69.05 mph	63.67 mph	67.39 mph
95th % Speed	(West)	72.87 mph	71.44 mph	69.02 mph	71.19 mph
	(East)	73.17 mph	73.78 mph	68.15 mph	71.90 mph
% Exceeding by 10 mph or more (%)	(West)	24.40 %	23.40 %	20.95 %	[illegible] %
	(East)	32.29 %	32.29 %	15.87 %	27.43 %

Table VI-2

The eastbound vehicles were traveling at an average speed of 60.62 MPH. During periods of no visible enforcement the expected value for the average daily speed was 61.91 MPH. With two and four units of visible enforcement, patrolling at 50 MPH, the expected values were 62.51 and 56.80 MPH. The correlation coefficient between enforcement and average speed was calculated at -.4748 with a 99% confidence level. When holding constant for precipitation the coefficient declined slightly to -.4508 with confidence level of 99%.

The average daily speed of both east and westbound vehicles was lower under maximum enforcement than no enforcement. The expected values of the average daily speed was 2.4 MPH less for westbound vehicles and 5.11 MPH less for eastbound vehicles. However, correlation analyses revealed only the eastbound vehicles to have a significant inverse relationship between enforcement and average daily speed.

2) Measures of Dispersion

The measures of dispersion of the vehicle speed distribution were the standard deviation of the vehicle speed distribution, the speed range between the 5th and 95th percentiles, and the percentage of vehicles in a 10 MPH pace. The expected value for the standard deviation of westbound vehicles measured by the traffic data recorders was 7.48 MPH (Table VI-2). During periods of no visible enforcement the expected value was 7.98 MPH. With two and four units of visible enforcement, patrolling at 55 MPH, the expected values were 7.67 and 6.70 MPH. Parametric correlation analysis revealed a trend for enforcement to be inversely related to the standard deviation of the vehicle speed distribution. The correlation coefficient was -.2585 with a confidence level above 90%. The non-parametric correlation coefficient was calculated (Kendall's tau) to guard against invalid correlation assumptions. The Pearson correlations require that the samples be of interval scale and from a normal population. The non-parametric test enables relationships to be discovered without any assumptions about the data or its distribution. The result of the Kendall test was a coefficient of -.3068 with a confidence level above 98%. When holding constant for precipitation the strength of association increased slightly, represented by a coefficient of -.2715 with a confidence level of greater than 95%.

The expected value for the standard deviation of eastbound vehicles was 7.58 MPH. During periods of no enforcement the expected value was 8.52 MPH. With two and four units of visible enforcement, patrolling at 55 MPH, the values were 7.14 and 7.06 MPH.

Parametric correlation analysis revealed a strong inverse relationship between enforcement and the standard deviation of vehicle speed distribution for eastbound vehicles. The result was a correlation coefficient of -.5397 with a confidence level above 99%. The non-parametric coefficient was calculated at -.4588 with a confidence level above 99%. When holding constant for precipitation the coefficient declined minimally to -.5339 with a 99% confidence level. The results of the correlational analysis on I-94 revealed enforcement to be inversely related to the standard deviation of the vehicle speed distribution. As enforcement was increased the standard deviation in the speed distribution declined.

A second measure of the dispersion of the vehicle speed distribution was the speed range (mph) between the 5th and 95th percentiles. The expected value for the speed range of the westbound vehicles was 22.09 MPH. This means that between the 5th and 95th percentiles of the vehicle speed distribution there was a speed difference of 22 MPH. During period of no enforcement the expected value was 24.21 MPH. With two and four units of visible enforcement, patrolling at 55 MPH, the expected values were 20.54 and 21.44 MPH. There was a trend for inverse relationship between enforcement and the speed range, represented by a coefficient of -.3257. This figure was supported by a confidence level just above 90%. The non-parametric coefficient was -.3184 with a confidence level above 98%. When holding constant for precipitation the degree of association strengthened. The result was a coefficient of -.4130 with a confidence level of 98%.

The expected value for the speed range for eastbound vehicles was 22.82 MPH. During periods of no enforcement the value was 22.12 MPH. With two and four units of visible enforcement, patrolling at 50 MPH, the expected values were 21.36 and 22.05 MPH. Parametric correlation analysis revealed no significant association between the range and enforcement represented by a coefficient of -.0164. The non-parametric coefficient was found to be -.0864 with an insignificant confidence level. When holding constant for precipitation the result was not altered. A coefficient of -.0076 was calculated with a confidence level of 65%.

A third measure of dispersion of the vehicle speed distribution was the percentage of vehicles in a 10 MPH pace. The pace was the 10 MPH speed range driven by the greatest number of vehicles. The expected value for the pace of the westbound vehicles was 59.96%. During periods of no enforcement the expected value was 57.22%. With two and four units of visible enforcement, patrolling at 55 MPH, the expected values were 61.67 and 61.12%. Parametric correlation analysis revealed a direct relationship between enforcement and the percentage of vehicles in a 10 MPH pace. The result was a coefficient of .3101 with a confidence level above 90%. The non-parametric coefficient was a .2865 with a confidence level above 95%. When controlling for precipitation the degree of association strengthened. The coefficient was calculated at .4059 with a confidence level above 95%.

The expected value for the pace of the eastbound vehicles was 59.78%. During periods of no visible enforcement the expected value was 60.11%. During periods of two and four units of visible enforcement, patrolling at 50 MPH, the expected values were 61.40 and 57.37% respectively. Parametric correlation analysis revealed no significant association between enforcement and the pace of eastbound vehicles. When controlling for precipitation the coefficient was calculated at -.0951 with an insignificant confidence level.

The results of the correlational analysis on the measures of dispersion of the vehicle speed distribution for I-94 during the different enforcement levels displayed several interesting results. There was an inverse relationship between enforcement and the standard deviation of the vehicle speed distribution for both eastbound and westbound vehicles. The tests performed were supported by confidence levels above 90%. However, the other measures of dispersion of the vehicle speed distribution did not react in the same manner. The speed range between the 5th and 95th percentiles was found to be inversely related to enforcement for westbound vehicles. There was no significant relationship between the speed range and enforcement for eastbound vehicles. For westbound vehicles the pace was found to increase as enforcement increased. For eastbound vehicles the pace was found to have no significant association with enforcement.

3) Measures of the Speed Distribution Extremes

The extremes of the vehicles speed distributions for both highways were measured by the 15th, 85th, 95th speed percentiles and the percentage of vehicles exceeding the speed limit by 10 MPH or more. The expected value of the 15th percentile speed for westbound vehicles was 53.57 MPH (Table VI-2). During periods of no visible enforcement the expected value was 53.89 MPH. During periods of two and four units of visible enforcement, patrolling at 55 MPH, the expected values were 54.74 and 51.88 MPH, respectively. Parametric correlation analysis revealed no significant association between enforcement and the 15th percentile speed. The result was a correlation coefficient of -.2110, supported by a confidence level below 90%. When precipitation was held constant in the partial correlation the relationship between the 15th percentile speed and enforcement weakened. Through the tests performed it was determined that there was no significant relationship between the 15th percentile speed and enforcement for westbound vehicles on I-94.

The expected value of the 15th percentile speed for eastbound vehicles was 54.41 MPH. During periods of no visible enforcement the expected value was 56.18 MPH. During periods of two and four units of visible enforcement, patrolling at 50 MPH, the expected values were 56.45 and 49.88 MPH, respectively. Parametric correlation analysis revealed that there was an inverse relationship between the 15th percentile speed and enforcement. The result was a coefficient of -.5016 with a confidence level above 99%. When precipitation was held constant in the partial correlation the degree of association declined slightly. The partial correlation coefficient was -.4799 with a confidence level above 99%. Through the tests performed it was

CONTINUED

2 OF 3

determined that there was a significant inverse relationship between the 15th percentile speed and enforcement for eastbound vehicles on I-94.

A second measure of the speed distribution extremes was the 85th percentile speed. The expected value of the 85th percentile speed for westbound vehicles was 66.40 MPH. During periods of no visible enforcement the expected value was 67.48 MPH. During periods of two and four units of visible enforcement, patrolling at 55 MPH, the expected values were 66.97 and 64.54 MPH, respectively. Parametric correlation analysis revealed an inverse relationship between the 85th percentile speed and enforcement. The result was a coefficient of -.2689 with a confidence level above 90%. When precipitation was held constant in the correlation the degree of association strengthened slightly. The result was a partial correlation coefficient of -.2756 with a confidence level above 90%.

The expected value of the 85th percentile speed for eastbound vehicles was 67.39 MPH. During periods of no visible enforcement the expected value was 68.84 MPH. During periods of two and four units of visible enforcement, patrolling at 50 MPH, the expected values were 69.05 and 63.67 MPH, respectively. Parametric correlation analysis revealed an inverse relationship between the 95th percentile speed and enforcement. The result was a coefficient of -.5123 with a confidence level above 99%. When precipitation was held constant the degree of association declined slightly. The partial correlation coefficient was -.4908 with a confidence level above 99%. Through the tests performed it was determined that there was a significant inverse relationship between the enforcement and the 85th percentile speed.

A third measure of the speed distribution extremes was the 95th percentile speed. The expected value of the 95th percentile for westbound vehicles was 71.19 MPH. During periods of no visible enforcement the expected value was 72.87 MPH. During periods of two and four units of visible enforcement, patrolling at 55 MPH, the expected values was 71.44 and 69.02 MPH respectively. Parametric correlation analysis revealed an inverse relationship between the 95th percentile speed and enforcement. The result was a correlation coefficient of -.3058 with a confidence level above 90%. When precipitation was held constant in the correlation the result was a coefficient of -.3158 with a confidence level above 90%.

The expected value of the 95th percentile speed for eastbound vehicles was 71.90 MPH. During periods of no visible enforcement the expected value was 73.17 MPH. During periods of two and four units of visible enforcement, patrolling at 50 MPH, the expected values were 73.78 and 68.15 MPH, respectively. Parametric correlation analysis revealed an inverse relationship between the 95th percentile speed and enforcement. The result was a correlation coefficient of -.4901 with a confidence level above 99%. When precipitation was controlled for in the correlation the result was a partial coefficient of -.4631 with a confidence level above 99%. Through the tests performed it was determined that there was a significant inverse relationship between the 95th percentile speed and enforcement.

A fourth measure of the extremes of the vehicle speed distribution was the percentage of vehicles exceeding the speed limit by 10 MPH or more.

The expected value of this measure for westbound vehicles on I-94 was 23%. During periods of no visible enforcement the expected value was 24.4%. During periods of two and four units of visible enforcement, patrolling at 55 MPH, the expected values were 23.4 and 20.95%. The trend was for the percentage of vehicles exceeding the speed limit to decline as enforcement increased. However, parametric correlation analysis revealed a relatively weak association between the percentage of vehicles exceeding the speed limit and enforcement. The correlation coefficient was -.1575 with a confidence level below 80%. Holding constant for precipitation did not alter the result. The partial correlation coefficient was -.1506 with a confidence level below 80%.

The expected value of this measure for eastbound vehicles was 27.43%. During periods of no visible enforcement the expected value was 32.29%. During periods of two and four units of visible enforcement, patrolling at 50 MPH, the expected values were 32.29 and 15.87%. Parametric correlation analysis revealed a strong inverse relationship between the percentage of vehicles exceeding the speed limit and enforcement. The correlation coefficient was -.6259 with a confidence level above 99%. Holding constant for precipitation did not alter the degree of the association. The partial correlation coefficient was -.6130 with a confidence level above 99%.

Summary of the Results

The speed distribution for vehicles on I-94 shifted to the left (downward) as the enforcement increased. During periods of maximum enforcement(four patrol units) all the measures of the speed distribution except the 10 MPH pace for eastbound vehicles shifted in the desired direction. The average daily speed, the standard deviation, the speed range, the 15th percentile speed, the 85th percentile speed, the 95th percentile speed and the percentage of vehicles exceeding the speed limit by 10 MPH or more all recorded lower values during periods of maximum enforcement, when compared to periods of no enforcement. The percentage of vehicles in a 10 MPH pace shifted in the desired direction for westbound vehicles. Including both directions of travel this represents 15 out of 16 measures of the speed distribution that shifted in the desired direction. Of the 15 measures, 11 were supported by correlation coefficients revealing the same direction with confidence levels above 90%.

Interstate # 29

1) Measure of Central Tendency

The data collected on I-29 displayed a relationship between enforcement and average daily speed quite dissimilar from that of I-94. The average daily speed was lower and did not decline as enforcement increased. The expected value for the average daily speed for northbound vehicles on I-29 was 54.54 MPH. During periods of no visible enforcement the value was 44.47 MPH. With two and four units of visible enforcement, patrolling at 50 MPH, the values were 59.11 and 56.56 MPH, respectively (Table VI-3). The relatively low average daily speed under the zero enforcement level causes suspicion as to the comparability of the data collected. Parametric correlation analysis revealed a strong positive correlation between enforcement and average speed. The coefficient was calculated at .5753 with confidence level above 99%. When holding constant for precipitation the relationship remained the same. The coefficient from the partial correlation was .5445 with a confidence level above 99%. It should be noted that the low average speed under the zero enforcement level contributed heavily to the strong correlation coefficient. The expected value for the average daily speed under the four enforcement level was lower than that of the two enforcement level.

The expected value for the average daily speed for southbound vehicles was 58.29 MPH. During periods of no visible enforcement the value was 57.65 MPH. With two and four units of visible enforcement, patrolling at 55 MPH, the values were 57.44 and 60.96, respectively. Parametric correlation analysis revealed a strong positive correlation between enforcement and average daily speed. The correlation coefficient was .4057. When holding constant for precipitation the coefficient increased slightly to .4155 with a confidence level above 95%.

INTERSTATE # 29

		No Enforcement	2 Units of Enforcement	4 Units of Enforcement	All Levels of Enforcement
Average Daily Speed (Mean)	(North)	44.47 mph	59.11 mph	56.56 mph	54.54 mph
	(South)	57.65 mph	57.44 mph	60.96 mph	58.29 mph
Standard Deviation	(North)	18.35 mph	11.68 mph	14.44 mph	14.13 mph
	(South)	10.97 mph	12.54 mph	9.32 mph	11.38 mph
Speed Range (5th to 95th Percentiles)	(North)	50.77 mph	38.99 mph	52.02 mph	45.16 mph
	(South)	36.62 mph	44.09 mph	24.24 mph	37.54 mph
10 mph Pace	(North)	42.83 %	56.45 %	47.60 %	50.73 %
	(South)	54.67 %	57.09 %	61.00 %	57.32 %
15% Speed	(North)	22.45 mph	51.22 mph	43.40 mph	41.59 mph
	(South)	47.22 mph	49.14 mph	55.70 mph	50.11 mph
85% Speed	(North)	63.35 mph	68.04 mph	67.48 mph	66.63 mph
	(South)	66.53 mph	66.62 mph	68.02 mph	66.91 mph
95% Speed	(North)	68.52 mph	74.04 mph	78.46 mph	73.54 mph
	(South)	71.73 mph	70.93 mph	72.58 mph	71.52 mph
% Exceeding 10 mph or more	(North)	11.83 %	29.02 %	21.48 %	22.62 %
	(South)	20.72 %	22.70 %	28.72 %	23.53 %

Table VI-3

2) Measures of Dispersion

The dispersion of the speed distribution on I-29 was measured by the standard deviation, the speed range between the 5th and 95th percentiles and the percentage of vehicles in a 10 MPH pace. The expected value of the standard deviation for the vehicle speed distribution of northbound vehicles was 14.13 MPH. During periods of no visible enforcement the expected value was 18.35 MPH. During periods of two and four units of visible enforcement, patrolling at 50 MPH, the expected values were 11.68 and 14.44 MPH, respectively. Parametric correlation analysis revealed enforcement to be inversely related to the standard deviation of the vehicle speed distribution. The result was a coefficient of -.3915 with a confidence level above 95%. The non-parametric coefficient was calculated at -.2307 with a confidence level above 90%. When holding constant for precipitation the strength of the association declined slightly. The coefficient from the partial correlation was -.3572 with a confidence level above 90%.

The expected value for the standard deviation of the vehicle speed distribution of southbound vehicles was 11.38 MPH. During periods of no visible enforcement the expected value was 10.97 MPH. During periods of two and four units of visible enforcement, patrolling at a speed of 55 MPH, the expected values were 12.54 and 9.32 MPH, respectively. The correlation coefficient for the relationship between enforcement and the standard deviation was found to be -.2056 with a confidence level above 90%. The non-parametric coefficient was calculated at -.2300 with a confidence level above 90%. When holding constant for precipitation the relationship declined slightly. The result was a coefficient of -.2095 with a confidence level below 90%.

A second measure of the dispersion of the speed distribution on I-29 was the speed range (mph) between the 5th and 95th percentiles. The expected value of the speed range for northbound vehicles was 45.16 MPH. During periods of no visible enforcement the expected value was 50.77 MPH. During periods of two and four units of visible enforcement, patrolling at 50 MPH, the values were 38.99 and 52.02 MPH, respectively. Parametric correlational analysis revealed the speed range to have no significant association with enforcement. The non-parametric test revealed the same result. Holding constant for precipitation did not alter the results. Through the use of parametric, non-parametric and partial correlation analysis it was determined that there was no significant association between the speed range of northbound vehicles and enforcement.

The expected value of the speed range for southbound vehicles was 37.54 MPH. During periods of no visible enforcement the expected value was 36.62 MPH. During periods of two and four units of visible enforcement, patrolling at 50 MPH, the expected values were 44.09 and 24.24 MPH, respectively. Parametric correlation analysis revealed the speed range to be inversely related to enforcement. The correlation coefficient was -.3420 with a confidence level above 95%. The non-parametric test revealed similar results. The coefficient was -.2517 with a 95% confidence level. When precipitation was held constant in the correlation the result was a coefficient of -.3672 with a confidence level above 95%. Through the tests performed it was determined that there was significant inverse relationship between the speed range of southbound vehicles and enforcement.

A third measure of the dispersion of the vehicle speed distribution on I-29 was the percentage of vehicles in a 10 MPH pace. The expected value of the pace for northbound vehicles was 50.73%. During periods of no visible enforcement the expected value was 42.83%. During periods of two and four units of visible enforcement, patrolling at 50 MPH, the expected values were 56.45 and 47.60%. Parametric correlation analysis revealed a trend in the percentage of vehicles in a 10 MPH pace to be directly related to enforcement. The result was a correlation coefficient of .2217 with a confidence level below 90%. The non-parametric coefficient was .1949 with a confidence level below 90%. When precipitation was held constant in the correlation the degree of association weakened. Through the tests performed it was determined that there was no significant association between the pace of northbound vehicles and enforcement.

The expected value of the pace for southbound vehicles was 57.32%. During periods of no visible enforcement the expected value was 54.67%. During periods of two and four units of visible enforcement, patrolling at 55 MPH, the expected values were 57.09 and 61.00%. Parametric correlation analysis revealed the pace to have a strong direct relationship with enforcement. The result was a correlation coefficient of .3815 with a confidence level above 95%. The non-parametric coefficient was .3045 with a confidence level above 95%. When precipitation was held constant in the correlation the relationship weakened. The result was a partial correlation coefficient of .3664 with a confidence level of 95%. Through the tests performed it was determined that there was a significant direct relationship between the pace of southbound vehicles on I-29 and enforcement.

3) Measures of the Speed Distribution Extremes

The extremes of the vehicle speed distributions for I-29 was measured by the 15th, 85th, 95th speed percentiles and the percentage of vehicles exceeding the speed limit by 10 MPH or more.

The expected value of the 15th percentile speed for northbound vehicles was 41.59 MPH. During periods of no visible enforcement the expected value was 22.45 MPH. During periods of two and four units of visible enforcement, patrolling at 50 MPH, the expected values were 51.22 and 43.40 MPH, respectively. Parametric correlation analysis revealed a trend for enforcement and the 15th percentile speed to be directly related. The result was a correlation coefficient of .5407 with a confidence level above 99%. When precipitation was held constant in the partial correlation the relationship between the 15th percentile speed and enforcement remained strong. The result was a correlation coefficient of .5090 with a confidence above 99%. Through the tests performed it was determined that there was a significant direct relationship between the 15th percentile speed and enforcement for northbound vehicles on I-29.

The expected value of the 15th percentile speed for southbound vehicles was 50.11 MPH. During periods of no visible enforcement the expected value was 47.22 MPH. During periods of two and four units of visible enforcement, patrolling at 55 MPH, the expected values were 49.14 and 55.70 MPH, respectively. Parametric correlation analysis revealed that there was a direct relationship between the 15th percentile speed and enforcement. The result was a coefficient of .3438 with a confidence level above 90%. When precipitation was held constant in the partial correlation the degree of association declined only slightly. The partial correlation coefficient was .3216 with a confidence level above 90%. Through the tests performed it was determined that there was a significant direct relationship between the 15th percentile speed and enforcement for southbound vehicles on I-29.

A second measure of the speed distribution extremes was the 85th percentile speed. The expected value of the 85th percentile speed for northbound vehicles was 66.63 MPH. During periods of no visible enforcement the expected value was 63.35 MPH. During periods of two and four units of visible enforcement, patrolling at 50 MPH, the expected values were 68.04 and 67.48 MPH, respectively. Parametric correlation analysis revealed a direct relationship between the 85th percentile speed and enforcement. The result was a coefficient of .4996 with a confidence level above 98%. When precipitation was held constant in the correlation the degree of association weakened slightly. The result was a partial correlation coefficient of .4747 with a confidence level above 98%.

The expected value of the 85th percentile speed for southbound vehicles was 66.91 MPH. During periods of no visible enforcement the expected value was 66.53 MPH. During periods of two and four units of visible enforcement, patrolling at 55 MPH, the expected values were 66.62 and 68.02 MPH, respectively. Parametric correlation analysis revealed a direct relationship trend between the 85th percentile speed and enforcement. The result was a coefficient of .2791 with a confidence level below 90%. When precipitation was held constant the degree of association increased slightly. The partial correlation coefficient was .3071 with a confidence level above 90% Through the tests performed it was determined that there was a significant direct relationship between the enforcement and the 85th percentile speed on I-29.

A third measure of the speed distribution extremes was the 95th percentile speed. The expected value of the 95th percentile for northbound vehicles was 73.54 MPH. During periods of no visible enforcement the expected value was 68.52 MPH. During periods of two and four units of visible enforcement, patrolling at 50 MPH, the expected values were 74.04 and 78.46 MPH, respectively. Parametric correlation analysis revealed a strong direct relationship between the 95th percentile speed and enforcement. The result was a correlation coefficient of .6630 with a confidence level above 99%. When precipitation was held constant in the correlation the result was a coefficient of .6604 with a confidence level above 99%.

The expected value of the 95th percentile speed for southbound vehicles was 71.52 MPH. During periods of no visible enforcement the expected value was 71.73 MPH. During periods of two and four units of enforcement, patrolling at 55 MPH, the expected values were 70.93 and 72.58 MPH, respectively. Parametric correlation analysis revealed no significant relationship between the 95th percentile speed and enforcement. The result was a correlation coefficient of .1166 with insignificant confidence level. When precipitation was controlled for in the correlation the result was a partial coefficient of .1589 with a confidence level below 80%. Through the tests performed it was determined that there was a significant direct relationship between the 95th percentile speed and enforcement for northbound vehicles on I-29. There was no significant relationship between the 95th percentile speed and enforcement for southbound vehicles on I-29.

A fourth measure of the extremes of the vehicle speed distribution was the percentage of vehicles exceeding the speed limit by 10 MPH or more. The expected value of this measure for northbound vehicles was 22.62%. During periods of no visible enforcement the expected value was 11.83. During periods of two and four units of visible enforcement, patrolling at 50 MPH, the expected values were 29.02 and 21.48%. Parametric correlation analysis revealed a direct relationship between the percentage of vehicles exceeding the speed limit and enforcement. The correlation coefficient was .3117 with a confidence level above 90%. Holding constant for precipitation did alter the result. The partial correlation coefficient was .2713 with a confidence level below 90%.

The expected value of this measure for southbound vehicles was 25.53%. During periods of no visible enforcement the expected value was 20.72%. During periods of two and four units of visible enforcement, patrolling at 55 MPH, the expected values were 22.70 and 28.72%. Parametric correlation analysis revealed a direct relationship between the percentage of vehicles exceeding the speed limit and enforcement. The correlation coefficient was .3325 with a confidence level above 90%. Holding constant for precipitation increased the degree of the association. The partial correlation coefficient was .3601 with a confidence level above 95%.

Summary of the Results

The speed distribution for vehicles on I-29 shifted to the right (upward) as the enforcement increased. During periods of maximum enforcement all the measures of the speed distribution except the standard deviation, the 10 MPH pace and the southbound speed range shifted in the opposite direction. The average daily speed, the northbound speed range and the measures of the distribution extremes were higher during periods of maximum enforcement than during no enforcement.

Traffic Accidents During Speed Enforcement

During the 18 week speed enforcement program there was a total of 30 traffic accidents on I-94 and I-29. Of this total five occurred between the hours of 11 A.M. and 7 P.M., on the selected four-lane highway segments. Only one of the five accidents occurred during a period of visible patrol. When compared to the same four month period for three years of baseline data (1971, 1972 and 1973) the result was similar. There was an average of 5.33 traffic accidents during the months of March through June on the same highway segments between the hours of 11 A.M. and 7 P.M. There was no significant change in the number of traffic accidents during the speed enforcement program when compared to the basline period. It should be noted nevertheless, that none of the five accidents during the speed enforcement program were related to speed infractions.

CONCLUSION

The evaluation of the speed enforcement program was severely constrained by factors outside the control of the evaluators and the North Dakota Highway Patrol. The lack of adequate substitute traffic data recorders, the availability of only one recorder on each highway and the inclement weather conditions helped contribute to the loss of two thirds of the available data. These three major constraints on the evaluation of the program, coupled with the fact that the data was not transformed and sent to the evaluators until after the end of operations in North Dakota, made it virtually impossible to perform the kind of analysis which would have been most meaningful and reliable. Nevertheless, it was the objective of this evaluation to identify any and all changes in the vehicle speed distribution parameters with the corresponding levels of enforcement. The available data was analyzed and the results of the tests performed were reported in the section on experimental results.

Traffic volumes were of sufficient size to give an adequate representation of the speed distribution for any given day. However, the small number of days of data and the gaps in the data prevented any evaluation of long range exposure of enforcement or the varied levels of enforcement with changes in the speed parameters. The evaluation process was limited to identify trends in the movements of the speed parameters with the three allocations of enforcement. The evaluation of combinations of enforcement allocations was virtually eliminated.

There were enough days of data available to get statistically significant results from the tests performed in the analysis of the program. However, it should be noted that the results of the tests on several of the key parameters revealed contradictory results when I-94 and I-29 were compared. So contradictory were the results that it causes suspicion as to whether the parameters did have any relationship to enforcement.

The measures of central tendency of the speed distribution and the measures of the speed distribution extremes revealed con-contradictory results for I-94 and I-29. The measures of central tendency (average daily speed) were inversely related to the enforcement allocations on I-94. As the enforcement increased average daily speed declined. The measures of central tendency were directly related to the enforcement allocations on I-29. As the enforcement increased the average daily speed increased. The measures of the speed distribution extremes (the 15th, 85th, 95th speed percentiles and the percentage of vehicles exceeding the speed limit by 10 MPH or more) revealed results similar in direction to the results of central tendency. The measures of the speed distribution extremes were inversely related to enforcement on I-94 and directly related to enforcement on I-29. The enforcement was allocated in such a manner that when there was no enforcement on I-94 there was four units of enforcement on I-29, and vise versa. The data received on I-94 was in a descending order of enforcement over time, and in an ascending order of enforcement over time on I-29. With an enforcement schedule such as this, the trends in the movements of the central tendency and the distribution extremes could be explained as time related. This would mean that the enforcement was not related to the movements in these parameters, but instead, the vehicle speeds increased over the time of the program as the weather improved.

The dispersion of the speed distribution did not react in this fashion. The standard deviation of the speed distribution was inversely related to enforcement on both I-29 and I-94. The pace and the range were inversely related to enforcement for the westbound vehicles on I-94 and the southbound vehicles on I-29. There was no significant relationship between the two parameters and enforcement in the other two directions.

In summary, even though the results of the evaluation do not imply cause and effect, they disclose a likelihood that the dispersion of the vehicle speed distribution was inversely related to the enforcement allocations. No other conclusions can be drawn due to the variability in the results received.

SECTION VII

SUMMARY

CONCLUSION

During the three years of STEP in North Dakota, five different selective enforcement experiments were conducted and evaluated. Because each was different, no single conclusion can adequately reflect all that occurred. This STEP project was unique in that the selective enforcement was undertaken by a state law enforcement agency in areas of comparatively low traffic density. This contrasts sharply to the other STEP demonstration projects which were conducted by local law enforcement agencies in densely populated urban areas. The traditional concepts of selective enforcement would lead one to believe that sites such as Grand Forks County and Cass County North Dakota are less than ideal to demonstrate the effectiveness of STEP. In fact, the results in these two counties indicate that the North Dakota STEP was one of the few projects in which it was possible to identify statistically significant relationships between the enforcement effort and the impact parameters.

The number and severity of traffic accidents in Grand Forks County was significantly lower during STEP than during the three year baseline period. This occurred despite the fact that accidents and injuries in the rest of the state increased during STEP.

Because of the national energy crisis and with the reduced speed limits, comparisons to baseline data in Cass County would have been meaningless. Nevertheless, it was found that there was a significant inverse correlation between the number of manhours spent on selective enforcement and the number of accidents occurring each month under STEP. In fact, this relationship was stronger than the relationship between citations and accidents.

The use of pre-arrest breath testers by the North Dakota Highway Patrol was associated with a significant lowering of average blood alcohol content of drivers arrested for DWI. Additionally, the officers who used the devices during the experiment made significantly more DWI arrests while they were issued the device than while they were in the control groups.

The enforcement of the 65 mile per hour speed limit on U.S. 81, using a stationary radar countermeasure preceded by a public information campaign, was associated with a substantial increase in the proportion of vehicles in compliance with the law. More than half of this increase occurred following the public information campaign and before any enforcement.

All four of the above experiments produced results that clearly support the effectiveness of the program. The fifth experiment, utilizing visible line patrol to enforce the 55 mile per hour speed limit on I-29 and I-94, did not provide such conclusive results. The lack of data, and the high variability of the data that was obtained, made it impossible to perform the kind of analysis which would have been most meaningful. Nevertheless, the evaluation did find a strong indication that line patrol can significantly influence the dispersion of vehicle speeds.

The significance of these findings should not be overlooked. It is the opinion of the evaluator that the North Dakota STEP project successfully demonstrated the effectiveness of selective enforcement in reducing the number and severity of traffic accidents in relatively low traffic density areas. Specifically, the line patrol countermeasure of conspicuous observation appears to have been an excellent enforcement strategy. Despite the small number of accidents occurring in areas such as these, when compared to major population centers, the highway traffic safety problem there is no less real. The success of the North Dakota STEP in alleviating this problem, while similar results were not obtained at other STEP sites, indicates that selective enforcement may be extremely important to many areas of the country.

We feel that the success of the North Dakota STEP is explainable in terms of several key factors. Our subjective evaluation indicates that the esprit de corps and the public image of the STEP task force made it a particularly effective group. Beyond that, however, it is our conclusion that much of the success can be attributed to the very nature of the safety problem there. Because of the relatively low traffic volumes, traffic flow conflicts do not appear to play a major role in accident causation. This is in contrast to urban areas where a single high accident intersection can account for more than a hundred accidents a year. It seems plausible that accidents arising out of traffic conflicts would be influenced only minimally by selective enforcement. Thus, while STEP projects in urban areas could not convincingly demonstrate an impact on accidents and injuries, the North Dakota STEP may have been successful because the kinds of accidents occurring in North Dakota were not predominantly due to traffic congestion and conflicts. If this is true, selective enforcement should receive more attention in lower population density areas where an accident problem has been identified.

RECOMMENDATIONS

As a result of our evaluation we feel several recommendations are in order. These can be broken into two groups: operational or procedural and program recommendations.

From a procedural point of view, we feel that it is most important that a closer working relationship be fostered between the National Highway Traffic Safety Administration and the demonstration project prime contractor. The Contract Technical Manager and the Demonstration Evaluation Division representative should have more frequent on-site visits. Such visits always were beneficial to the project, and many procedural difficulties could have been avoided if there had been more. Also, from a purely procedural point of view, it is recommended that evaluation reports, from the various similar demonstration projects, be made available to other evaluation subcontractors on a regular basis.

As a result of the experience in the final speed enforcement study, it is strongly recommended that the use of the sophisticated speed recording equipment owned by NHTSA be accompanied by sufficient preparation to test out the equipment at the site prior to collection of experimental data. This would allow the evaluator to receive timely reports and to identify any problems which might develop.

We also feel that two program recommendations are appropriate. First, because it was impossible to satisfy all the evaluation objectives of the last speed enforcement experiment, we recommend that the experiment should be expanded and repeated. Specifically, the impact on vehicle speed distributions of line patrol enforcement should be compared to the impact of stationary radar enforcement. This kind of information would be extremely helpful to law enforcement agencies throughout the country.

Finally, because of the success of the North Dakota STEP, we recommend that selective traffic programs aimed at reducing accidents in areas of moderate traffic volumes should be supported by the North Dakota Highway Patrol and the National Highway Traffic Safety Administration. In particular, conspicuous observation in a moving environment should be supported in new jurisdictions to validate its effectiveness.

END