SKID RESISTANCE STUDY

Final Report

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IMPLEMENTATION STATEMENT

Phase I

The elimination of one of the hot mixes from Louisiana's Specifications based on the findings of this study was accomplished some time ago. While the study cannot take complete credit for all the guidelines set forth in the Department's "Skid Accident Reduction Program," a part of these findings were considered when the guidelines were written. A copy of part of this "Engineering Directive and Standard Manual" is included in this report.

Phase II

This Phase of the study was completely implemented by the Louisiana Department of Transportation and Development in 1971.

SUMMARY

This is a report of a research project involving, in Phase I, the skid resistance of asphaltic concrete overlays. Phase II is a report of a pilot study set up in order to determine the best way to perform a skid resistance inventory of the highway network in Louisiana.

Phase I was conducted from August 1969 to August 1974 and included the skid testing of 19 dense-graded, asphaltic concrete overlays with hard rock (stream deposited, chert gravel) as the coarse aggregate. The skidding was conducted every six months for the five-year period. Also included herein are the results of a study of the pavement texture by means of the stereo-photographic method. The salient conclusions that were reached were: (1) Type 3 mixes with limestone screenings were unable to withstand high traffic counts for the five-year study period; (2) Type 1 mixes and Type 3 mixes with chert gravel screenings held an acceptable skid number under 2500 ADT/lane or less for approximately 4 1/2 years, and (3) the standard deviation of the difference between the locked wheel skid number and the skid number determined by photo-interpretation was 7.10 skid numbers.

Phase II established that a skid resistance inventory could be run using the ground rules set by the Department's Traffic and Planning Section. Reporting would be in a graphical form, and the basic

unit of the highway inventory would be the control unit (C.U.). It was decided that a skid test every two miles was sufficient, that no less than five tests per C.U. would be performed, and the most economical and efficient way to run the inventory was to drive the road from end to end across the entire state. Unfortunately, the highway network is not constructed to facilitate that type of inventory. The final inventory procedure arrived at was to test major and minor arterials once a year and the feeder roads after the major and minor were completed. It was anticipated that the entire system could be inventoried at least once in a two-year period, arterials twice and feeders once.

INTRODUCTION

The Skid Resistance Study was initiated in an attempt to discover two things. Phase I of the Project was an attempt to discover or investigate the skid characteristics of Louisiana's asphaltic overlays, the improvement they afford to existing pavements, and how they deteriorate with time and traffic with regard to skid resistance. This phase continued for five years, and it included a study of pavement texture by photo-interpretation suggested by Schonfeld (2)*. The results will be discussed in the report.

Phase II was a pilot study for the initation of a Skid Resistance Inventory. This phase lasted a year and was concurrent with Phase I. It included investigations into study area size, statistical significance of the numbers, economic evaluations of various inventory methods, and a general investigation of problems likely to arise during such an inventory.

* Underlined numbers in parentheses refer to the references listed in the back of this report.

P H A S E I

PHASE I

SCOPE

As mentioned in the Introduction, the main thrust of Phase I of this study was to determine the effectiveness of the overlay program of the early 1970's from the standpoint of skid resistance. The techniques included measuring the skid resistance of the overlay and how it varied with time and traffic; measuring the surface texture by the stereo-photographic method and how it varied; determining the hot mix properties; and studying the accidents that occurred on the various overlays. Significant findings came from all but the accident study. This method of evaluation was abandoned when it was realized that such a study would be unfeasible, since it would require an untold number of man-hours to pursue. The projects studied included only hot mixes with hard rock (river-deposited chert) aggregate, quartz sand and asphalt. None of the friction courses just making an appearance at the time of initiation of this study, the light weight hot mixes, or surface treatments (chip seals) were included. The overlay program at the time was limited to asphaltic concrete.

METHODOLOGY

Thirty-two overlay projects were considered for study, of which 19 were chosen to be studied. The remainder were dropped from the study due to late construction or complete cancellation of the project. The 19 jobs studied are listed below and shown in Figure 1.

TABLE 1
LISTING OF PROJECTS STUDIED

Project Name		Project No.	Route No.	Parish
1.	Texas St. Bgd-Webster Parish Line	1-03-37	U. S. 80	Bossier
2.	Quebec-Tallulah	2-04-24	U. S. 80	Madison
3.	Tallulah-Delta Pt.	2-05-23	U. S. 80	Madison
4.	Mermentau-Crowley	3-09-18	U. S. 90	Acadia
5.	New Iberia-Jeanerette	4-06-17	La. 182	Iberia
6.	Calumet-Centerville	4-07-09	U. S. 90	St. Mary
7.	Industrial Pkway.-Chef Men.	6-90-13	U. S. 90	Orleans
8.	Williams Boulevard-Kent Avenue	7-02-53	U. S. 61	Orleans
9.	Florida Street-Mississippi River Bridge	7-09-56	U. S. 61	E. Baton Rouge
10.	Vortex Spur-Alex.	14-06-19	U. S. 165	Rapides
11.	Columbia-Monroe	15-07-16	U. S. 165	Caldwell
12	Ferriday-Clayton	26-03-10	La. 15	Concordia

Project Name		Project No.	Route No.	Parish
13.	Ringgold-Minden	27-03-19	La. 7	Webster
14.	Plaquemine-Port Allen	50-07-28	La. 1	W. Baton Rouge
15.	Cloutierville-Monet Ferry	53-03-22	La. 1	Natchitoches
16.	Ironton-Junior	62-02-43 62-03-09	La. 23	Plaquemines
17.	Cotton Valley-Cullen	86-02-15	La. 7	Webster
18.	Zachary-Slaughter	250-01-10	La. 19	E. Baton Rouge
19.	West Bank Expressway	283-09-22	U. S. 90	St. Charles

Each of the 19 projects had six test sections chosen at random with the use of a random number table. The sections were biased, however, by the fact that curves were excluded. Three of the sections were placed in one lane and three in the opposing lane. Outside lanes were used in the case of multilane highways. The number of the section was marked with a sign on the edge of the shoulder. A rectangle the size of the camera box, necessary to take stereo-photographs, was painted in the left wheel path. A small nail was driven into the hot mix at the center of this rectangle for a reference in the photographs.

Three skid tests were run at 40 m.p.h. (64 km/h) on each of the six sections, for a total of 18. This series of tests was run before overlay, immediately after overlay and every six months thereafter for a period of five years. Stereo-photographs were

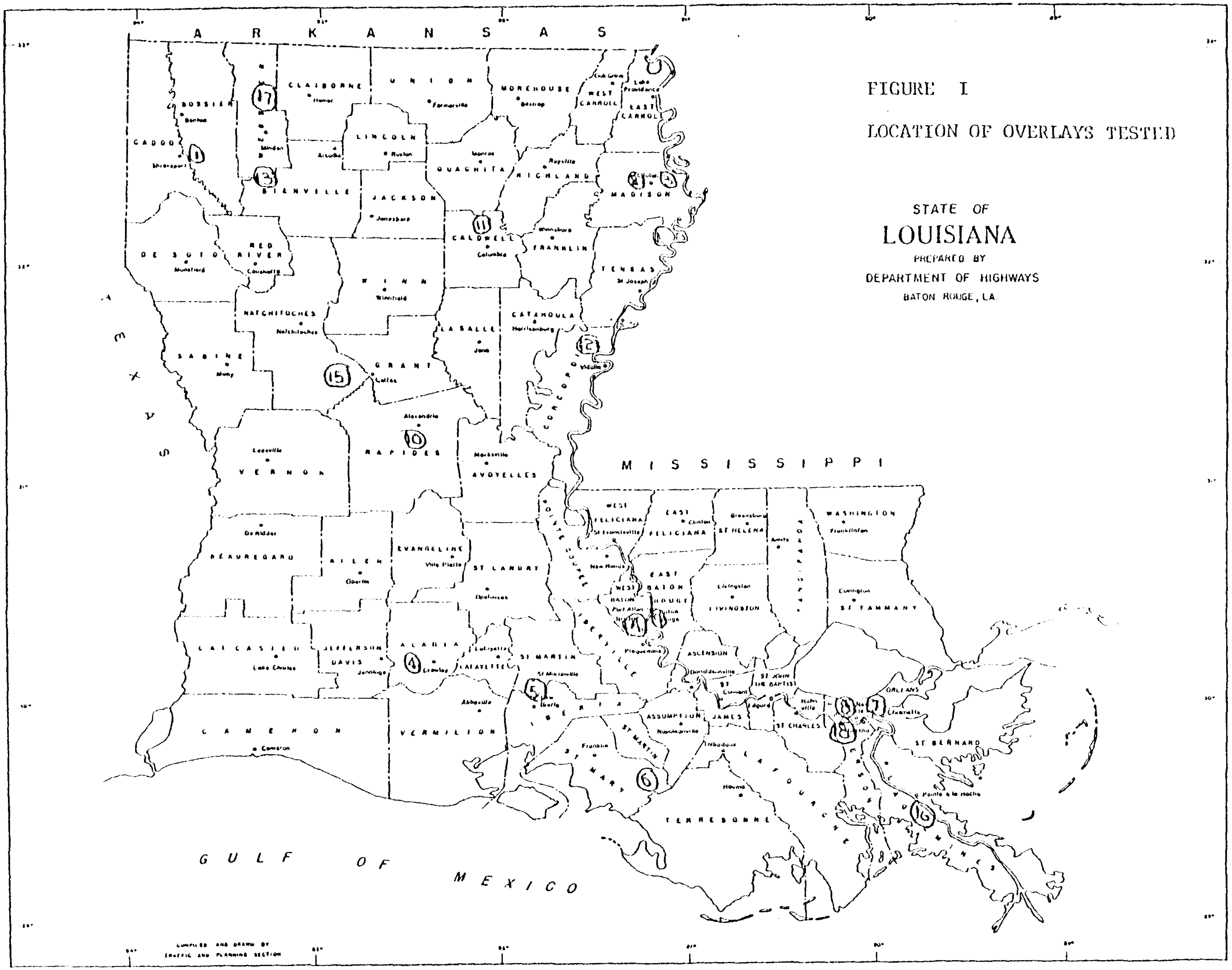
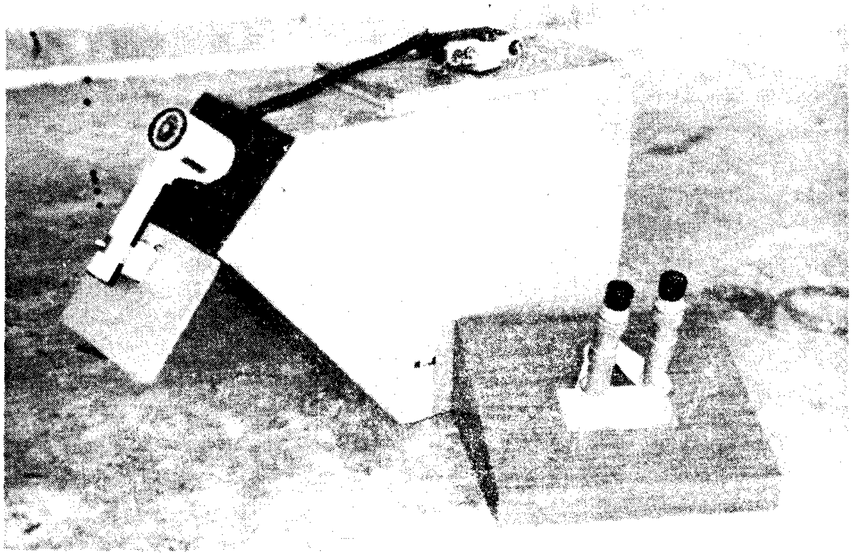


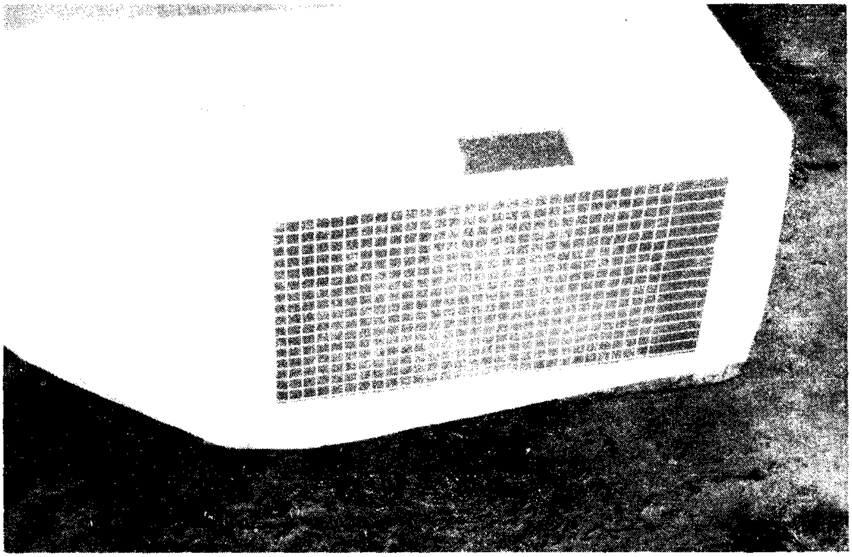
FIGURE I

LOCATION OF OVERLAYS TESTED

taken at the same time. The method of interpretation of the photographs bears explanation, since the procedure was changed during the data acquisition period and appears in ASTM E 559, "Tentative Recommended Practice for Classifying Pavement Surface Texture Suitable for Skid-Resistance Photo-Interpretation."

Figure 2 shows the equipment necessary to make the texture estimate through photo-interpretation. Instead of the "Vertical Scale Wedge" and the "Transparent Grid" recommended by ASTM E 559, Louisiana used a grid of 2.0 cm, (0.78 in.) attached to the bottom of the camera box. This grid, shown in Figure 2, is raised 2 mm (0.07 in.) off the bottom plane of the box. Therefore, parameter A, the height of the projections, and parameter B, width of the projections, can both be estimated without the extra vertical scale wedge and transparent grid.





EQUIPMENT NECESSARY TO MAKE TEXTURE-SKID NUMBER ESTIMATE

FIGURE 2

DISCUSSION OF RESULTS

Skid Tests

The results of the skid tests (SN 40) are presented in Table 2 and in the plots of variance of skid resistance and skid resistance versus traffic shown in the Appendix. Each skid number in Table 2 and shown in the plots is an average of 18 tests (three tests for each of the six test sections per project). Two curves are shown on the "Skid Resistance Variance" figure in the Appendix. The solid-line curve is skid number versus time while the dashed line plots the statistical variance (the square of the standard deviation or σ^2) of the six test sections versus time. The scale of SN's is to the left and the scale of σ^2 is on the right margin of the page.

As seen in Table 2, all but two projects were improved from the standpoint of skid resistance, at least by the second time of testing. Arena, P. J., Jr., (1)* suggested the following explanation: When asphaltic concrete is first laid the aggregate is coated with asphalt, yielding relatively low skid numbers. As traffic (number of vehicle passes) increases, the asphalt coating is worn off of the aggregate and the SN goes up. In the

TABLE 2
SKID TEST RESULTS

1 State Project No. 1-03-37 Texas State Bridge-Webster Parish Line U. S. 80 in Bossier Parish ADT 15,069 Type 3 W/GR			2 State Project No. 2-04-26 Quebec-Tallulah U. S. 80 Madison ADT 7018 Type 1			3 State Project No. 2-05-23 Tallulah-Delta Pt. U. S. 80 Madison ADT 7807 Type 1		
Run #	Date	SN*	Run #	Date	SN*	Run #	Date	SN*
Original	7/69	32	Original	7/69	43	Original	7/69	43
1	8/70	45	1	11/69	36	1	5/70	48
2	2/71	44	2	8/70	50	2	1/71	53
3	9/71	39	3	2/71	52	3	7/71	52
4	3/72	40	4	9/71	48	4	1/72	46
5	8/72	41	5	1/72	46	5	8/72	46
6	2/73	34	6	8/72	46	6	2/73	43
7	9/73	34	7	2/73	43	7	9/73	38
8	2/74	39	8	9/73	41			

*Each SN is an average of 18.

TABLE 2
SKID TEST RESULTS

4
State Project No. 3-09-18
Mermentau-Crowley
U. S. 90 - Acadia
ADT 4534
Type 1

Run #	Date	SN*
Original	8/69	36
1	8/70	47
2	2/71	49
3	8/71	53
4	2/72	45
5	8/72	45
6	3/73	43
7	8/73	42
8	4/74	42

5
State Project No. 4-06-17
New Iberia-Jeanerette
Iberia - 03
ADT 7372
Type 3 W/Gr

Run #	Date	SN*
Original	7/69	34
1	6/70	51
2	12/70	51
3	6/71	50
4	12/71	42
5	6/72	47
6	12/72	47
7	8/73	41
8	12/73	36

6
State Project No. 4-07-09
Calumet-Centerville
U. S. 90 - St. Mary 03
ADT 8384
Type 3 W/LS

Run #	Date	SN*
Original	8/69	39
1	12/69	40
2	8/70	45
3	2/71	42
4	8/71	48
5	2/72	39
6	8/72	41
7	2/73	37
8	8/73	37
9	4/74	39

*Each SN is an average of 18.

TABLE 2
SKID TEST RESULTS

7
State Project No. 6-90-13
Industrial Parkway - Chef Menteur
U. S. 90 - Orleans 02
ADT 13128
Type 3 W/LS

Run #	Date	SN*
Original	8/69	42
1	8/70	48
2	2/71	47
3	9/71	46
4	2/72	42
5	8/72	41
6	2/73	39
7	9/73	35
8	2/74	41

8
State Project No. 7-02-53
Williams Blvd - Kent Ave.
U. S. 61 - Jefferson 02
ADT 36529
Type 3 W/LS

Run #	Date	SN*
Original	8/69	35
1	5/70	49
2	12/70	40
3	6/71	40
4	12/71	34
5	6/72	39
6	12/72	38
7	8/73	31
8	12/73	31

9
State Project No. 7-09-56
Florida St.-Miss. River Bridge
U. S. 61 - East Baton Rouge
ADT 26900
Type 3 W/LS

Run #	Date	SN*
Original	8/69	34
1	11/69	49
2	5/70	41
3	11/70	38
4	5/71	36
5	11/71	33
6	5/72	36
7	11/72	39
8	5/73	32
9	11/73	32

* Each SN is an average of 18.

TABLE 2
SKID TEST RESULTS

10
State Project No. 15-07-16
Columbia - Monroe
U. S. 165 - Caldwell - 58
ADT 3400 Type 3 W/GR

Run #	Date	SN*
Original	7/69	45
1	1/72	42
2	8/72	43
3	2/73	36
4	9/73	39
5	2/74	44

11
State Project No. 26-03-10
Ferriday - Clayton
U. S. 65 - Concordia - 58
ADT 5520 Type 1

Run #	Date	SN*
Original	7/69	42
1	11/69	38
2	8/70	47
3	2/71	49
4	9/71	44
5	3/72	39
6	8/72	43
7	2/73	40
8	9/73	35
9	4/74	39

12
State Project No. 27-03-19
Ringgold - Minden
La. 7 - Webster - 04
ADT 3582 Type 1

Run #	Date	SN*
Original	7/69	19
1	1/70	55
2	8/70	57
3	2/71	53
4	9/71	47
5	3/72	45
6	8/72	49
7	2/73	42
8	9/73	41
9	2/74	45

* Each SN is an average of 18.

TABLE 2
SKID TEST RESULTS

13			14			15		
State Project No. 14-06-16			State Project No. 50-06-37 & 50-07-28			State Project No. 53-03-22		
Vortex - Alexandria			Plaquemine - Port Allen			Cloutierville - Monet Ferry		
U. S. 165 - Rapides - 08			La. 1 - West Baton Rouge - 61			La. 1 - Natchitoches		
ADT 5842			ADT 8780			ADT 3438		
Type 1			Type 3 W/Gr			Type 1		
Run #	Date	SN*	Run #	Date	SN*	Run #	Date	SN*
Original	7/69	42	Original	8/69	42	Original	7/69	47
1	11/69	36	1	8/70	45	1	12/69	49
2	8/70	45	2	2/71	48	2	8/70	54
3	2/71	46	3	8/71	46	3	2/71	50
4	9/71	42	4	2/72	45	4	9/71	43
5	3/72	40	5	8/72	44	5	3/72	40
6	8/72	42	6	2/73	40	6	8/72	46
7	2/73	40	7	8/73	41	7	2/73	43
8	11/73	38	8	2/74	42	8	11/73	40
9	2/74	42				9	2/74	40

* Each SN is an average of 18.

TABLE 2
SKID TEST RESULTS

16 State Project No. 62-03-09 Ironton - Junior La. 23 - Plaquemine - 02 ADT 7650 Type 3 W/Gr			17 State Project No. 86-02-15 Cotton Valley - Cullen La. 7 - Webster - 04 ADT 4714 Type 3 W/Gr			18 State Project No. 250-01-10 Zachary - Slaughter La. 19 - East Baton Rouge - 61 ADT 7174 Type 1		
Run #	Date	SN*	Run #	Date	SN*	Run #	Date	SN*
Original	8/69	50	Original	7/69	17	Original	8/69	45
1	8/70	48	1	8/70	62	1	8/70	45
2	2/71	56	2	2/71	54	2	2/71	47
3	9/71	50	3	10/71	50	3	9/71	43
4	2/72	47	4	3/72	45	4	2/72	41
5	8/72	50	5	8/72	48	5	8/72	42
6	2/73	45	6	2/73	42	6	2/73	40
7	8/73	46	7	9/73	40	7	8/73	39
8	2/74	45	8	2/74	46	8	3/74	36

* Each SN is an average of 18.

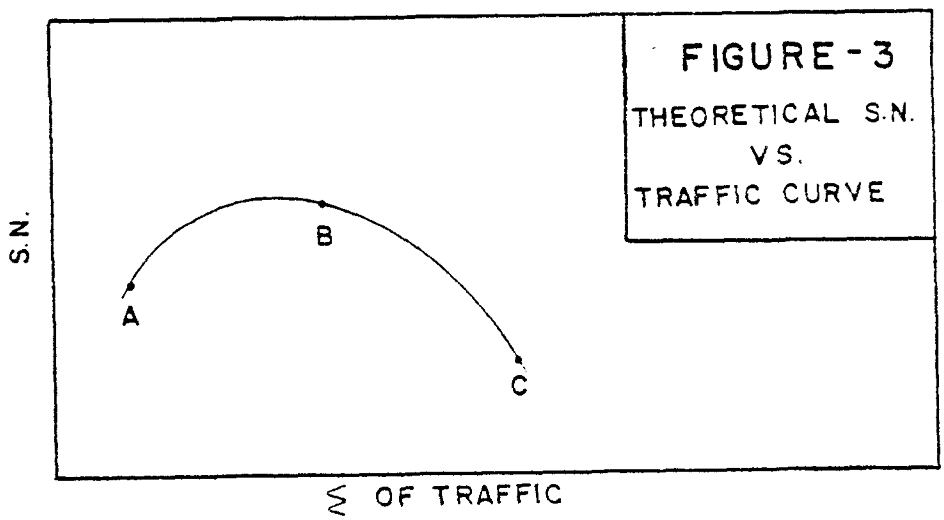
TABLE 2
SKID TEST RESULTS

19
State Project No. 283-09-22
West Bank Expressway
U. S. 90 - Jefferson - 02
ADT 32,440
Type 3 W/LS

Run #	Date	SN*
Original	7/69	50
1	11/69	55
2	8/70	45
3	2/71	45
4	9/71	43
5	2/72	37
6	8/72	38
7	2/73	37
8	8/73	35

* Each SN is an average of 18.

case of chert, which was used for all projects reported on herein, the skid number will then go down as the aggregate polishes with traffic. Figure 3 below presents the situation graphically.



The skid numbers are more traffic dependent than they are time dependent. Thus, if for this study the first skid tests fell near Point A and the second near Point B, there would be an increase in the numbers. If instead, the first tests fell on or near Point B, and the second near Point C, then a decrease would be found.

Discussion of Graphs

The graphs of skid number variation generally follow the trend described above. In looking at the skid resistance, almost all of the projects were improved because of overlaying through the first 2 to 2-1/2 years. The most notable exceptions to this were Columbia-Monroe, 15-07-16, page 17 and West Bank Expressway, 283-09-22, page 19. For the Columbia-Monroe job the skids stayed below the figure taken before overlay and except for the first run on West Bank, the SN's were below the original. However, it must be remembered that at that time the primary purpose of overlay was not to improve the skid resistance, but to improve the ride. In addition, no definite trend is discernable which would lead to the conclusion that there is seasonal variation in skid number.

For 13 out of 19 projects, the variance is greatest immediately after lay down. This phenomenon may be explained by the asphalt coating the aggregate at the time of overlay. When the asphalt is worn by traffic from the exposed surfaces the SN's tend to become uniform, displaying a lower variance. This initial high degree of variance reflects the non-uniformity of the asphalt coat at the time of overlay.

The plots of skid numbers versus traffic showed nothing of significance that has not already been discussed. No conclusion can be drawn about the maximum number of vehicles that these types of overlays can stand from the standpoint of skid resistance because of some factors to be discussed later in this report. The only conclusion that can be drawn is that certain of the asphalt mixes can stand up to 2500 ADT/lane for a 4-1/2 year period.

Hot Mix Properties

Three classes of hot mix were used on the projects of this study. Two of them fall into what is called the Type 3 category and the other is Type 1. The properties of the wearing course are given below.

Type	1	3
U. S. Sieve	Percent Passing (By Weight)	
1-1/4"	---	---
1"	100	100
3/4"	85 - 100	85 - 100
1/2"	70 - 100	70 - 100
3/8"	---	---
No. 4	40 - 70	40 - 70
No. 10	25 - 55	25 - 55
No. 80	4 - 20	4 - 20
No. 200	2 - 10	2 - 10

PERCENTAGES NEEDED:

Bitumen	3.5 - 7.0	3.5 - 7.0
Aggregate	93 - 96.5	93 - 96.5
Mineral Filler	3 MIN.	2 MIN.
Crushed & Retained # 4	75 MIN.	80 MIN.

It can be seen that the two mixes are virtually the same. The difference comes from the fact that "Type 3 wearing course mixtures shall contain a minimum of 15% screenings based on total aggregate."(2) Screenings are "washed and crushed aggregates that shall not have more than 10% passing No. 4 prior to the crushing; after crushing, the screenings shall meet gradation listed below."(2)

U. S. Sieve	Percent Passing (By Weight)
3/8"	100
No. 4	90 - 100
No. 40	10 - 45

As can be ascertained from the above, Type 3 mix is a much stronger mix than Type 1 in that the finer aggregates are more angular when the screenings are mixed into the total aggregate.

The fact that limestone was used for the most part on roads with high traffic counts can only be explained by coincidence. This can be seen in Table 3.

Nevertheless, from Table 2 it can be seen that generally the Type 3 projects with limestone screenings had lower skid numbers than either of the other two categories near the end of the study. When the last three skid numbers taken on each of the limestone jobs are averaged together, that average is 36, whereas the average of the same numbers of other two categories is 41 for both. The high ADT's notwithstanding, Type 3, hot mixed, asphaltic concrete with limestone screenings was eliminated for use as a wearing course material.

Surface Texture

The method used to determine surface texture was described previously in the Methodology section of this report. Even though Louisiana's method varies slightly from Schonfeld's [3] original method and the up-dated method that appears in ASTM E 559, it is felt that Louisiana's method of attaching the grid to the bottom of the camera box corresponds well with Schonfeld's transparent grid which is placed in the photograph. Both vertical and horizontal measurements were estimated from the attached grid.

TABLE 3

LIST OF TYPE 3 HOT MIX JOBS

Limestone State Project No.	ADT/Lane	Chert Gravel State Project No.	ADT/Lane
Calumet-Centerville 4-07-09	4192	Texas St. - Webster Parish Line 1-03-37	3767
INDTL Parkway-Chef Menteur 6-90-13	3282	New Iberia-Jeanerette 4-06-17	3685
Williams Boulevard-Kent Avenue 7-02-53	9132	Columbia - Monroe 15-07-16	1735
Florida St. - Miss. River Bridge 7-09-56	6725	Plaquemine-Port Allen 50-06-37 & 50-07-28	2195
West Bank Expressway 283-09-22	8110	Ironton-Junior 62-02-42 & 62-03-09	3825
		Cotton Valley-Cullen 86-02-15	2352

The skid number taken with the trailer is plotted against the skid number estimated from the stereo-photographs for the two test runs in Figure 4. Frequency distribution of the differences is shown in Figure 5. These figures lead to the following calculations:

$$N = 218$$

$$\sigma \text{ of Diff.} = 7.10$$

$$R^2 = 0.022$$

$$R = 0.147$$

The previous figures are the results of just two test runs on 19 jobs pooled to yield 218 observations. (Six test sec./project X 19 projects X 2 runs = 228, less 10 pictures that did not come out, etc.).

The last three figures tell the story. The truck has a repeatability 98% of the time of $\pm$ 3 SN's. Two standard deviations of the differences of truck and photos minus the 3 truck skid number variations would be 11 skid numbers at the 95% level (2σ). The R^2 says that 98% of the variation between photo-interpretation SN and truck SN is unaccounted for in the process of computing the correlation coefficient, R. But it is known that approximately 11 is the difference between photo and truck discounting truck variation. Therefore, the 11 numbers are probably in the interpreter's judgement of the parameters of texture and/or the

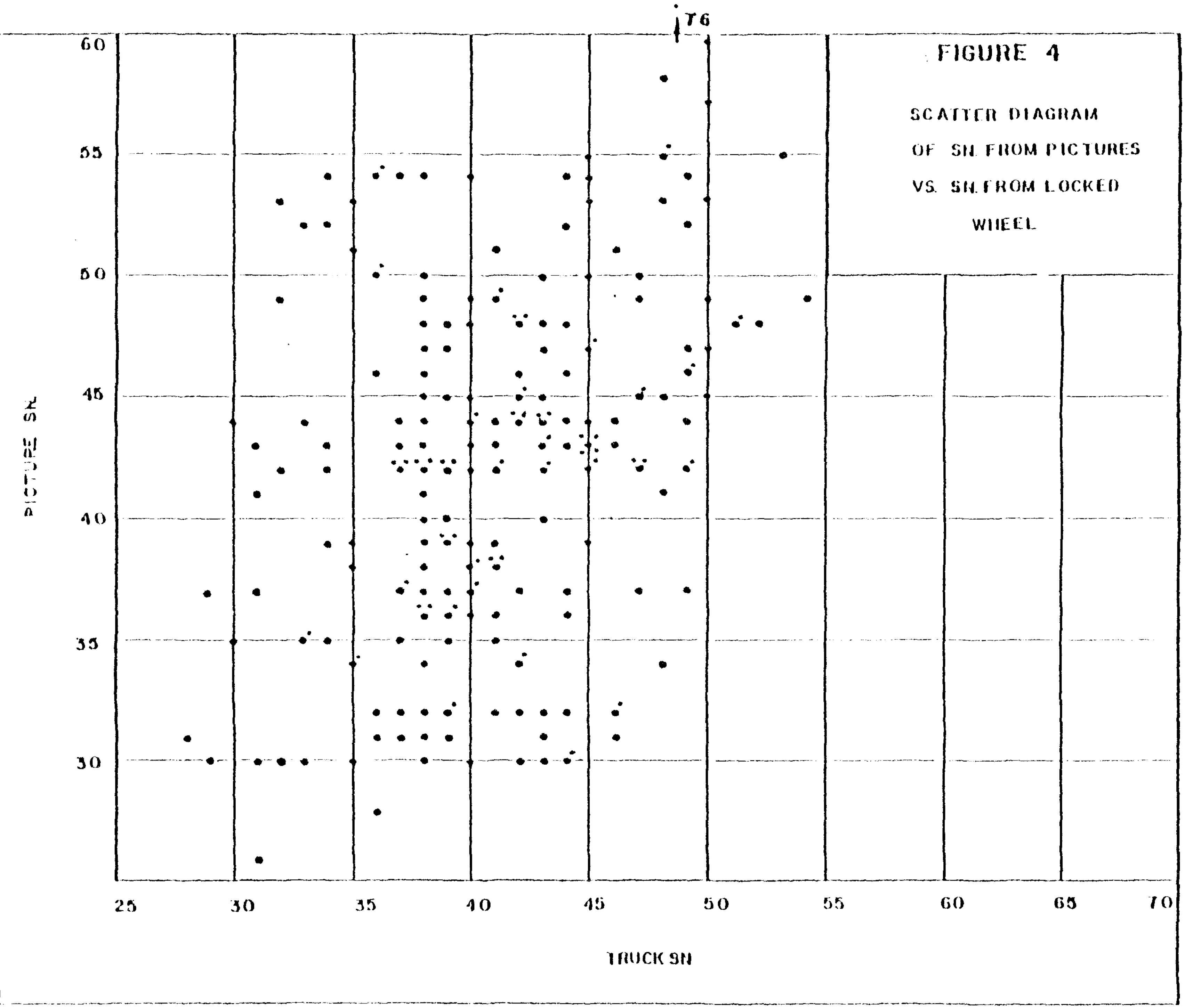
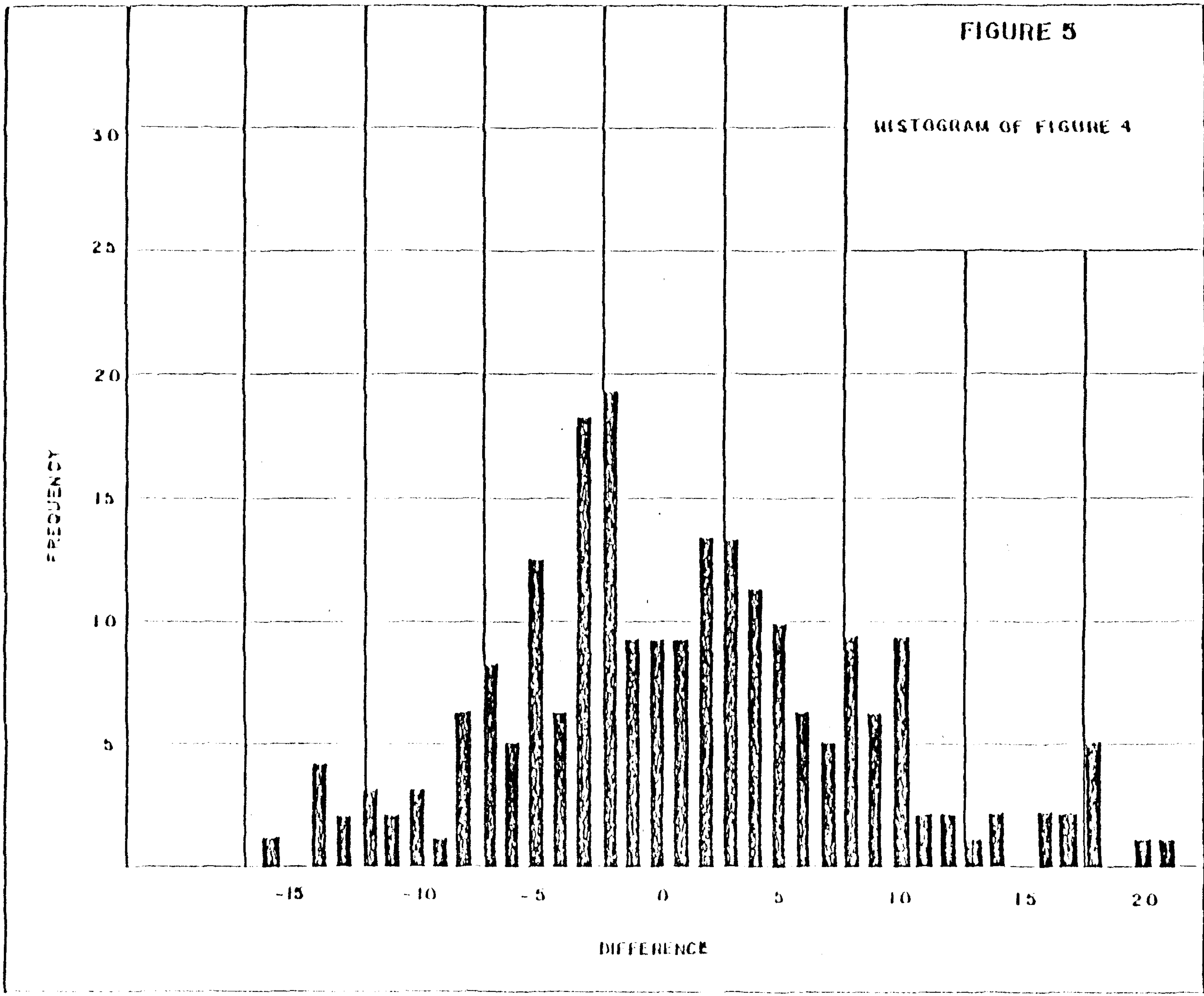


FIGURE 4

SCATTER DIAGRAM OF SN FROM PICTURES VS. SN FROM LOCKED WHEEL

FIGURE 5

HISTOGRAM OF FIGURE 4



method of converting these parameters into skid numbers. The correlation coefficients of each job varied from 0.522 to - 0.715.

One disadvantage inherent to the problem is the fact that the amount of pavement studied is so small compared to the amount tested with the locked wheel. (0.5 ft.^{2} (0.046 m^2) compared to 73 ft.^{2} (6.8 m^2) approximately). This may be additive when it is combined with the other two errors mentioned above. Another problem exists in the correlation effort in that three interpreters were used during the course of the research.

In all three cases the R's indicated a lack of correlation. The -0.7 was the highest coefficient in magnitude obtained, but the minus sign indicated that when the interpreted SN was high, the locked wheel SN was low. This -0.7 occurred in only two jobs out of the 19, and even this could be considered a mediocre correlation.

In spite of the above findings stereoscopic examination of pavement is a good method for determining surface texture, but not skid number. One should be able to tell what has happened to a surface, particularly if he has a series of pairs taken over an extended period. The interpreter should be able to tell whether the aggregate is being wiped off, the change of shape of the aggregate, or generally why the surface is in the shape it is. However, until a procedure is developed whereby the skid number can be better estimated, the use of stereo-photography for classifying pavement surfaces will be limited, at least in Louisiana.

CONCLUSIONS

This Phase of the study produced the following conclusions:

1. No seasonal variation in skid resistance is evident in the findings of this study. Slight seasonal variations can possibly be construed from these results on three or four of the 19 projects, but these variations are not in evidence on the others. However, it should be remembered that this study was concerned with dense-graded, hot mixed asphaltic concrete only.

2. Type 3 asphaltic concrete with limestone screenings is not suited to high traffic roadways because of a tendency to become slippery. Type 3 mixes are designed to be placed on highways with high ADT's; therefore, limestone screenings were disallowed in the wearing course of those mixes.

3. From the data given in this report, there is doubt in the usefulness of the stereo-photographic method of obtaining skid numbers. However, stereo-photographic examination of the pavement may be useful if it is limited to just examination to determine what has happened to the surface, why the pavement is slick, or why is it not, etc.

4. From the standpoint of skidding, the asphaltic concretes examined, with the exception of Type 3 with limestone screenings, appear to hold skid resistance under ADT's/ Lane up to 2500 for 4-1/2 years. Unfortunately, Type 3 with limestone was used under higher traffic only, and its skid characteristics did not hold. Therefore, this research can not comment on the reliability of that mix on lower traffic roads.

5. The pavements showed a tendency to be more variable in SN right after laying. Then, as time progressed or the number of vehicle passes increased, the variability was less evident.

EPILOGUE

In 1976 the Department adopted the following policy for asphaltic surfaces. It substantially is in agreement with the Conclusions presented above.

ASPHALTIC SURFACES

Current Traffic Volume (ADT/Lane)	Type Mixture Including Wearing Surface
50 or less	Asphaltic Surface Treatment (expanded clay, slag, stone)
50- to 999	Type 1, 2[a*] or 4[b*]
1000 to 1999	Type 1 or 4
2000 to 2999 (Speed limit 45 or less)	Type 3 or 4
2000 to 2999	Expanded Clay, Slag or Stone Plant Mix Seal over Type 1, 2 or 4
3000 + (Speed limit 45 or less)	Type 3 or 4
3000 + (Speed Limit greater than 45)	Slag or Stone Plant Mix Seal over Type 3 or 4

The criteria given above will be used on all projects where practical. The Road Design Engineer may make recommendations to the Chief Engineer to deviate from these requirements when project conditions dictate deviations.

a* Type 2 uses shell as aggregates.

b* Type 4 uses expanded clay as aggregates.

P H A S E I I

PHASE II

SCOPE

It should be recalled from the Introduction that the purpose of Phase II of this study was to:

1. Determine whether a highway should be tested every 0.1, 0.5, 1.0, 2.0 miles (0.161, 0.805, 1.61, 3.22 km) etc., to obtain an average SN which characterizes the surface friction of the highway.

2. Evaluate study area size, i.e., evaluate whether it is best to inventory on a statewide, on a highway district, or on a parish-wide basis.

3. Make an economic evaluation of the various appropriate methods of inventory to find out which is the least expensive.

4. Generally find out what problems may arise while conducting such an inventory.

METHODOLOGY

General Comments

Since the Traffic and Planning Section of the Department of Transportation and Development would be using results gathered from the inventory, it was natural that they should be consulted as to how the results should be presented. It was the consensus that the control unit should be the basic unit upon which the inventory would be run, since that is how all references to any section of any highway in Louisiana are denoted. The mode of acquisition, and hence the method of filing skid numbers of any section of highway, thus would be by district, parish, and then by control unit numbers.

A graphical form of presentation was the other opinion rendered from a meeting with the Traffic and Planning personnel. Figure 6 is a reproduction of the graph upon which the skids are presented. As can be seen, the horizontal axis is representative of the distance (usually logged miles) from the beginning or end of the control unit, (C.U.); while the vertical axis is representative of the SN, the upper half being one direction and the lower half being the other. Thus, it remained the study's responsibility to determine the rest of the parameters of the project.

22-110

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
MATERIALS SECTION

SKID RESISTANCE INVENTORY RESULTS

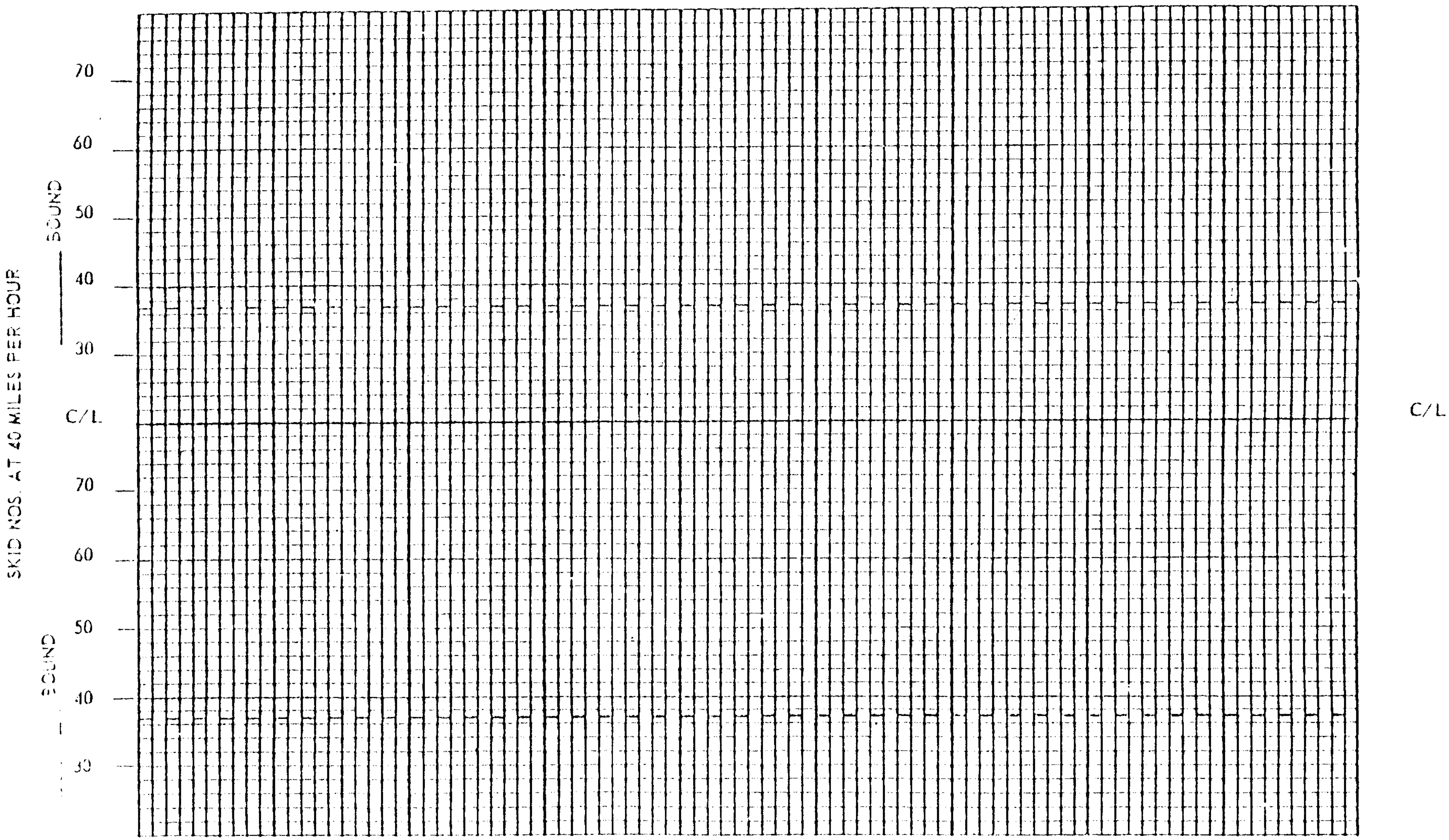
FIGURE 6

DATE ________ PARISH ________ DISTRICT ________ HIGHWAY NO. ________ CONTROL UNIT ________

TIME OF DAY ________ WEATHER CONDITION ________ PAVEMENT TYPE ________ LENGTH OF SECTION ________

TESTED SECTION BEGAN ________ TESTED SECTION ENDED ________

LANE AND WHEEL-PATH TESTED ________



LOGGED MILE = 1 INCH

Statistical Significance

The approach to this problem had to be one which realized that there were many different cases which could or would be encountered. The problem, simply stated, was how often a roadway should be tested in order to obtain an accurate average SN for that roadway, or as it turned out, for that control unit. C.U.'s in Louisiana are less than one mile in the case of some local roads, to in excess of 60 miles on some interstate highways. The surface may change within one control unit, or the coefficient of friction may be high along one section and low in another. The proper solution to such a problem would be to find an average control unit, with an average length, average number of slick spots, and an average number of skid resistant spots, etc. A test would then be run on this roadway to determine how many skids would produce an average which would accurately characterize the control unit's skid resistant properties.

This, of course, was not possible. The alternative that was chosen was the exact opposite. It was one in which 10 miles of roadway appeared uniform in all aspects including the riding surface.

Tests were run every 0.1 of a mile (0.161 km) for a distance of one mile (1.61 km), every 0.5 miles (0.805 km) for a distance of five miles (8.05 km) every mile for 10 miles (16.1 km), and every two miles (3.22 km) twice for a distance of 10 miles (16.1 km) The second two-mile (3.22 km) run was tested on the odd-mile marks so as to produce "shots" between the first set. Thus, each run, 0.1, 0.5, 1.0 and 2.0 miles (0.161, 0.805, 1.61, 3.22 km), had ten tests to analyze.

Evaluate Study Area Size

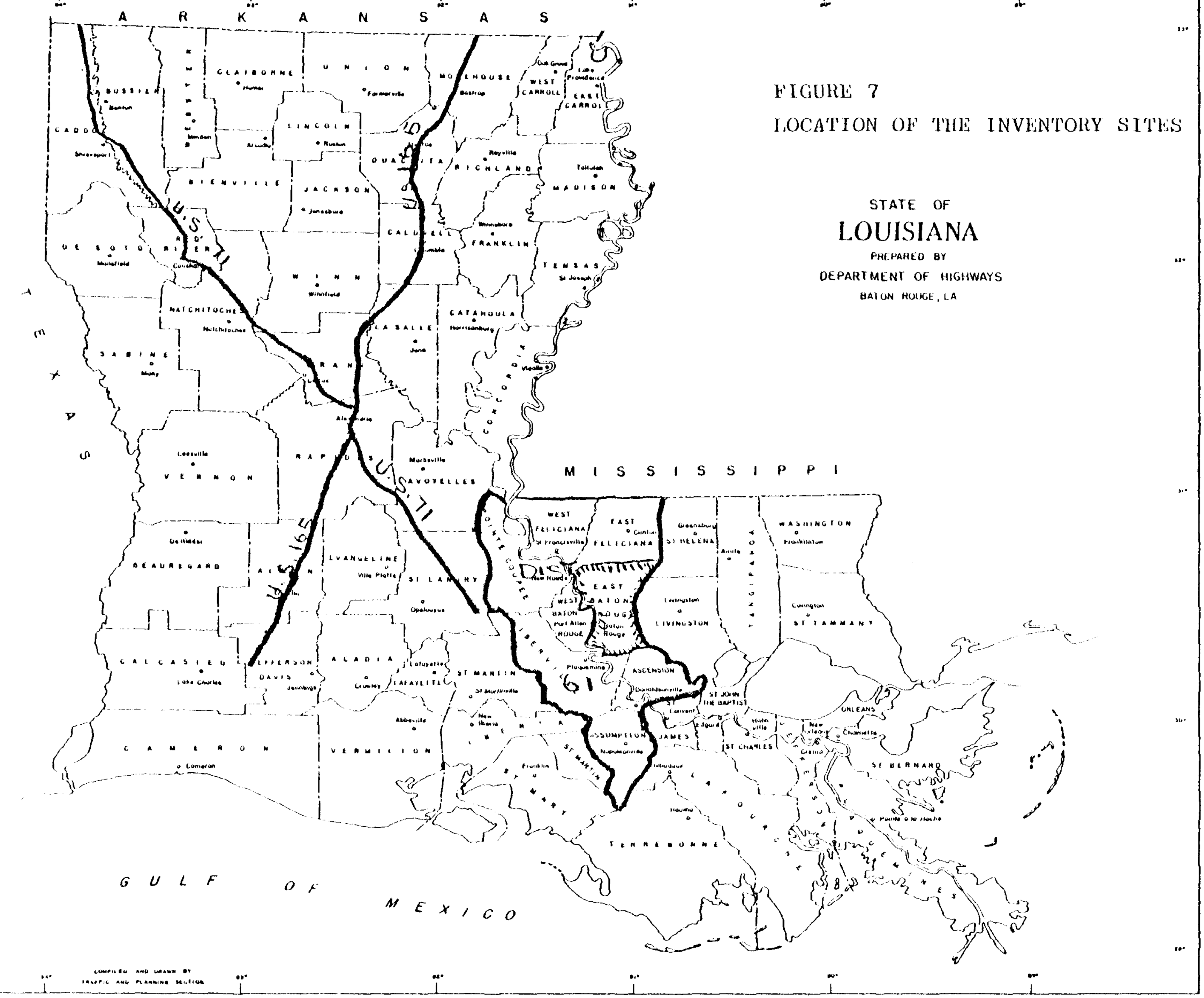
In order to evaluate the proper study area to inventory from the standpoint of ease of the inventory, it was decided to try on a parish basis, then on a district basis, and last on a statewide basis. East Baton Rouge Parish was chosen as the parish, and all roads tested were within the parish boundaries only, whether the highway continued on or not. The district chosen was 61, and the same procedure was used here, that is, all roads were tested from boundary-to-boundary only. For the statewide run, U.S. 71 and U.S. 165 were tested from one end to the other. Figure 7 shows the location of these two highways, plus the district and parish tested.

Economic Evaluation

The economic evaluation was simple division: the cost to run the inventory was divided by the number of miles tested during the time period required to inventory the three geographical units.

FIGURE 7

LOCATION OF THE INVENTORY SITES



There is one extra piece of information in the computations, and that is percent efficiency, or the number of miles tested divided by the number of miles put on the skid truck times 100, for each geographical unit run.

DISCUSSION OF RESULTS

Statistical Significance

Table 4 shows the results of the work accomplished for this section of the report. As can be seen, there is little difference between averages and their standard deviations of the four runs. This indicates that there would be little difference in how often to test a uniform road. These results have no bearing on non-uniform highways.

Therefore, it was decided that Louisiana should test every two miles (3.22 km) wherever possible. However, ASTM requires at least five tests on any surface. If a control unit is less than six miles (9.7 km) long, and a test was taken every two miles (3.22 km), that requirement of five tests on any surface would not be met. The skid operator is given a control unit manual which has a description of the limits of every control unit in the state and its length to the 1/100th mile (.016 km). He is instructed to have knowledge of each control unit's length before he tests it. If it is less than six miles (9.7 km), he is to adjust his tests so as to get five tests on the road, at the approximate beginning, middle and end of one lane, and at the approximate third points in the other. He is further instructed to test any unusual surface or patch in the highway and note it in sequence for SN's. Last, he is instructed to test bridges when possible.

TABLE 4
STATISTICAL SIGNIFICANCE OF SKID NUMBERS

Control Unit's 414-02 and 414-01, La. 30 (Nicholson Drive Extension) from Junction La. 74 in St. Gabriel northward for 10 miles to Junction 327.

1st. Run 0.1 Mile		2nd. Run 0.5 Mile		3rd. Run 1 Mile		4th Run 2 Miles	
Mile	SN_{40}	Mile	SN_{40}	Mile	SN_{40}	Mile	SN_{40}
0.0		0.0		0.0		0.0	
0.1	38	0.5	37	1.0	39	0.1	36
0.2	36	1.0	38	2.0	43	2.0	40
0.3	42	1.5	43	3.0	40	4.0	37
0.4	40	2.0	42	4.0	35	6.0	39
0.5	35	2.5	37	5.0	40	8.0	43
0.6	39	3.0	43	6.0	37	9.9	38
0.7	41	3.5	41	7.0	40	1.0	41
0.8	41	4.0	36	8.0	40	3.0	44
0.9	42	4.5	38	9.0	39	5.0	38
1.0	39	5.0	40	9.9	36	7.0	38
Avg.	39.3	Avg.	39.5	Avg.	38.8	Avg.	39.4
V =	5.78	V =	6.94	V =	14.9	V =	6.7
σ =	2.40	σ =	2.64	σ =	3.87	σ =	2.59

Study Area Size and Economic Evaluation

These two subjects will be discussed together since they were so closely related and led to the same conclusion. There were essentially no problems with the system of inventoring any of three geographical units. However, the operator did indicate that the statewide method was a lot easier than the district method, and the parish method was the hardest, simply because there was not as much stopping on the statewide method as with the others. The operator was required to stop periodically after running one or more control units in order to note the control unit/units he had run. The number of stops was more frequent during the parish-wide inventory than the district-wide inventory. Then too, the statewide system required less prior planning than the other two methods. Thus, running from state line to state line was simpler than the others and running a district was somewhat easier than running on a parish-by-parish basis.

These facts are even more enhanced when one looks at the economics of the three cases. Table 5 presents the figures as they were determined some time ago. It is true that they are not representative of today's costs, but the ratios of one to the other are believed to be still accurate.

It can be seen that cost per mile of the statewide survey is much less than the other two, and the efficiency is about 10% greater. A point should be brought out here also, and that is that the parish surveyed was East Baton Rouge, the home base of the skid measuring system and its operator. Thus, there were no expenses charged during the parish inventory. If there had been expenses charged, the cost of this type of inventory would have been approximately $1.09/mile tested. The ratios therefore are:

Statewide	- 1.00
District-Wide	- 1.98
Parish-Wide	- 2.22

In other words, it costs the public roughly twice as much to run a district or parish-wide survey as it does to run a statewide survey. Unfortunately, a skid inventory can not be run on a statewide basis only, because all highways do not traverse the state. A considerable portion of the mileage consists of feeder roads that might not extend outside a parish or two. These roads present

TABLE 5

COSTS OF ROADWAY INVENTORIES

PARISH SURVEY

East Baton Rouge Parish

August 26 - September 26, 1969

Number Lane Miles Tested	693.2	Total Salaries	$394.51
Number of Miles Driven	1282.0	Equipment Rental	$320.74
Percent Efficiency	54.1		
		Total	$715.25

Cost/Mile Tested
$1.03

DISTRICT SURVEY

District 61

October 6 - December 10, 1969

Number Lane Miles Tested	2538.2	Total Salaries	$1196.35
Number of Miles Driven	4591.0	Total Expenses	$ 75.00
Percent Efficiency	55.2	Equipment Rental	$1190.38
		Total	$2461.73

Cost/Mile Tested
$0.97

STATEWIDE SURVEY

U. S. 71 & U. S. 165

September 2 - September 4, 1969

Number Lane Miles Tested	832.0	Total Salaries	$138.46
Number of Miles Driven	1294.0	Total Expenses	$ 32.72
Percent Efficiency	64.3	Equipment Rental	$234.38
		Total	$405.56

Cost/Mile Tested
$0.49

a problem to the inventory. The manner in which the problem was resolved was as follows:

1. Inventory the highways that traversed the state first.
2. In so far as possible, the next step is to run the highways that traverse a district.
3. Then, in that same district, run the parishes.

Problems That Arose

There was one problem that arose during the year that this phase of the research lasted. The water tank [approximately 200 gal. (756 L)] was sufficient to last all day in most cases. Gasoline, however, became a slight problem. There were, on the average, two fill-ups for a day's run. The addition of a 43-gallon (162.4L) aluminum gas tank to a newer truck that was fabricated here in Louisiana took care of that problem. The gas and water came out about even or lasted about the same length of time.

Another situation that arose was the manner in which the water was delivered to the pavement. The research started with a pulley system working from a power takeoff (PTO) to a magnetic clutch attached to the pump. This system worked well but required special fabrication by Louisiana's shop and took considerable time to complete. The PTO could not be special-ordered from the factory on automatic transmissions. So a system was designed for a new skid measuring device which used a 12-volt Ford starter motor to turn the water pump. The speed at which the motor turns, which in turn governs the speed of the pump, is itself governed by the voltage received at the motor. This is controlled by three relays and a carbon rod offering resistance to the flow of current. The amount of water for 30, 40 and 50 m.p.h. is thus controlled by positioning the contacts on the carbon rod such that the proper voltage gets to the starter to produce the right amount of water.

This is a simple way to get water, however, it bears watching. After about a year the motor wears, begins to drag, and requires a higher voltage to turn the same RPM. The relays may gradually go bad or the connections may become slightly corroded, causing a voltage drop. These problems notwithstanding, it is the author's opinion that it is a good idea, and simple and easy for the driver, to operate the water rate speed selector switch whenever a different speed is required.

As an aside to this report, Louisiana has built five skid systems and is starting on its sixth. All of these systems have used electric brakes for locking the test tire. In spite of the negative comments from others, this system has worked well, provided a fiberous woven brake lining is used. The bonded type of lining that comes on the Kelsy - Hayes brake system is too dense, does not offer as much specific surface as is needed, and does not have the biting quality that the softer, woven lining does.

CONCLUSIONS

The research resulted the following conclusions:

1. That there was no statistical difference in testing what appeared to be a uniform road every 0.1, 0.5, 1.0 and 2.0 miles (0.16, 0.8, 1.6 and 3.2 km).

2. That from the operator's viewpoint, it is easier to run the roads from state line to state line.

3. That an economic evaluation of the three systems of inventorying, i.e., parish by parish, district by district, or inventorying those roads that traverse the state from state line to state line, proved the latter cost less by half than the other two, and was 10% more efficient from the mileage standpoint.

This means the highway network could be readily inventoried under the two ground rules set forth by the Traffic and Planning Section, which were, the basic unit of the inventory was to be the control unit, and the SN's were to be reported on a graph which plotted SN versus logged mile. For each control unit the approach was to do the major highways that travel from border to border first. Then each district would be run from border to border or nearly so, and last the local roads would be tested within that district before going to the next district. In this way it was anticipated that the inventory would be completed within two years.

EPILOGUE

The major and minor arterials would be run for the first months of each calendar year via the statewide system of inventory, then the feeder roads would be run. That way the roads that carry approximately 75% of traffic would be inventoried once a year, and the rest of the network would be tested every 2 to 2-1/2 years. All the rest of the inventory procedure remains the same.

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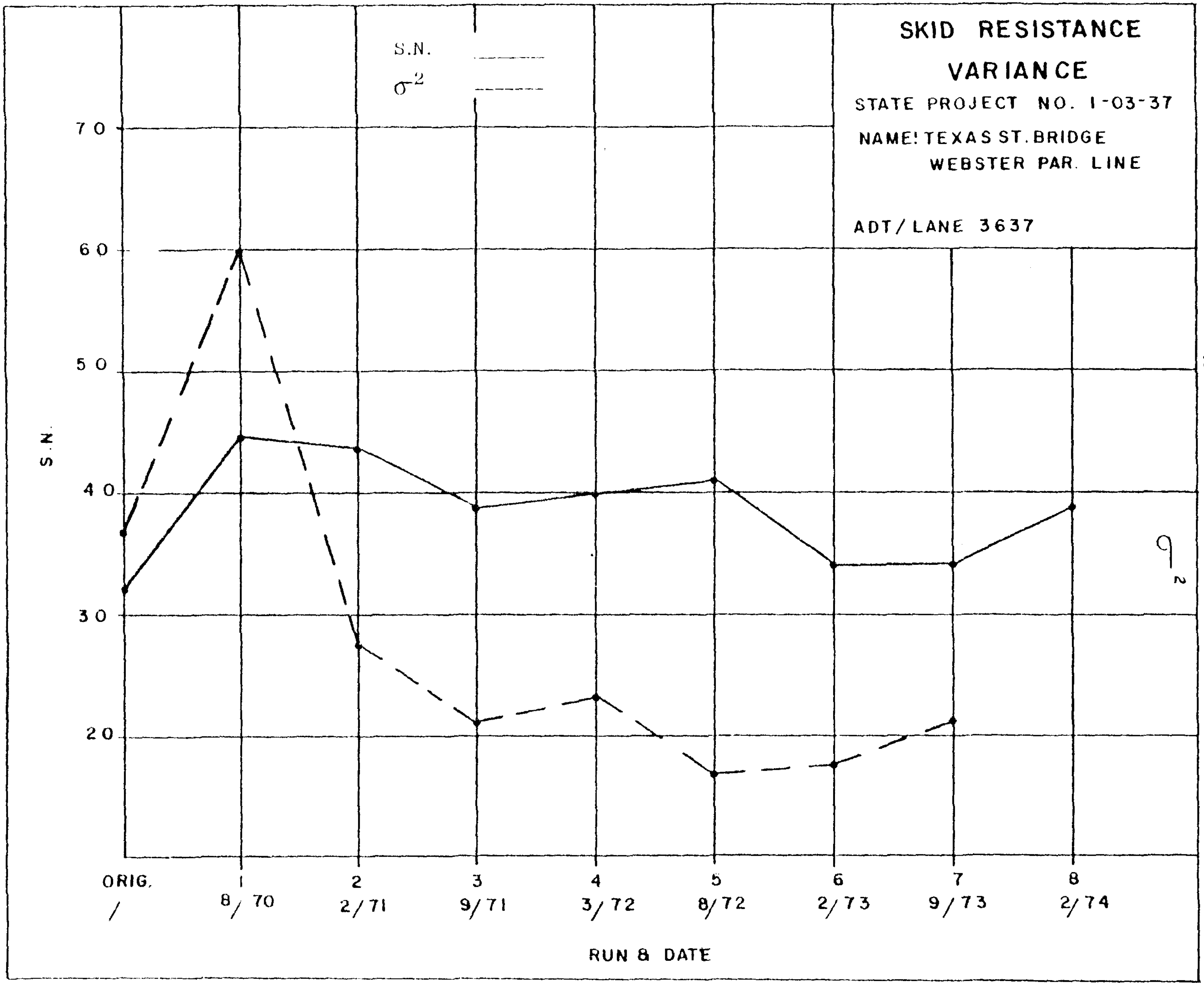
3. Schonfeld, R.,"Proposed Method for Classifying Pavement Surface Texture," Suitable for Skid Resistance Photo-Interpretation, Ministry of Transportation and Communications, Ontario, Canada, Presented to ASTM Task Group E-1723-70-3, December, 1972.

4. Ma, A. and Musgrove, G.,"Skid Resistance Photo-Interpreter's Guide," Ministry of Transportation and Communications, Ontario, Canada, Engineering Research and Development Branch, March, 1974.

A P P E N D I X


SKID RESISTANCE
VARIANCE
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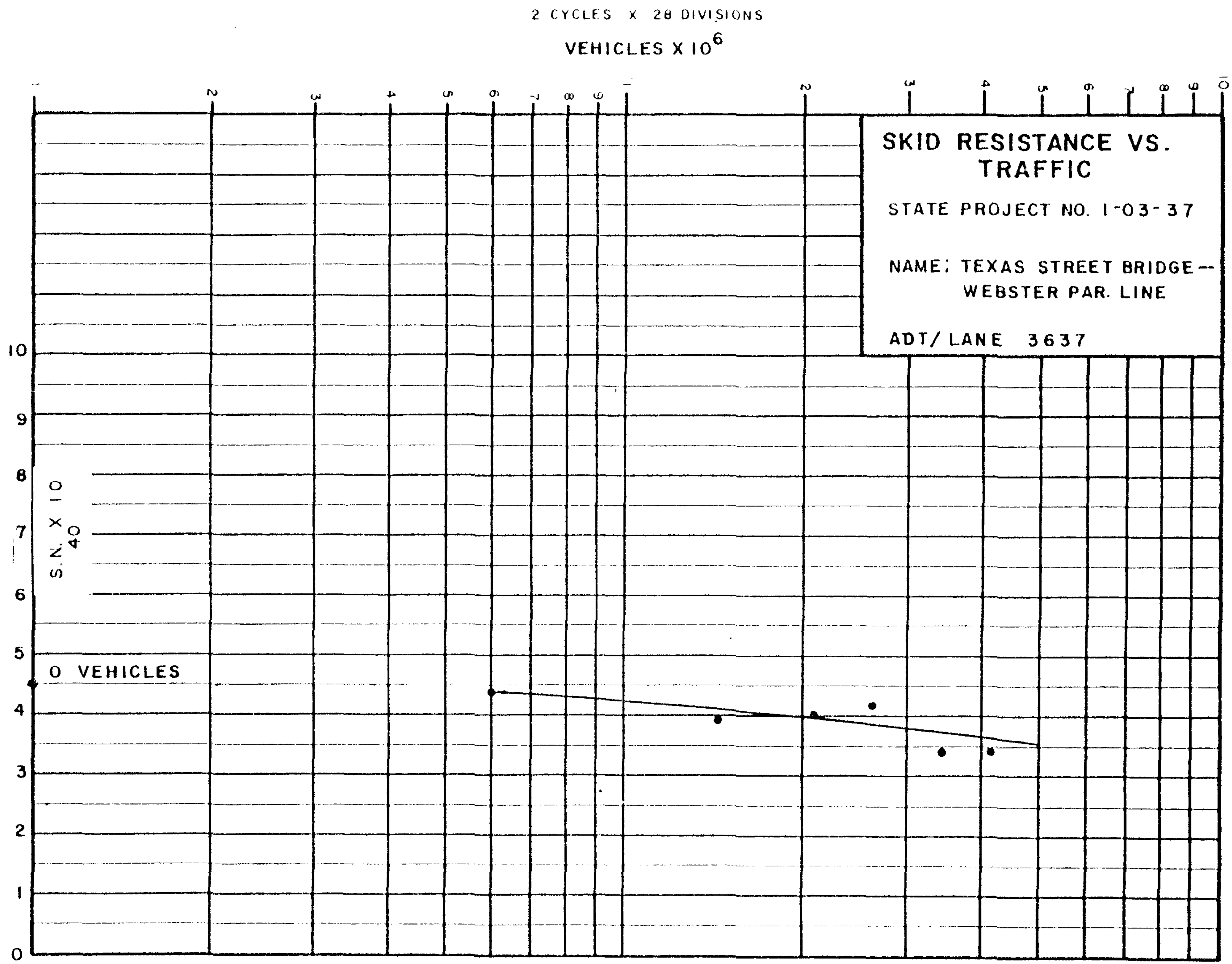
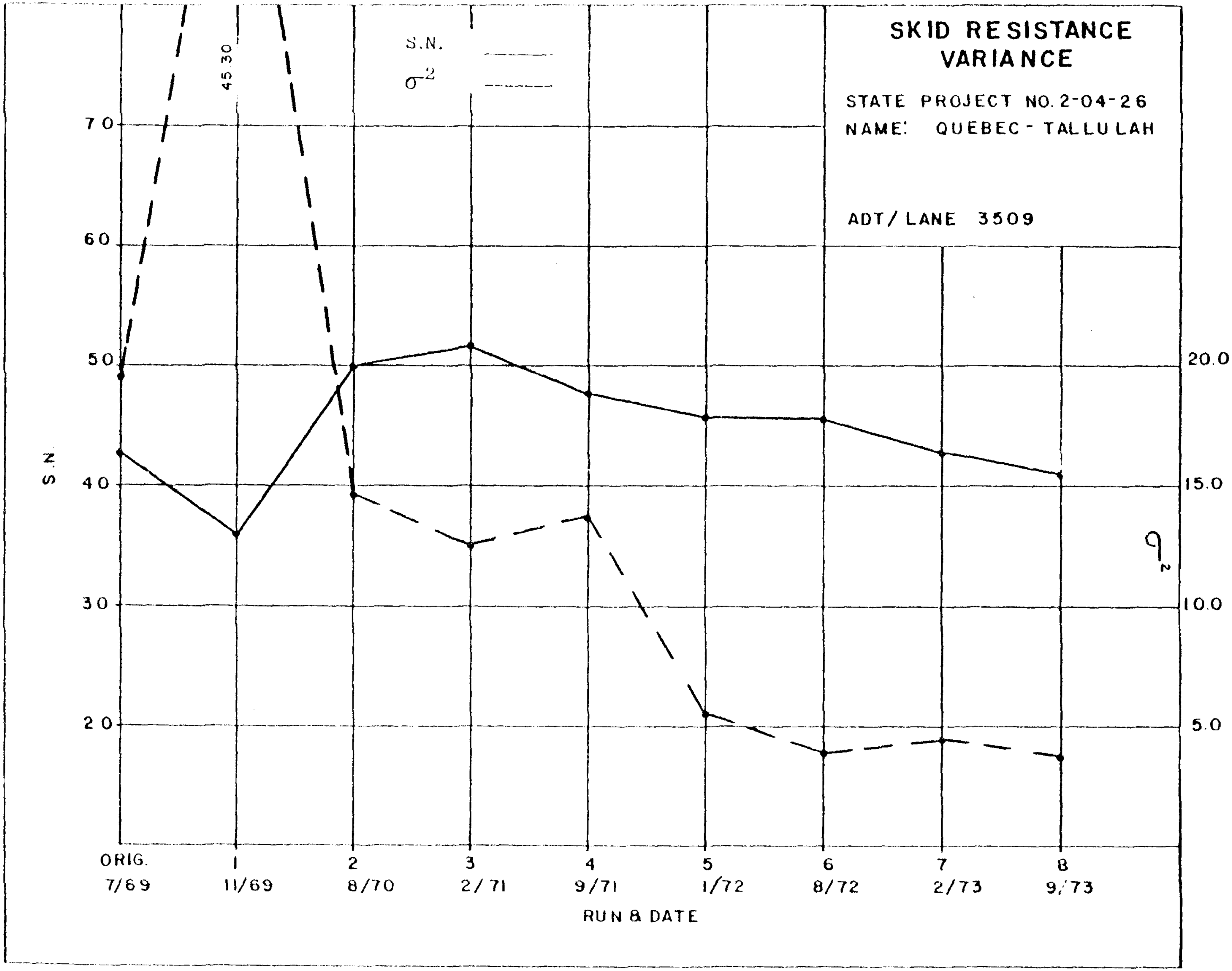
NAME: TEXAS ST. BRIDGE
WEBSTER PAR. LINE
ADT/LANE 3637
S.N.
σ^2
70
60
50
40
30
20
20.0
15.0
10.0
5.0
ORIG.
1 8/70
2 2/71
3 9/71
4 3/72
5 8/72
6 2/73
7 9/73
8 2/74
RUN & DATE



2 CYCLES X 28 DIVISIONS
VEHICLES X 10^6
SKID RESISTANCE VS. TRAFFIC
STATE PROJECT NO. 1-03-37
NAME: TEXAS STREET BRIDGE -- WEBSTER PAR. LINE
ADT/ LANE 3637
S.N. X 10
40
0 VEHICLES
0
1
2
3
4
5
6
7
8
9
10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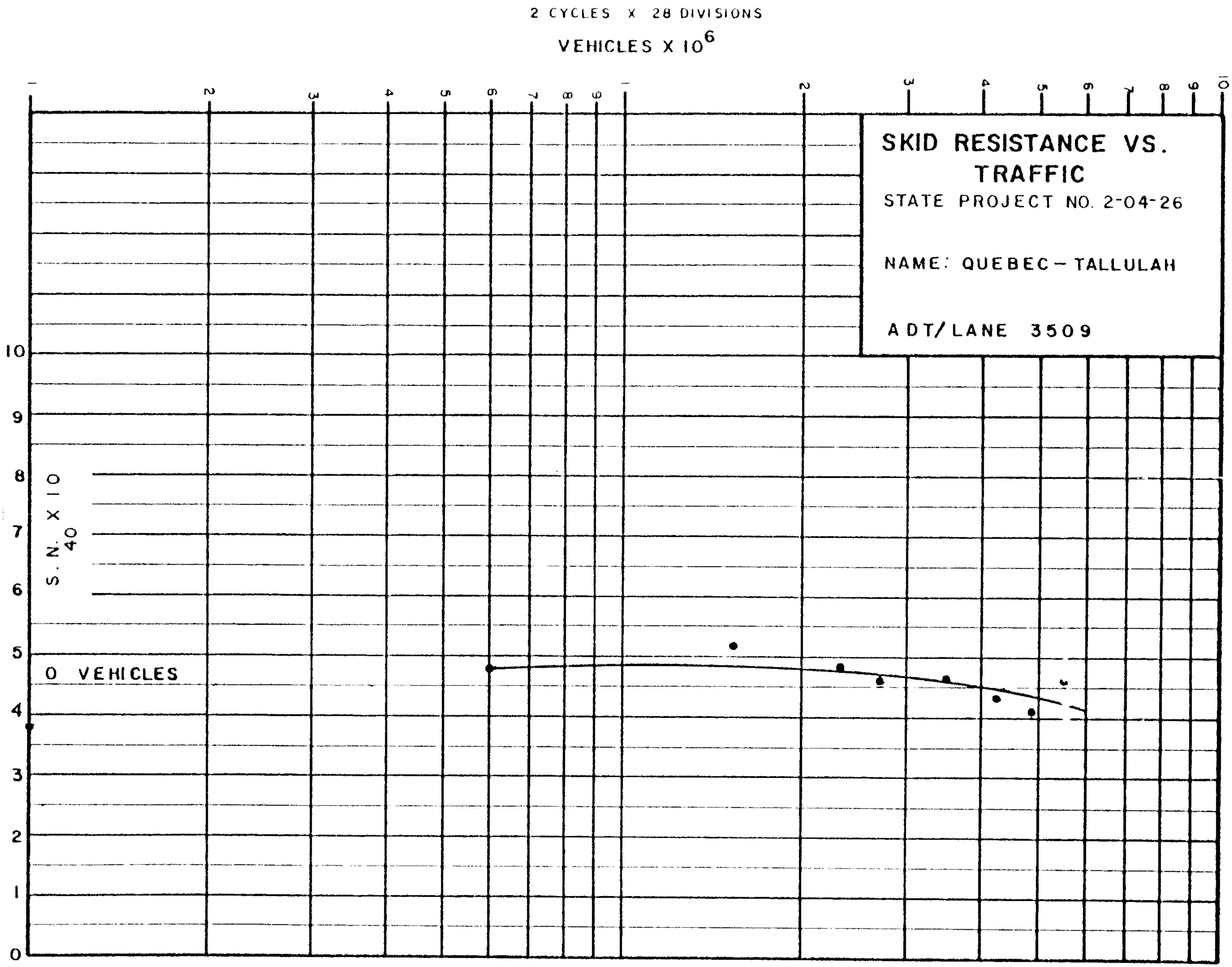
VARIANCE
STATE PROJECT NO. 2-04-26
NAME: QUEBEC - TALLULAH
ADT/ LANE 3509
S.N.
σ^2
45.30
70
60
50
40
30
20
S.N.
20.0
15.0
10.0
5.0
σ^2
ORIG. 7/69
1 11/69
2 8/70
3 2/71
4 9/71
5 1/72
6 8/72
7 2/73
8 9/73
RUN & DATE



2 CYCLES X 28 DIVISIONS
VEHICLES X 10^6
SKID RESISTANCE VS. TRAFFIC
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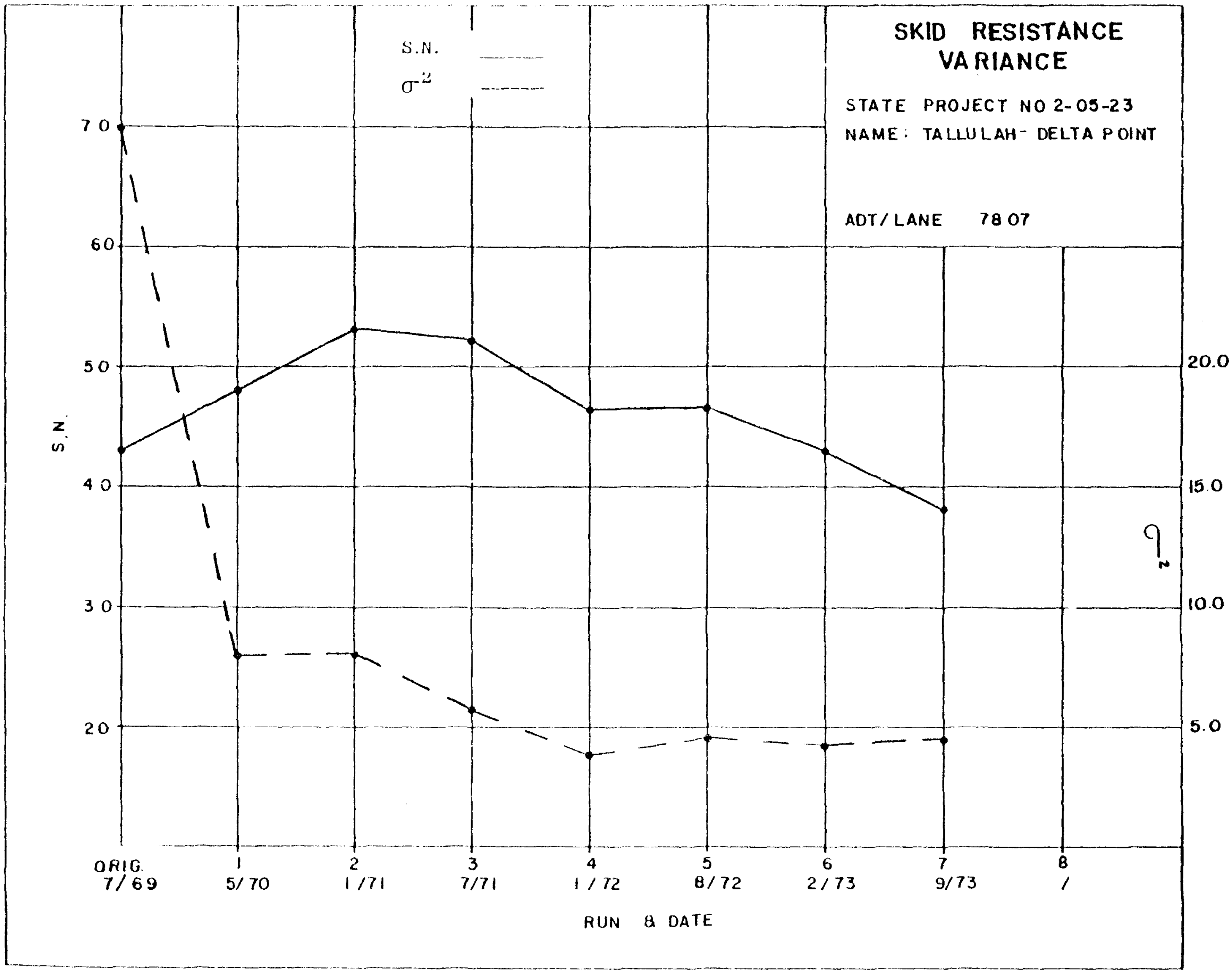
ADT/LANE 3509
S.N.40 X 10
0 VEHICLES



SKID RESISTANCE VARIANCE
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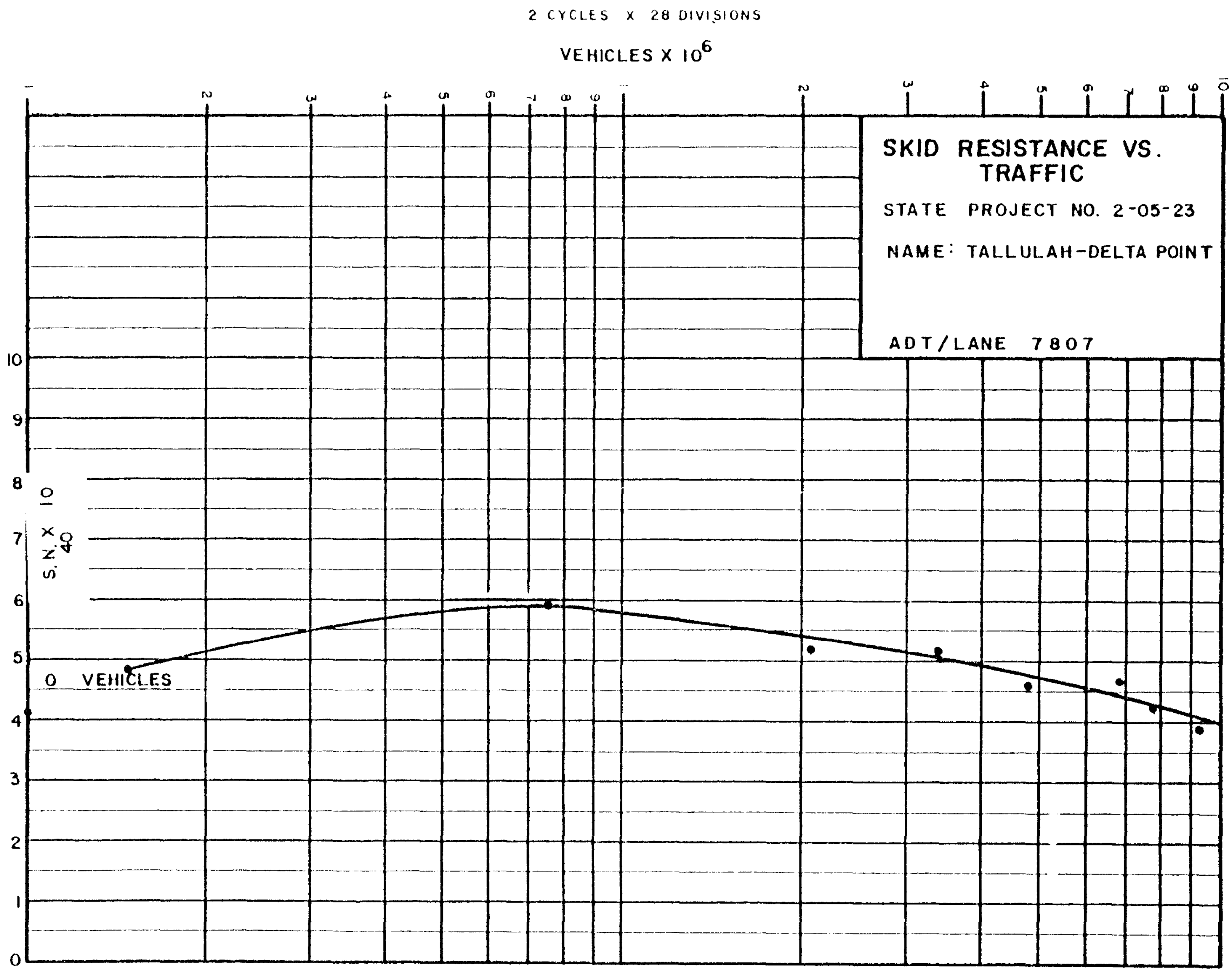
ADT/LANE 78 07
S.N.
σ^2
70
60
50
40
30
20
S.N.
20.0
15.0
10.0
5.0
ORIG. 7/69
1 5/70
2 1/71
3 7/71
4 1/72
5 8/72
6 2/73
7 9/73
8 /
RUN & DATE


2 CYCLES X 28 DIVISIONS
VEHICLES X 10^6
SKID RESISTANCE VS. TRAFFIC
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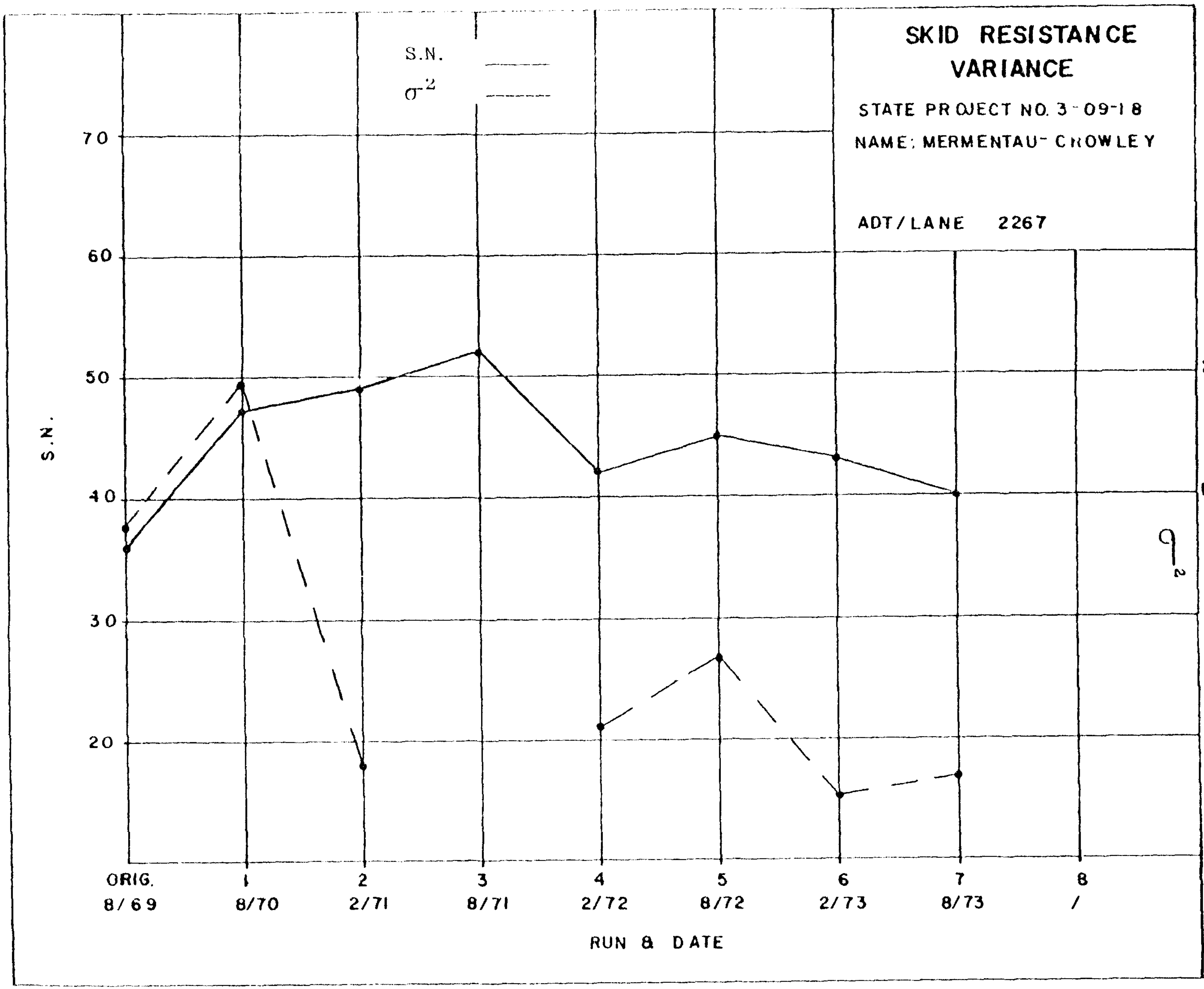
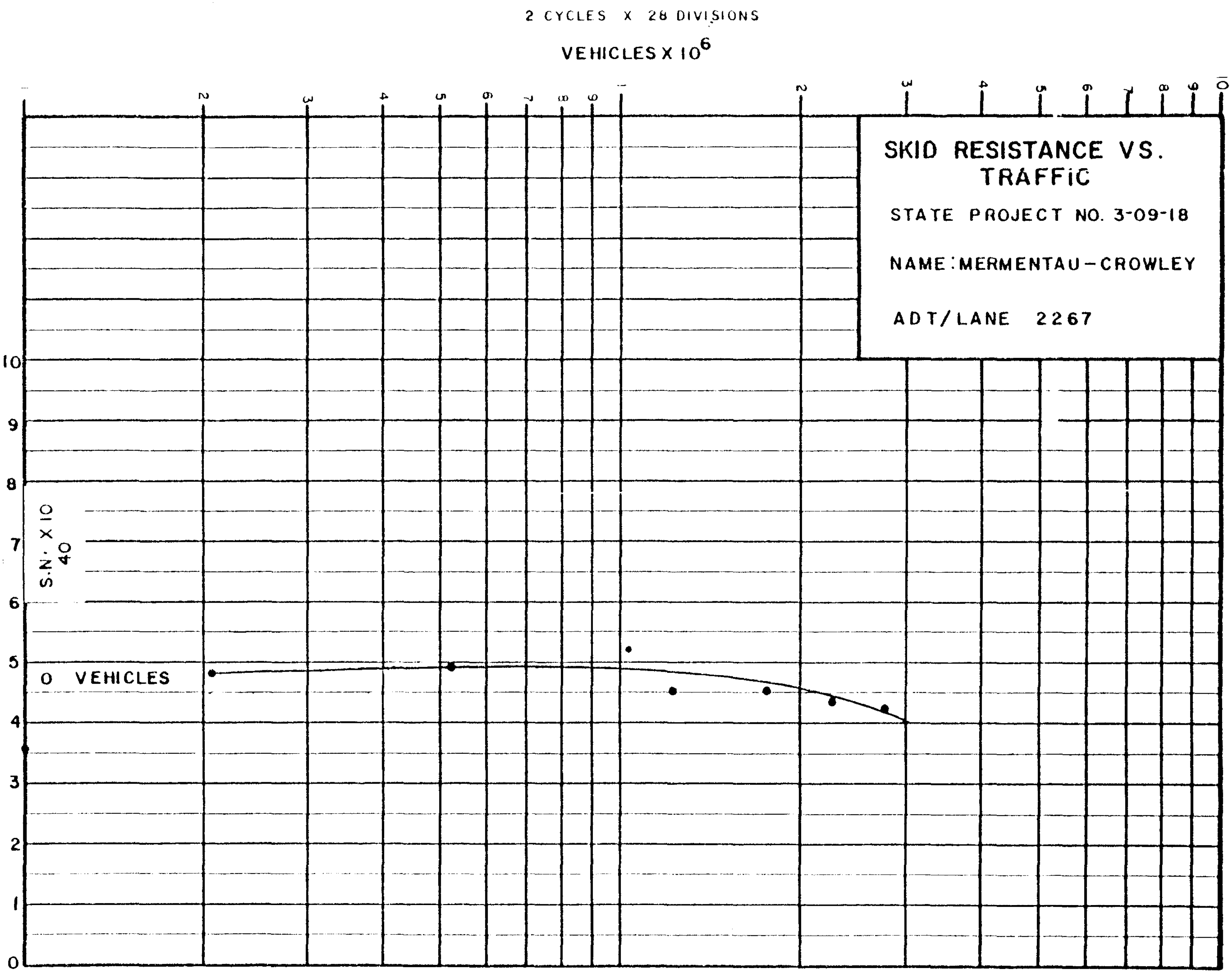
ADT/LANE 7807
S.N. X 10
0 VEHICLES


SKID RESISTANCE
VARIANCE
STATE PROJECT NO. 3-09-18
NAME: MERMENTAU-CROWLEY
ADT/LANE 2267
S.N.
σ^2
70
60
50
40
30
20
S.N.
20.0
15.0
10.0
5.0
σ^2
ORIG. 8/69
1 8/70
2 2/71
3 8/71
4 2/72
5 8/72
6 2/73
7 8/73
8 /
RUN & DATE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VEHICLES X 10^6
SKID RESISTANCE VS. TRAFFIC
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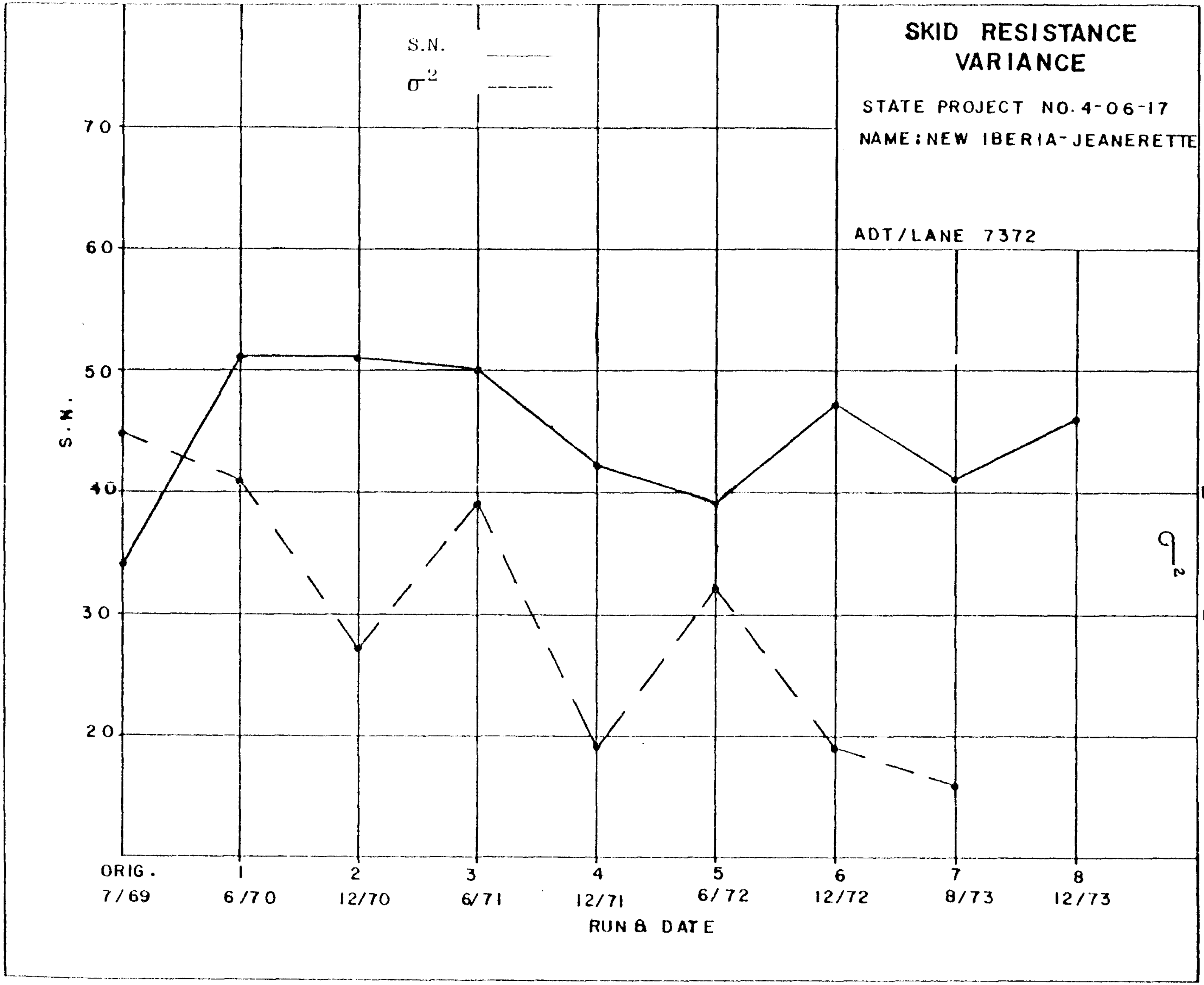
ADT/LANE 2267
S.N.40 X 10
O VEHICLES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ADT/LANE 7372
S.N.
σ2
70
60
50
40
30
20
S.N.
20.0
15.0
10.0
5.0
σ2
ORIG. 7/69
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2 12/70
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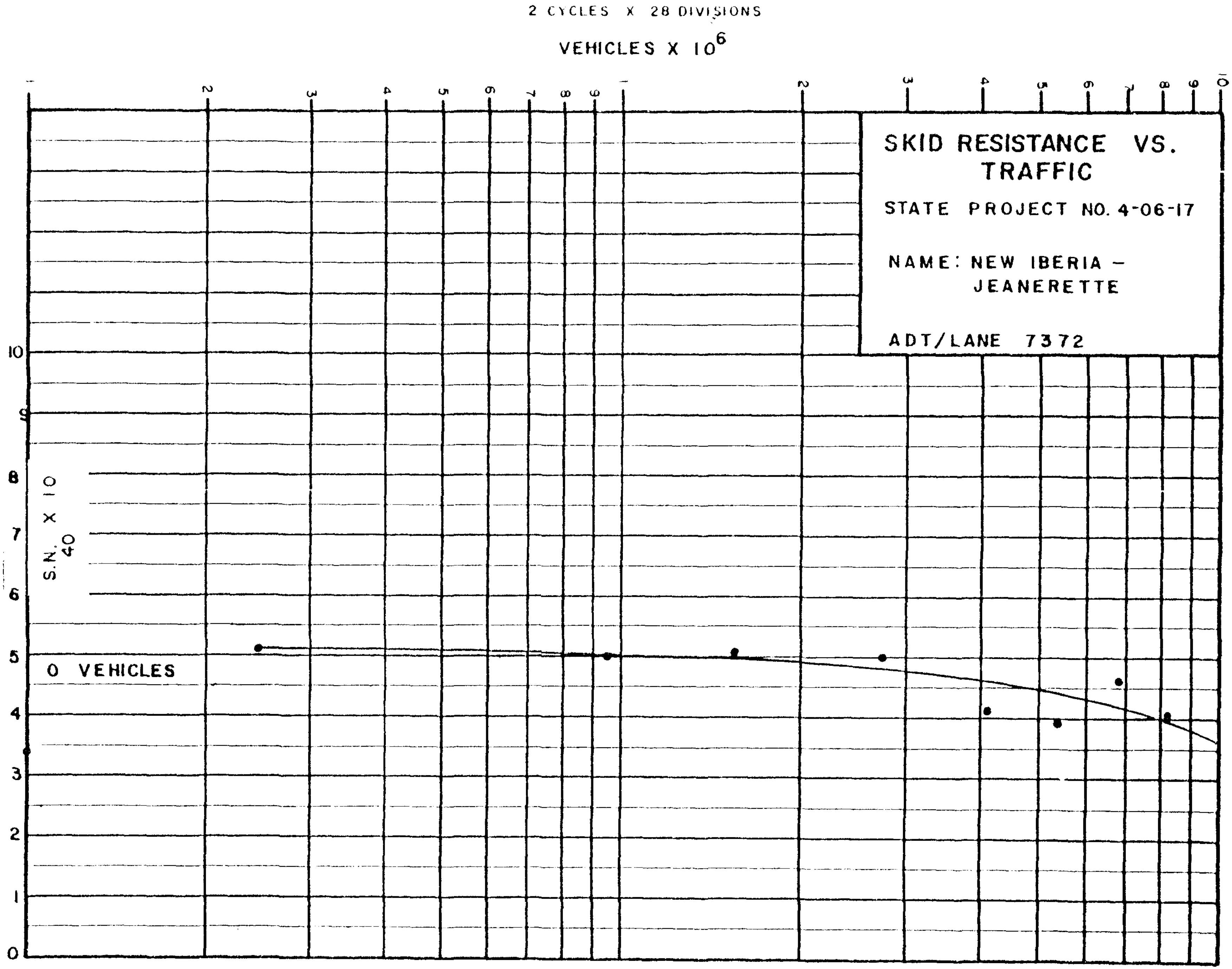
7 8/73
8 12/73
RUN & DATE



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VEHICLES X 10^6
SKID RESISTANCE VS. TRAFFIC
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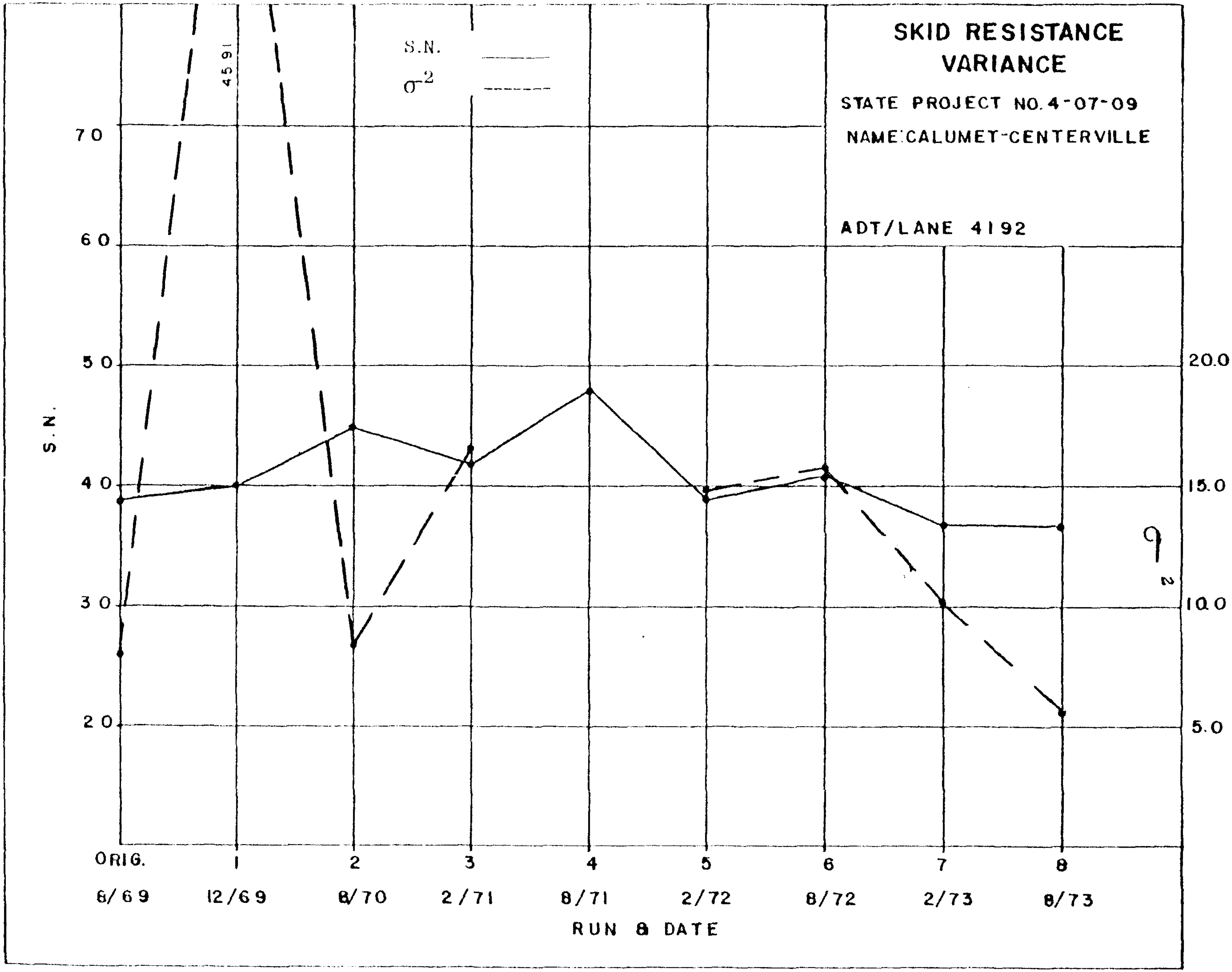
0 VEHICLES



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VARIANCE
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ADT/LANE 4192
S.N.
σ^2
45.91
70
60
50
40
30
20
S.N.
20.0
15.0
10.0
5.0
σ^2
ORIG.
1
2
3
4
5
6
7
8
6/69
12/69
8/70
2/71
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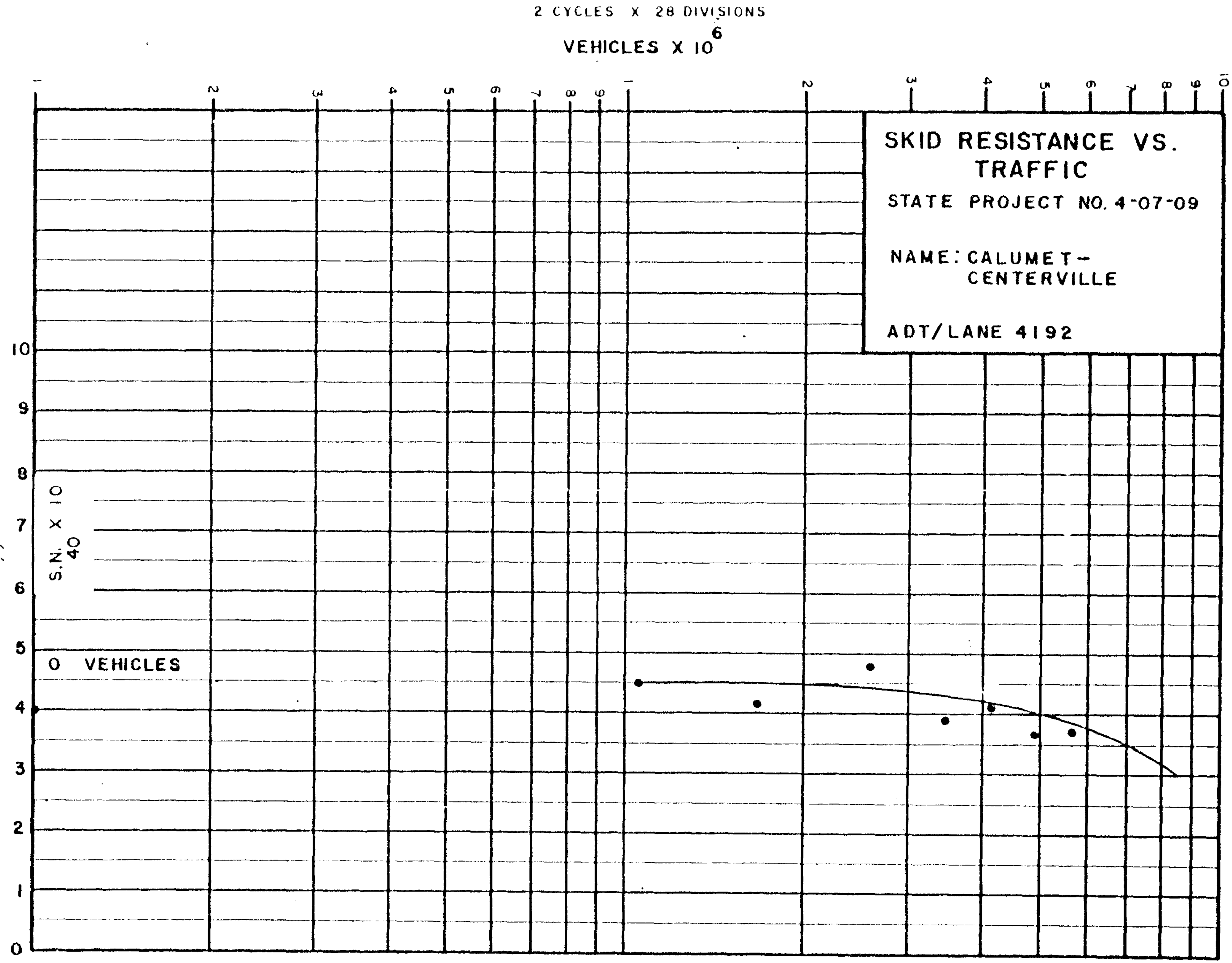
2/72
8/72
2/73
8/73
RUN & DATE



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VEHICLES X 10^6
SKID RESISTANCE VS. TRAFFIC
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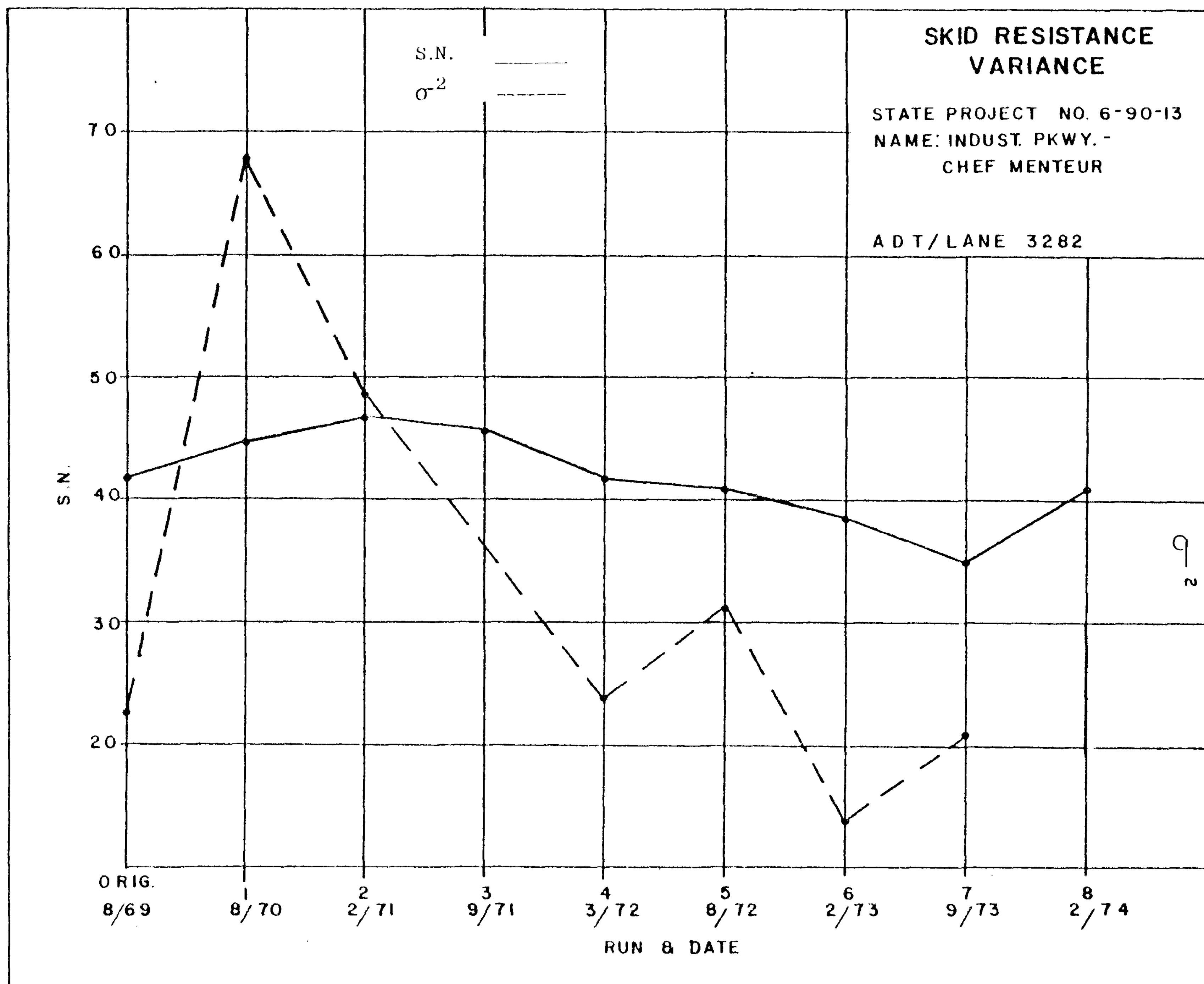
ADT/LANE 4192
S.N.40 X 10
0 VEHICLES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ADT/LANE 3282
S.N.
σ²
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60
50
40
30
20
20.0
15.0
10.0
5.0
ORIG. 8/69
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2 2/71
3 9/71
4 3/72
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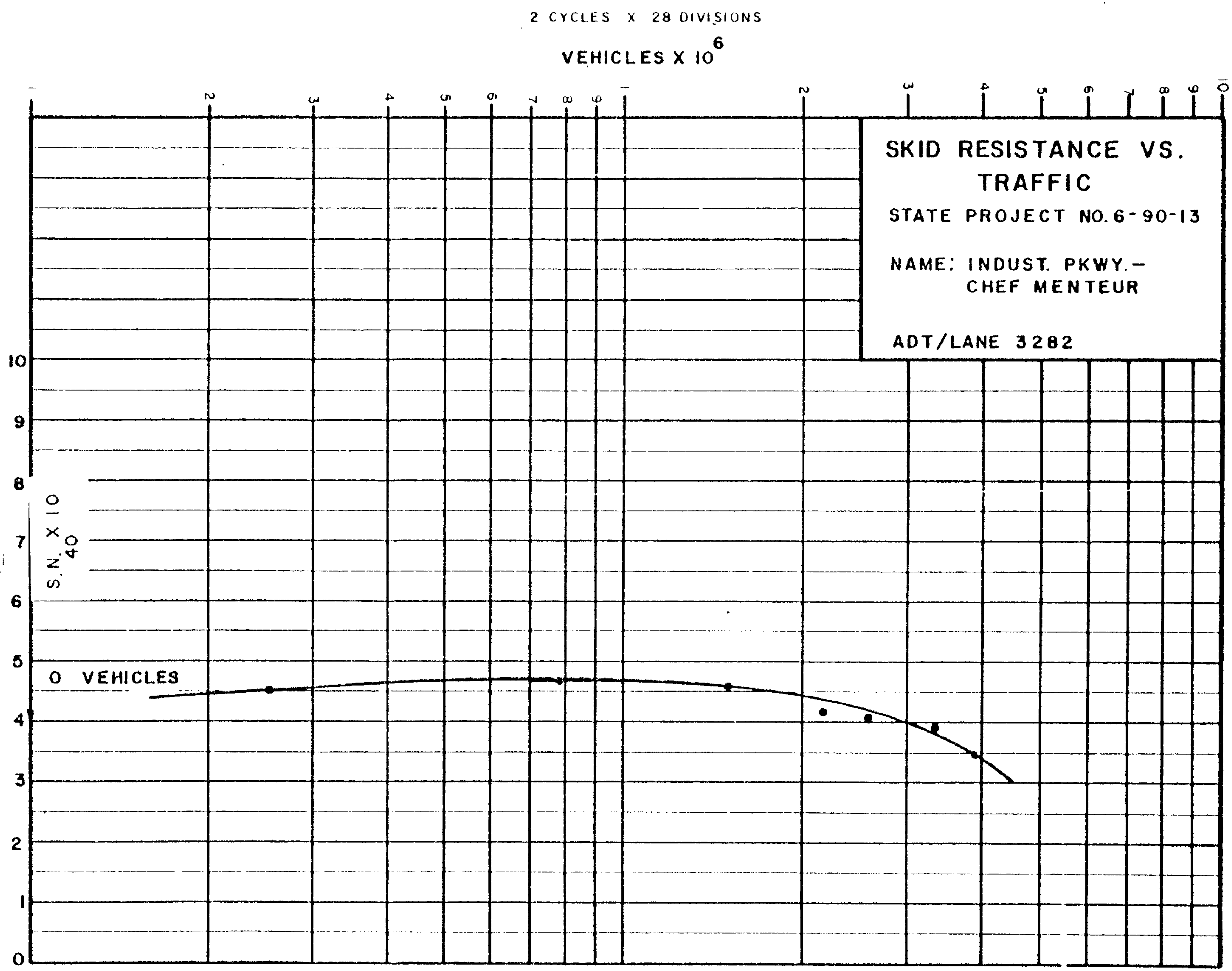
6 2/73
7 9/73
8 2/74
RUN & DATE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VEHICLES X 10^6
SKID RESISTANCE VS. TRAFFIC
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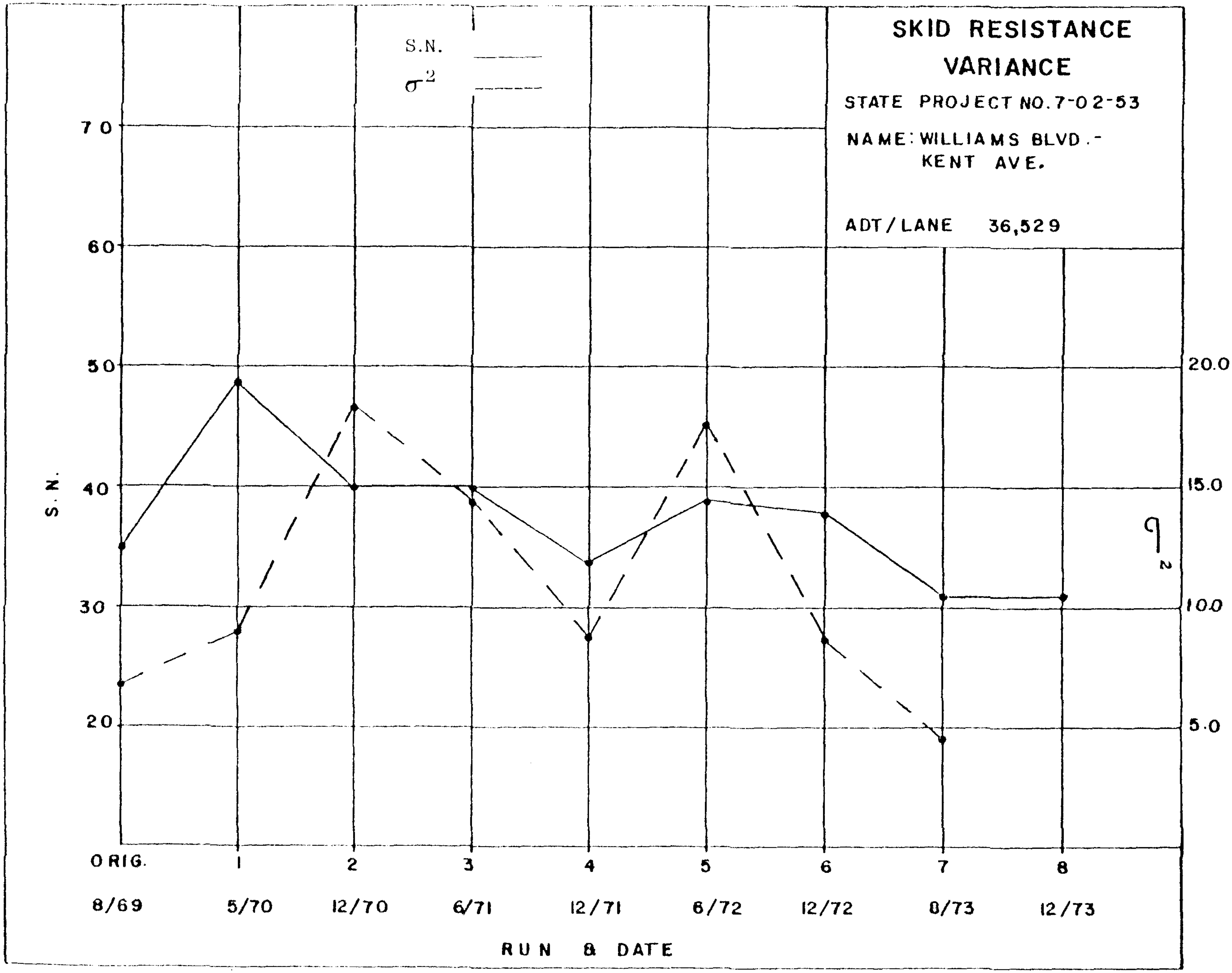
ADT/LANE 3282
S.N.40 X 10
0 VEHICLES


SKID RESISTANCE
VARIANCE
STATE PROJECT NO. 7-02-53
NAME: WILLIAMS BLVD. - KENT AVE.
ADT/LANE 36,529
S.N.
σ^2
70
60
50
40
30
20
20.0
15.0
10.0
5.0
ORIG.
1
2
3
4
5
6
7
8
8/69
5/70
12/70
6/71
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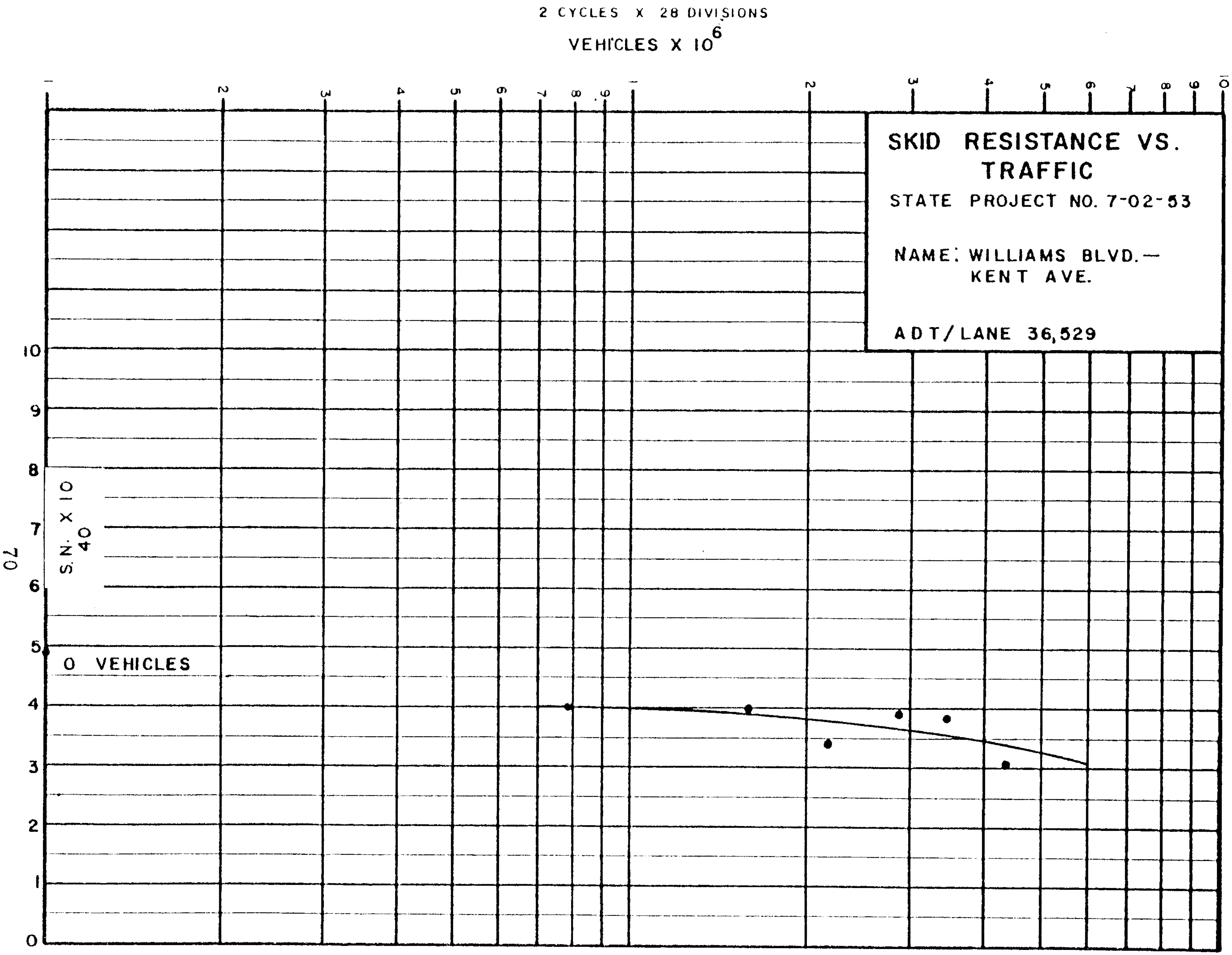
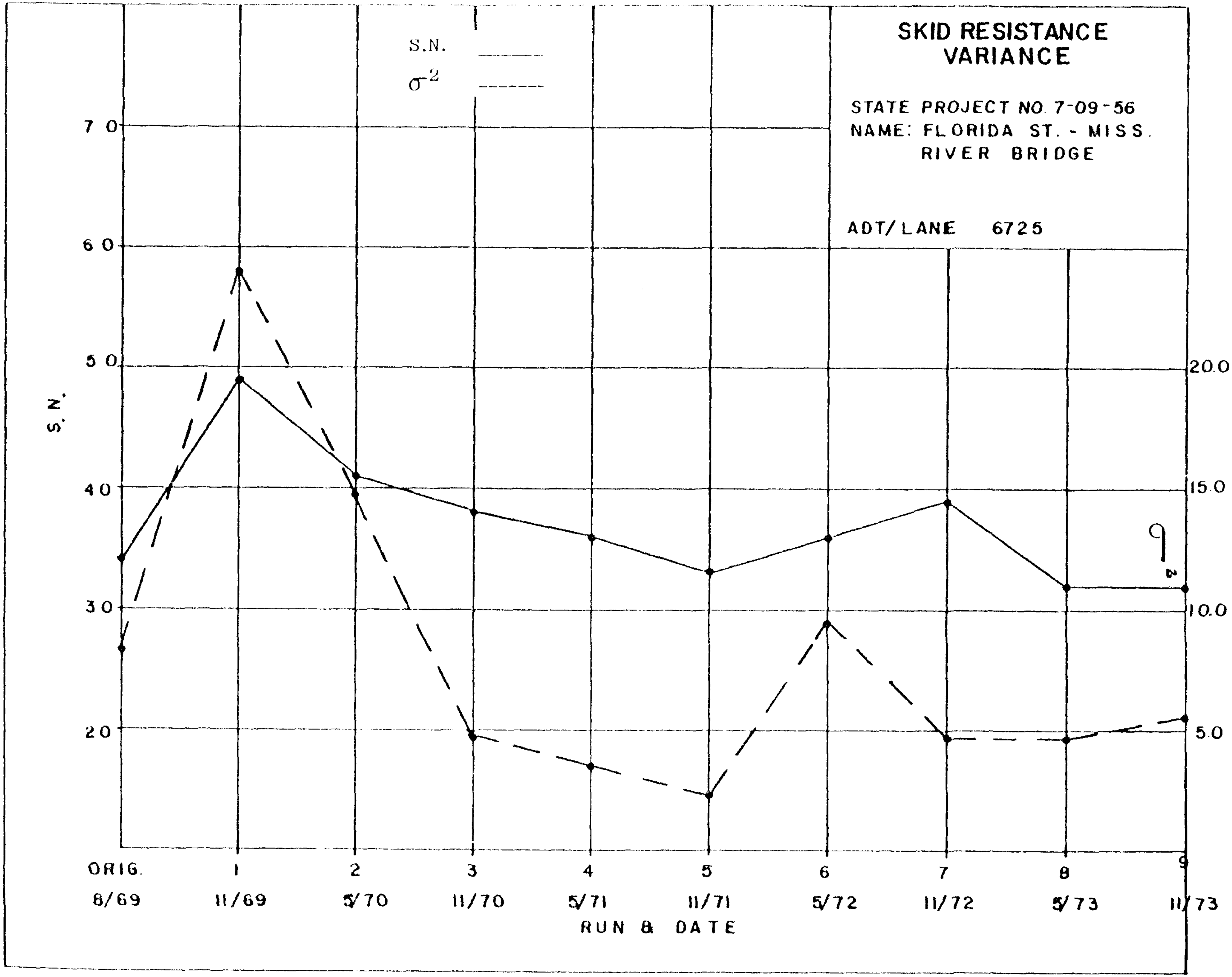
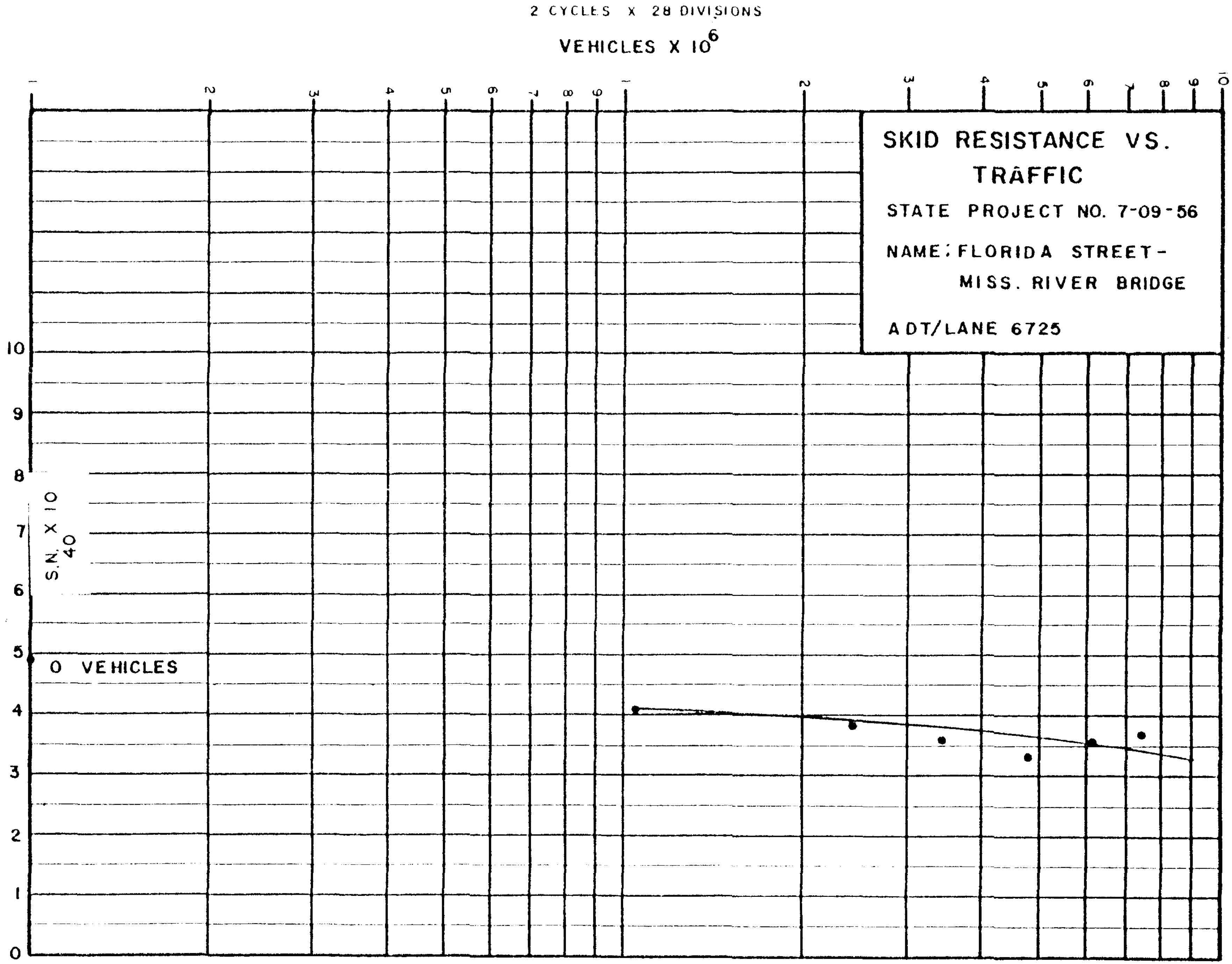
12/72
8/73
12/73
RUN & DATE

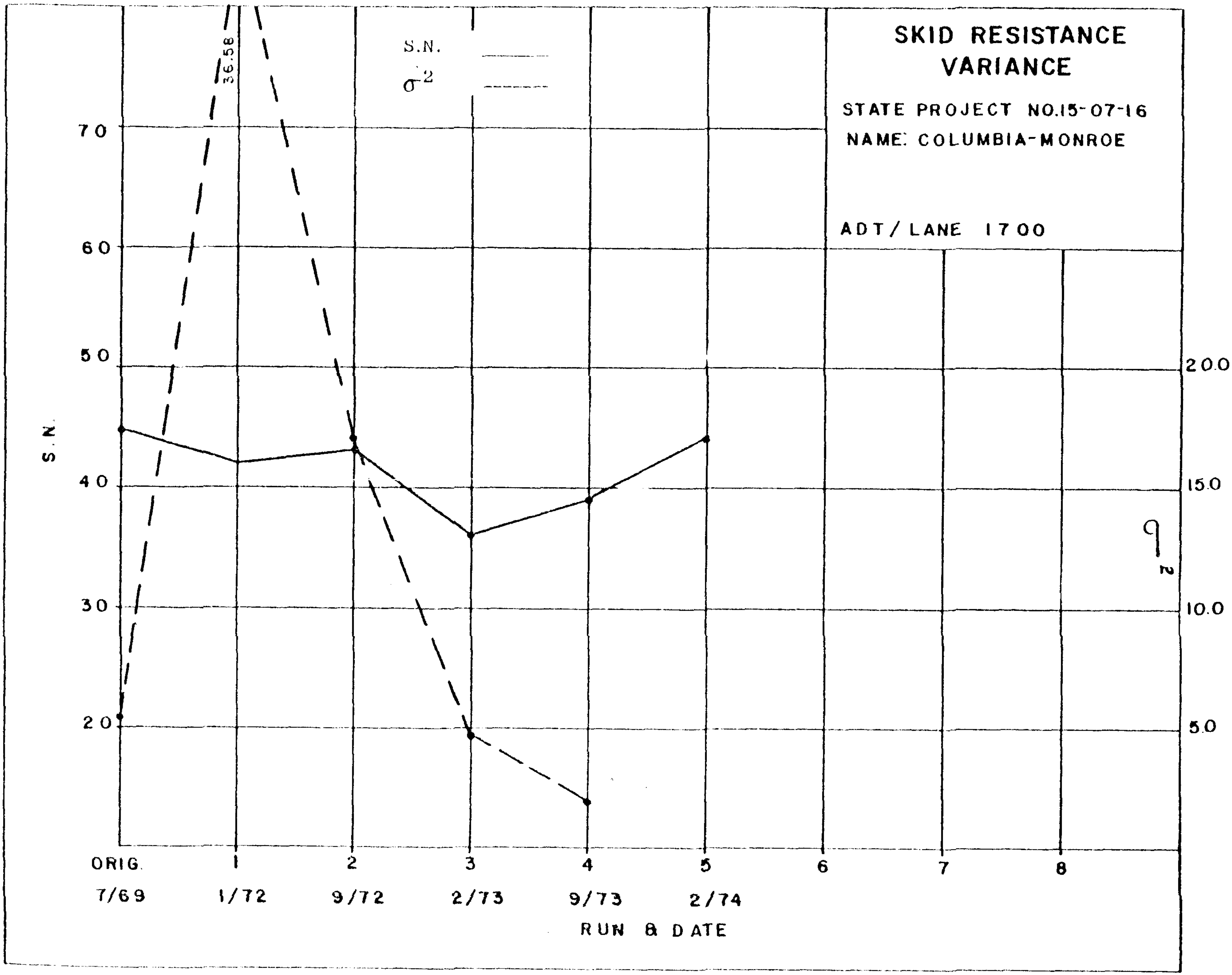


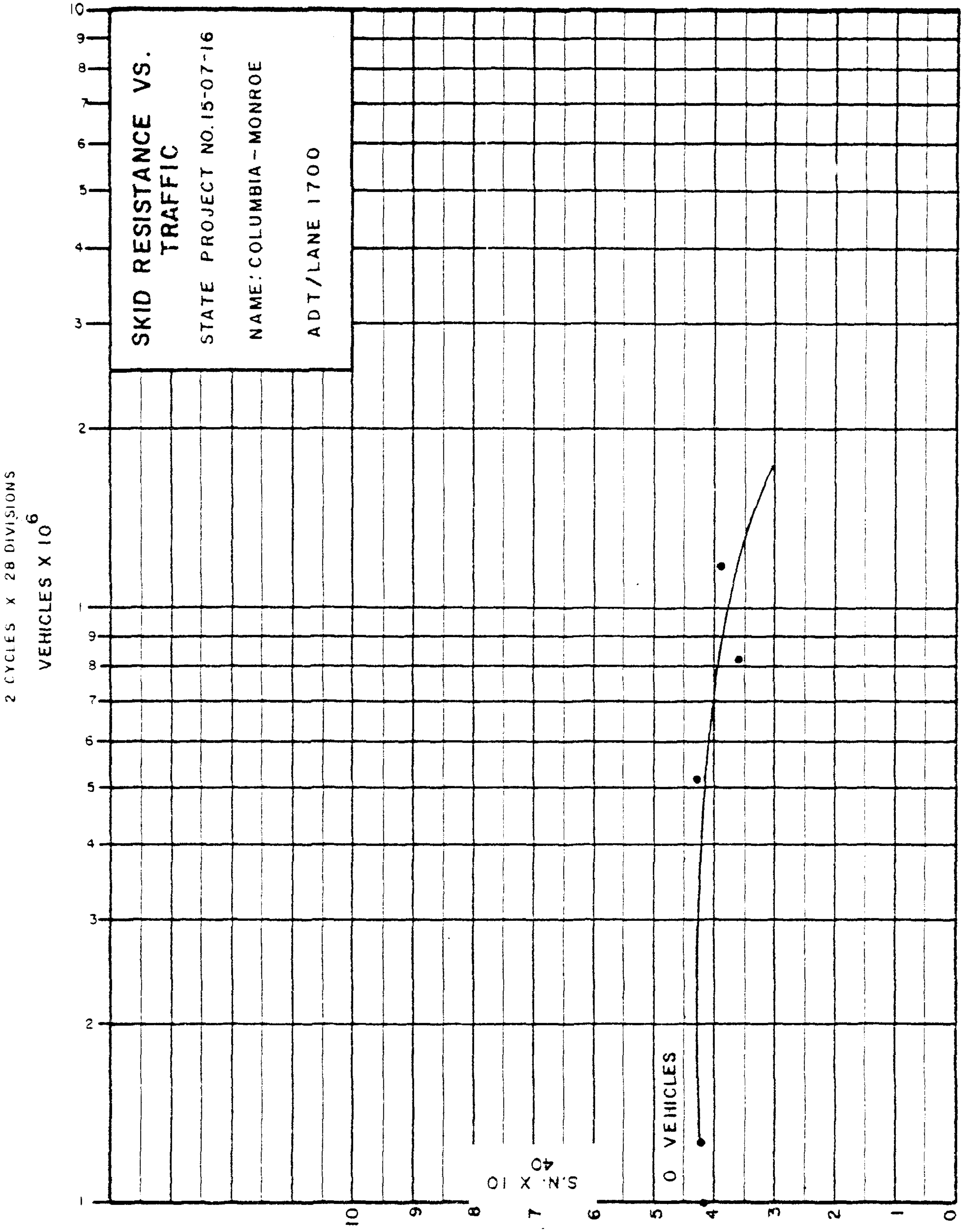
2 CYCLES X 28 DIVISIONS
VEHICLES X 10^6
SKID RESISTANCE VS. TRAFFIC
STATE PROJECT NO. 7-02-53
NAME: WILLIAMS BLVD. — KENT AVE.
ADT/LANE 36,529
S.N.40 X 10
0 VEHICLES

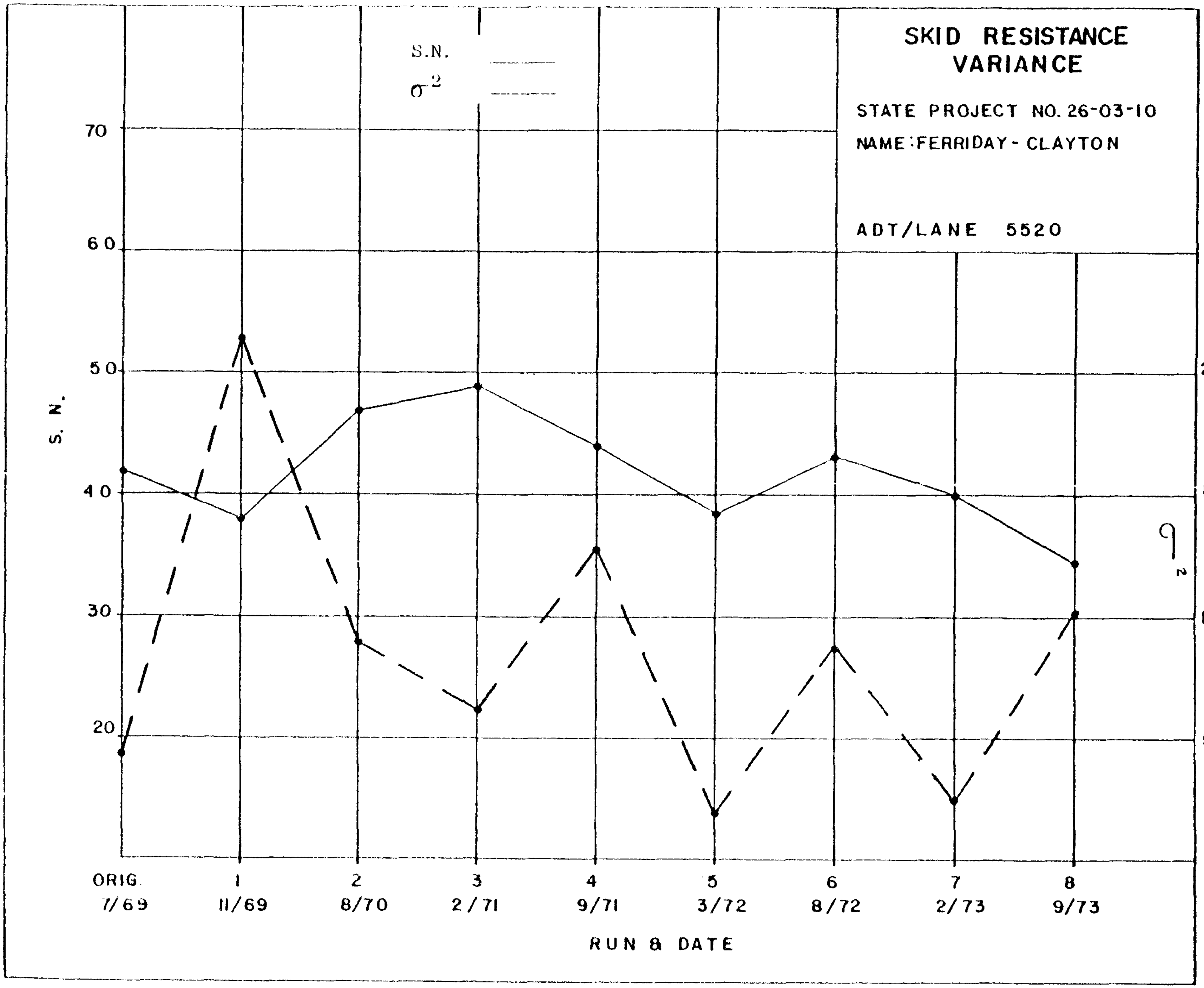

SKID RESISTANCE VARIANCE
STATE PROJECT NO. 7-09-56
NAME: FLORIDA ST. - MISS. RIVER BRIDGE
ADT/LANE 6725
S.N.
σ^2
S.N.
70
60
50
40
30
20
20.0
15.0
10.0
5.0
ORIG. 8/69
1 11/69
2 5/70
3 11/70
4 5/71
5 11/71
6 5/72
7 11/72
8 5/73
9 11/73
RUN & DATE

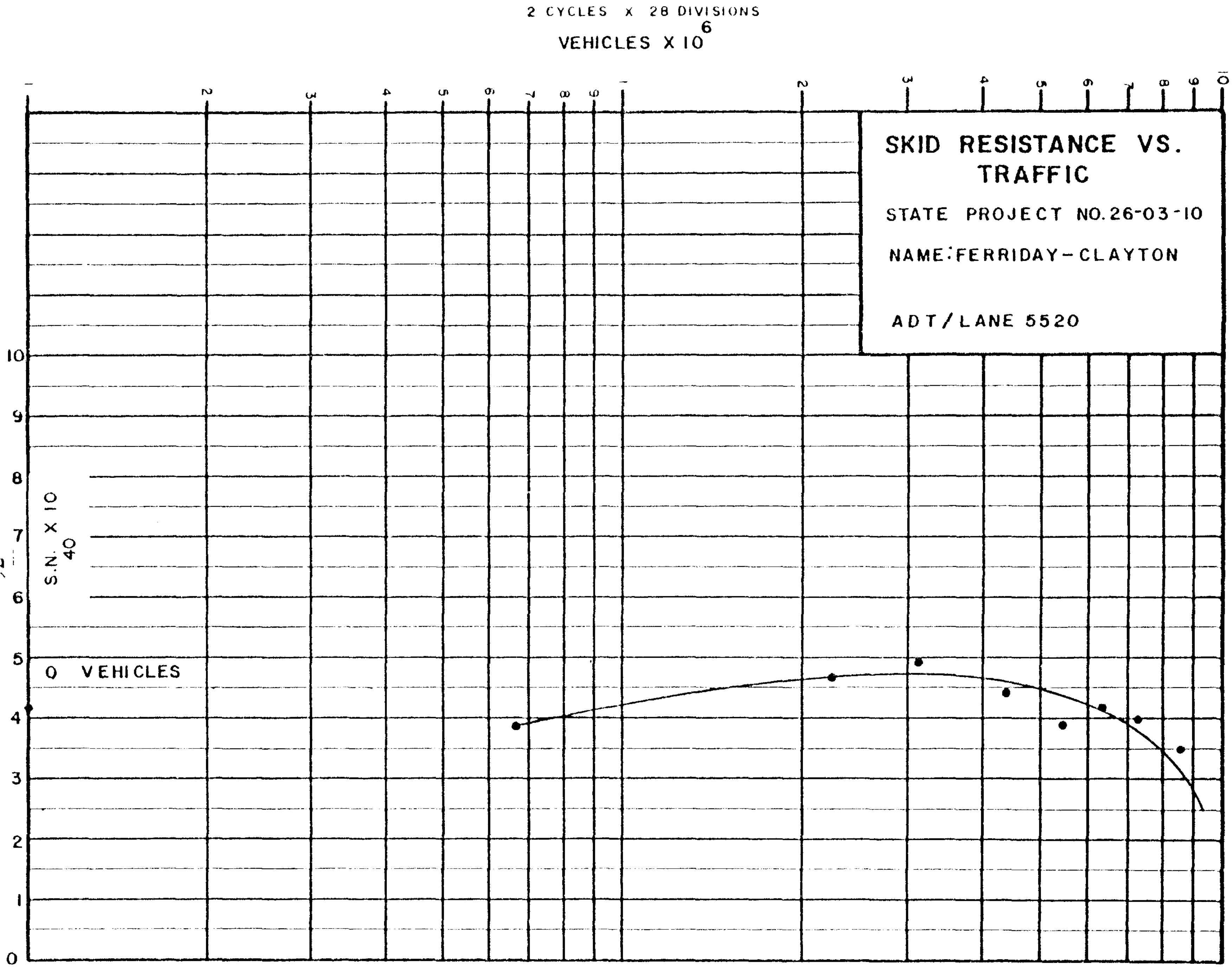


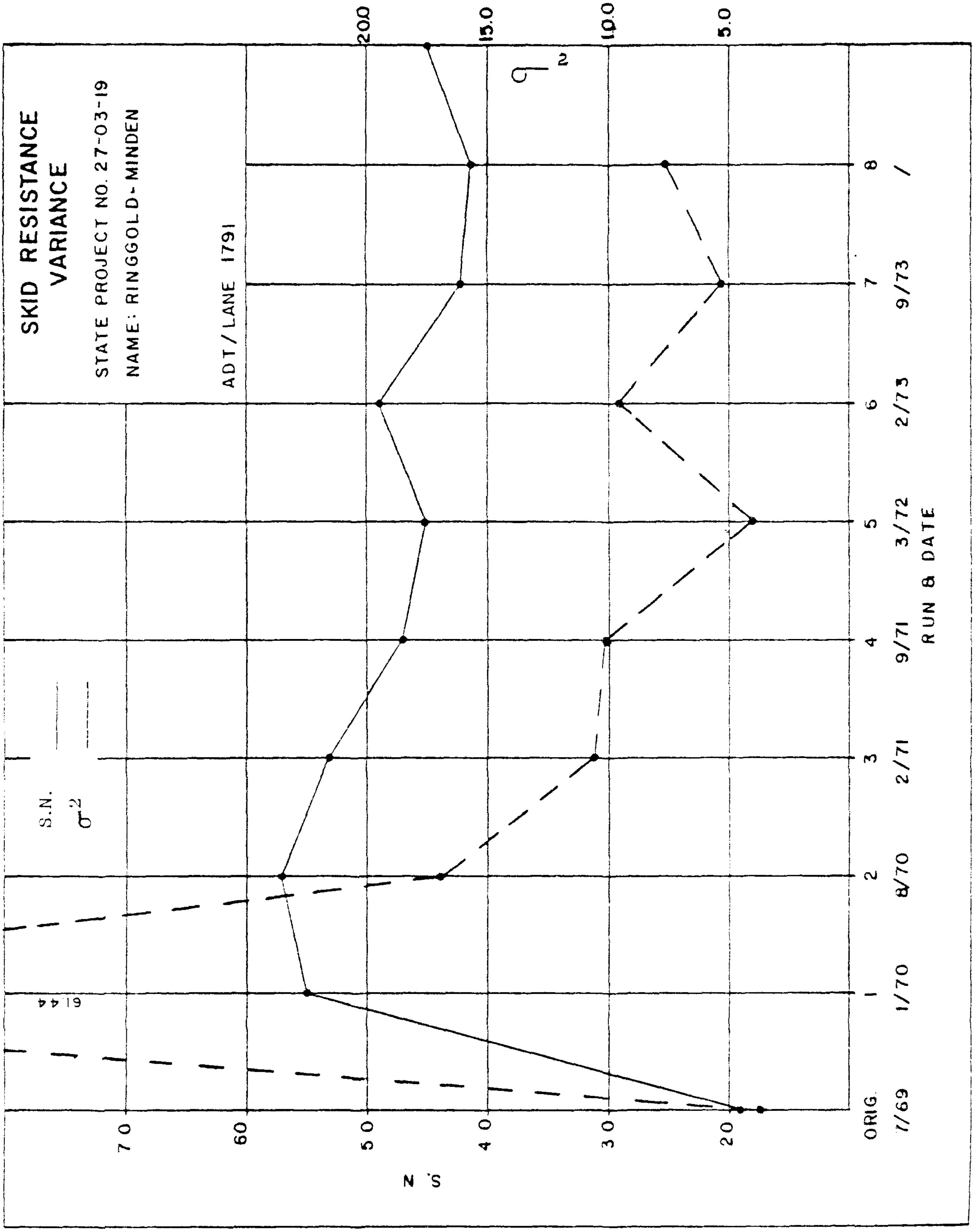
2 CYCLES X 28 DIVISIONS
VEHICLES X 10^6
SKID RESISTANCE VS. TRAFFIC
STATE PROJECT NO. 7-09-56
NAME: FLORIDA STREET-MISS. RIVER BRIDGE
ADT/LANE 6725
S.N.40 X 10
0 VEHICLES

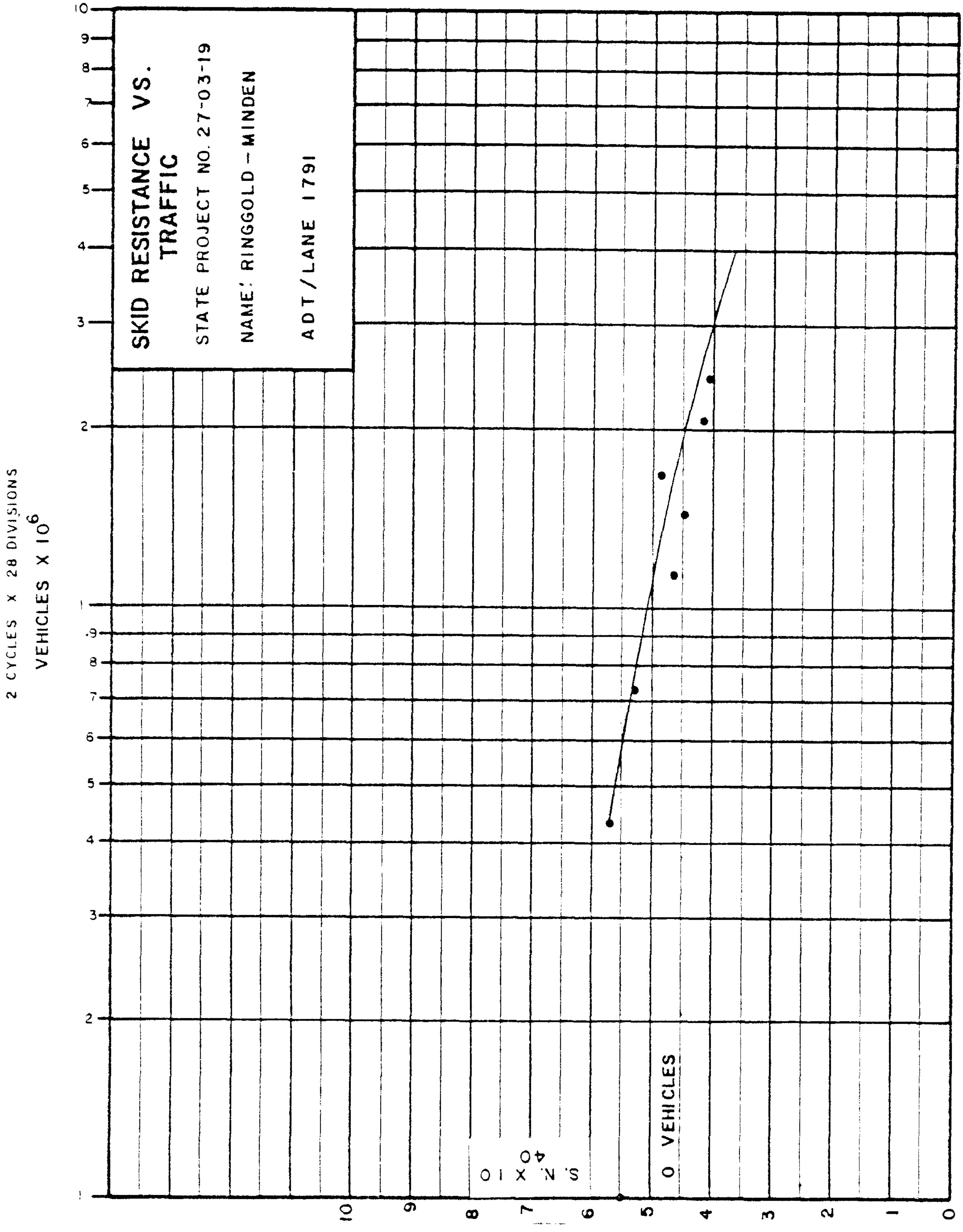

SKID RESISTANCE VARIANCE
STATE PROJECT NO.15-07-16
NAME: COLUMBIA-MONROE
ADT/LANE 1700
S.N.
σ²
36.58
70
60
50
40
30
20
S.N.
20.0
15.0
10.0
5.0
σ²
ORIG. 7/69
1 1/72
2 9/72
3 2/73
4 9/73
5 2/74
6
7
8
RUN & DATE


SKID RESISTANCE VS. TRAFFIC
STATE PROJECT NO. 15-07-16
NAME: COLUMBIA - MONROE
ADT/LANE 1700
2 CYCLES X 28 DIVISIONS
VEHICLES X 10^6
S.N. X 10
40
0 VEHICLES
10
9
8
7
6
5
4
3
2
1
0

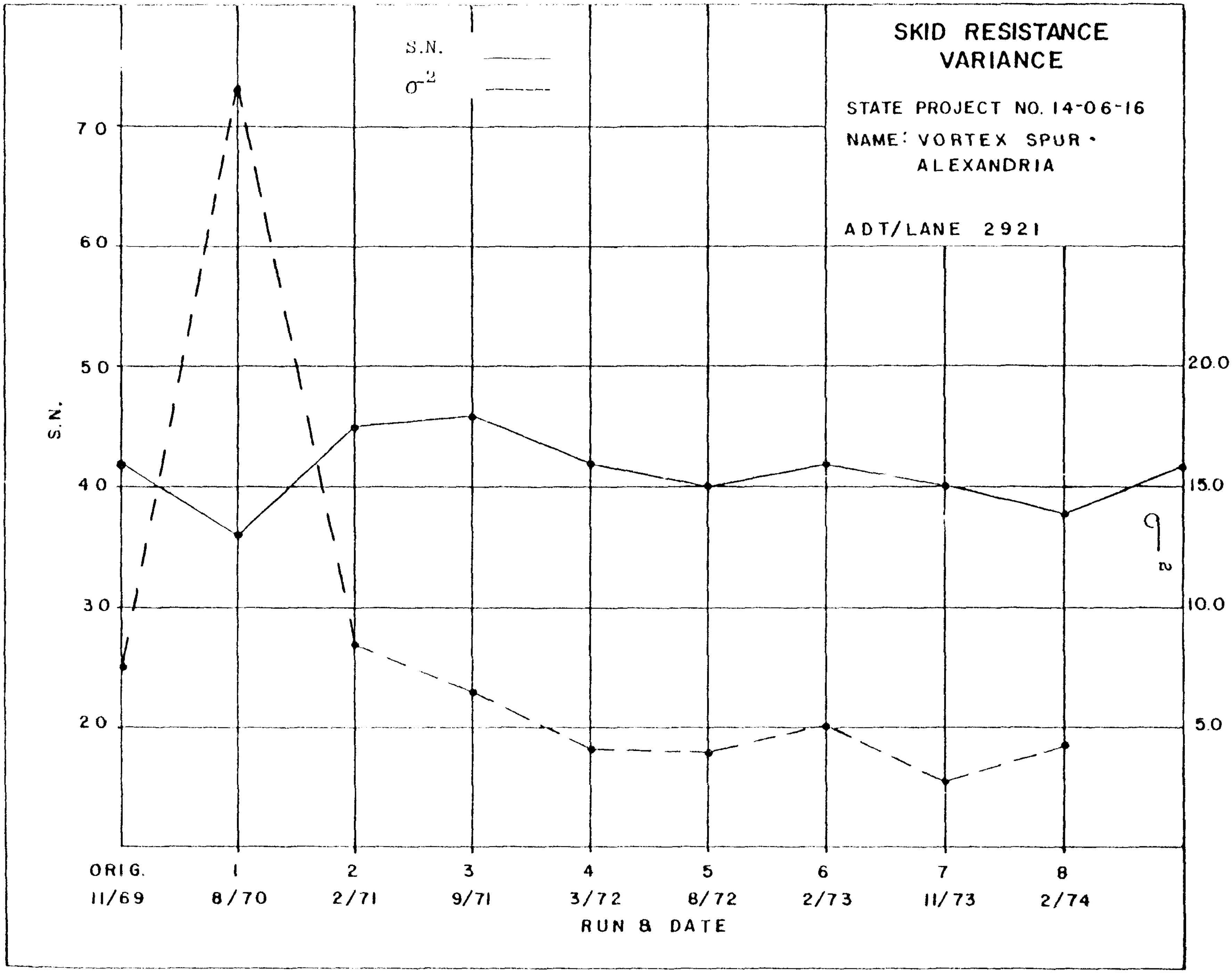

SKID RESISTANCE
VARIANCE
STATE PROJECT NO. 26-03-10
NAME: FERRIDAY - CLAYTON
ADT/LANE 5520
S.N.
σ2
S. N.
70
60
50
40
30
20
20.0
15.0
10.0
5.0
σ2
ORIG. 7/69
1 11/69
2 8/70
3 2/71
4 9/71
5 3/72
6 8/72
7 2/73
8 9/73
RUN & DATE

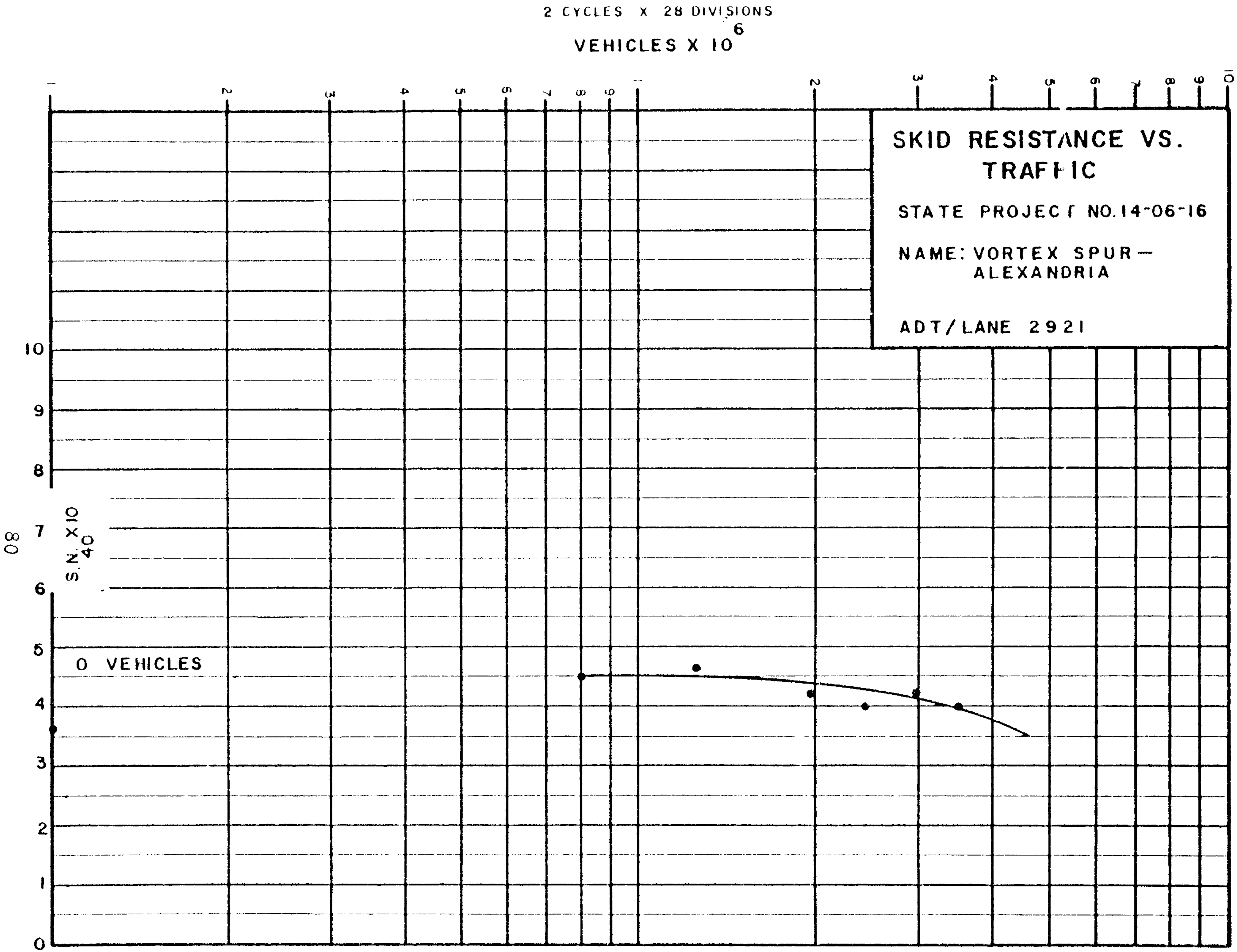

2 CYCLES X 28 DIVISIONS
VEHICLES X 10^6
SKID RESISTANCE VS. TRAFFIC
STATE PROJECT NO. 26-03-10
NAME: FERRIDAY - CLAYTON
ADT/LANE 5520
S.N.40 X 10
0 VEHICLES
0
1
2
3
4
5
6
7
8
9
10

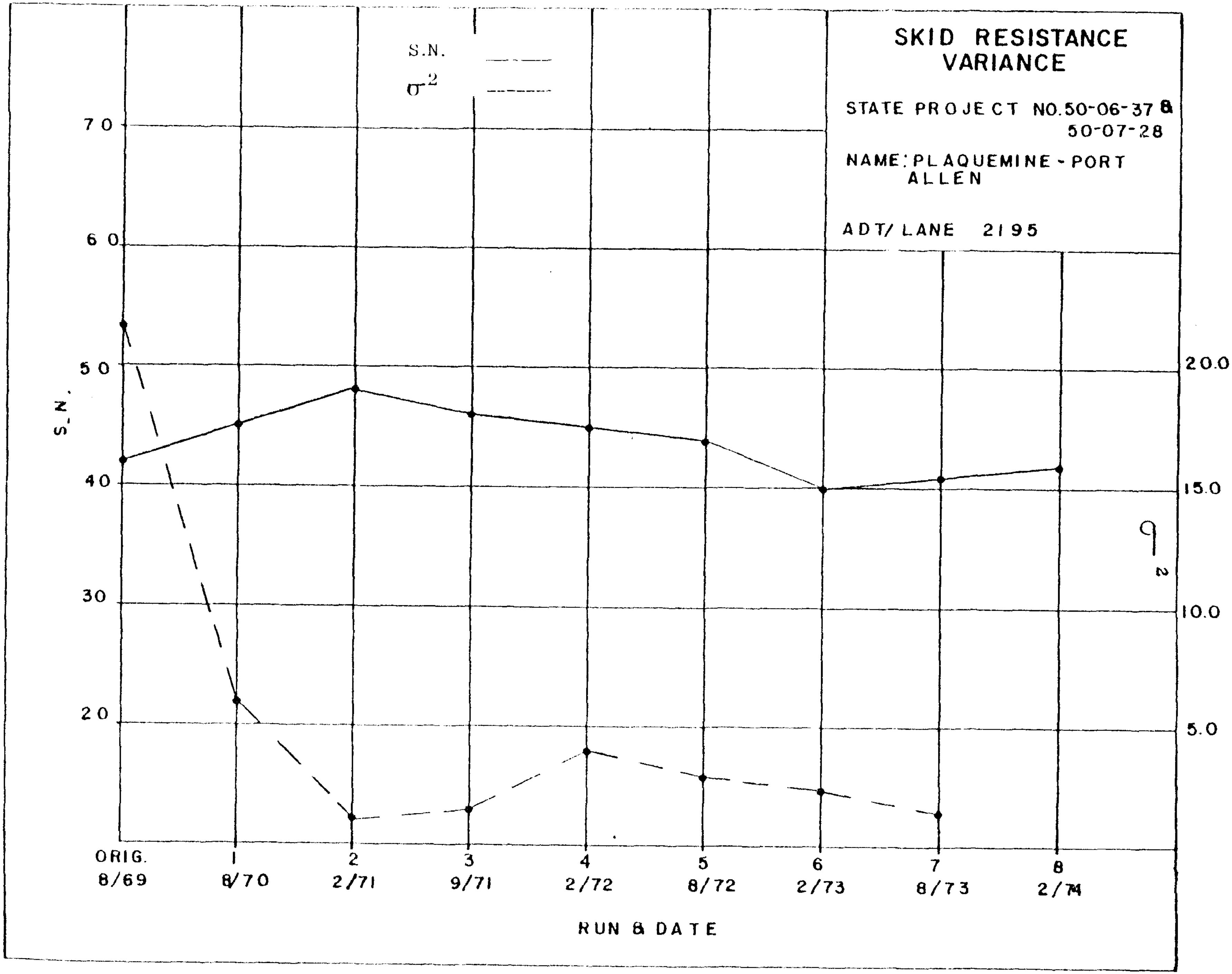

SKID RESISTANCE
VARIANCE
STATE PROJECT NO. 27-03-19
NAME: RINGGOLD-MINDEN
ADT/LANE 1791
S.N.
σ²
61.44
S.N.
RUN & DATE
ORIG. 7/69
1 1/70
2 8/70
3 2/71
4 9/71
5 3/72
6 2/73
7 9/73
8
20
30
40
50
60
70
5.0
10.0
15.0
20.0

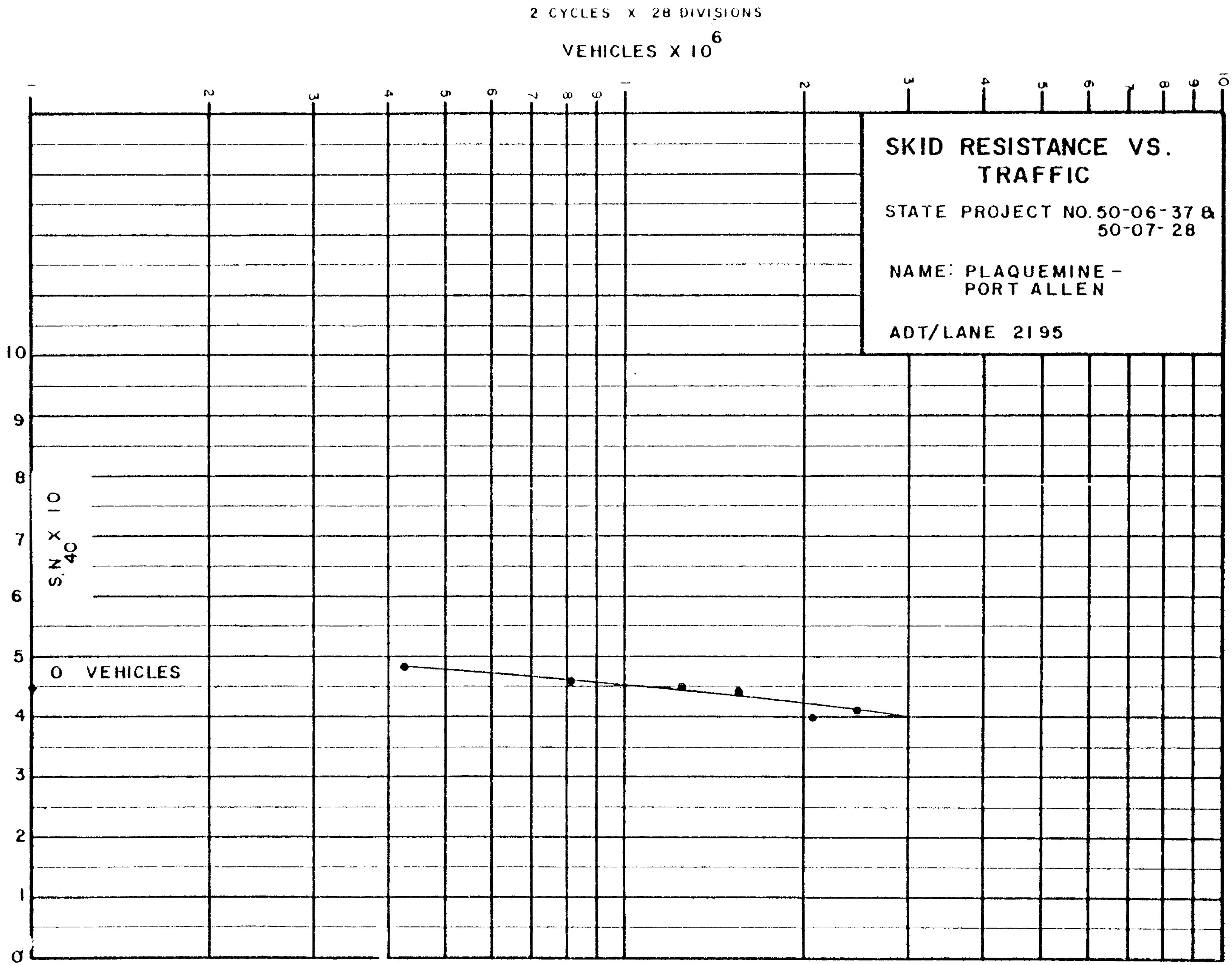


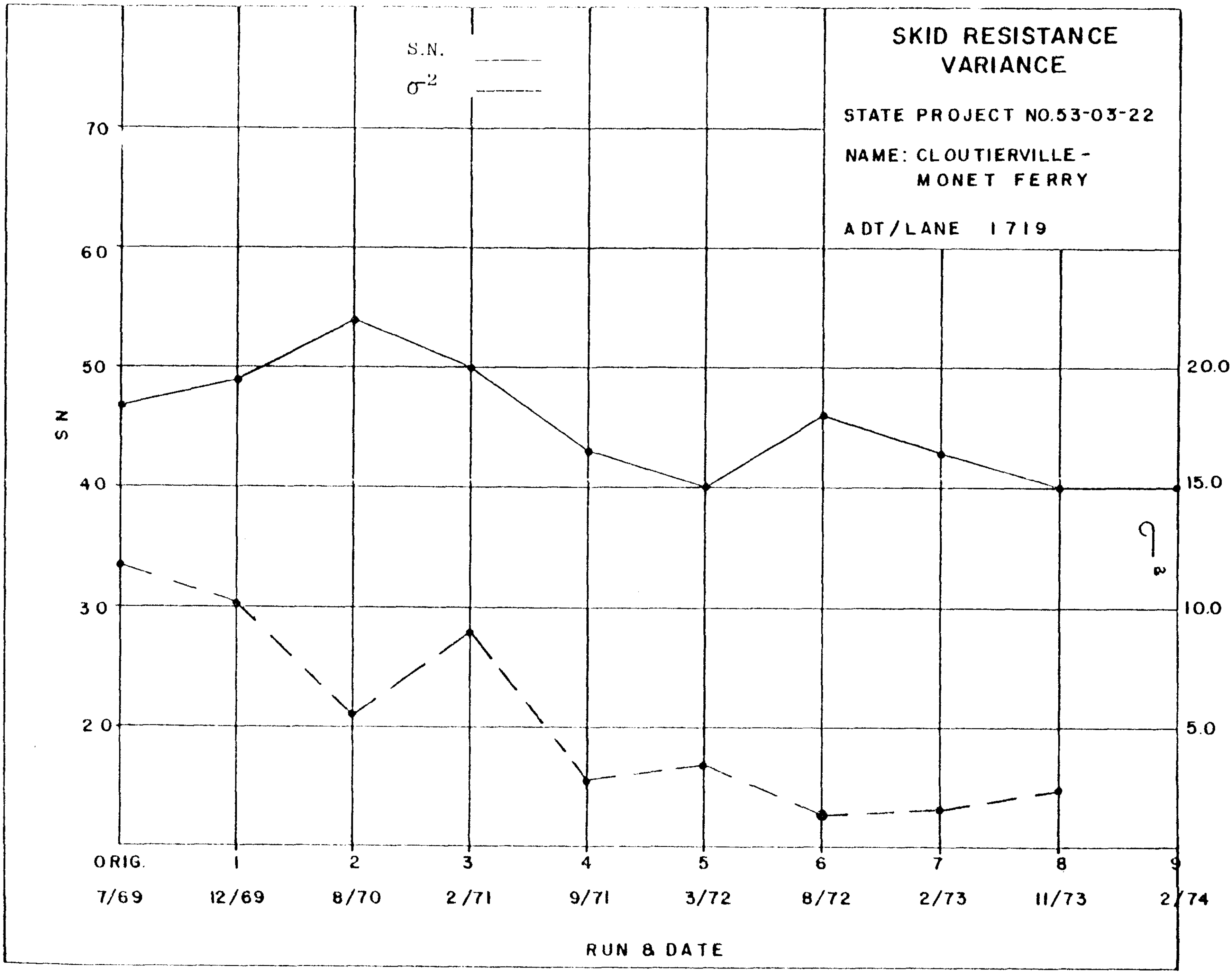
SKID RESISTANCE VS. TRAFFIC
STATE PROJECT NO. 27-03-19
NAME: RINGGOLD – MINDEN
ADT/LANE 1791
2 CYCLES X 28 DIVISIONS
VEHICLES X 10^6
S.N. X 10
40
0 VEHICLES

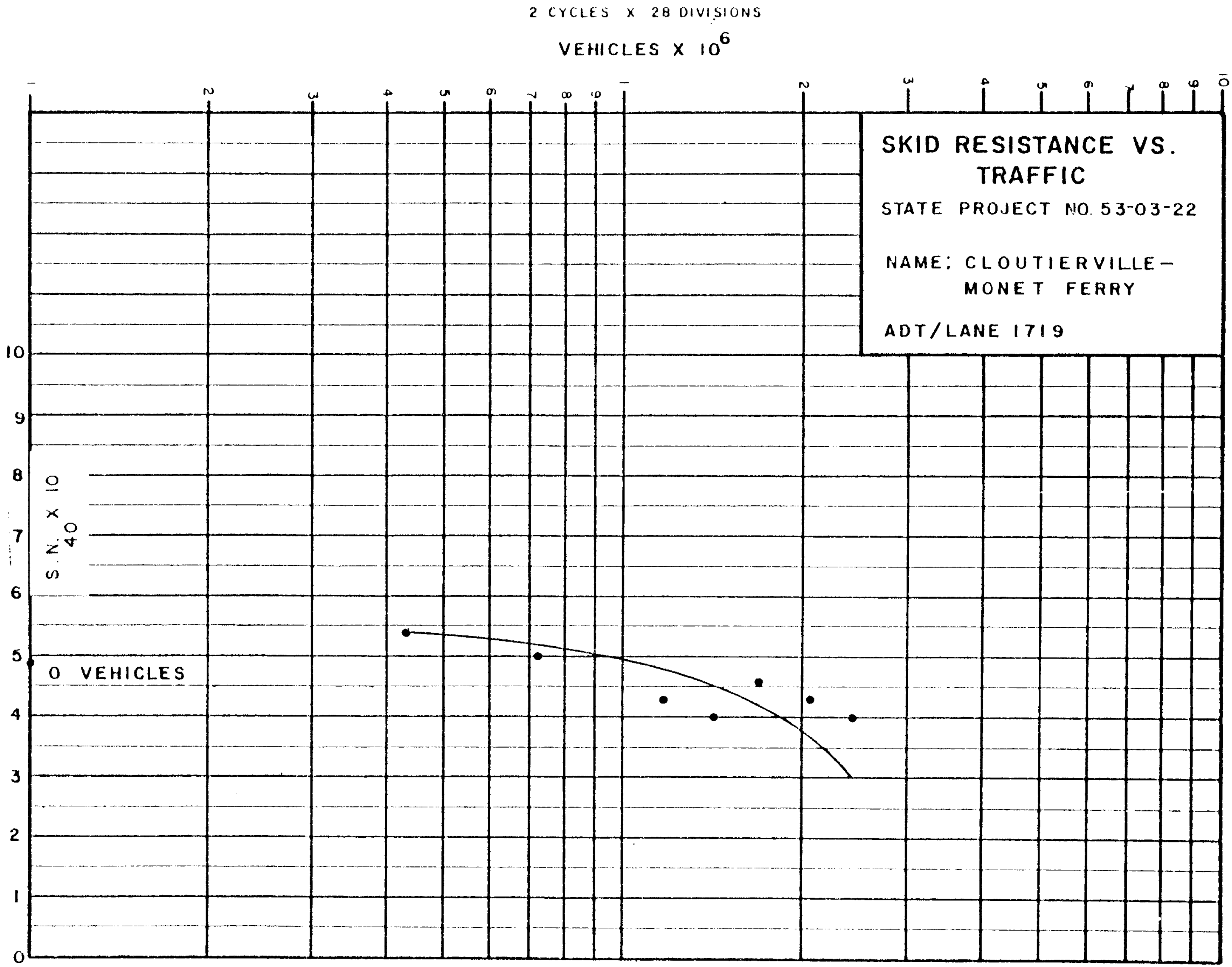

SKID RESISTANCE VARIANCE
STATE PROJECT NO. 14-06-16
NAME: VORTEX SPUR - ALEXANDRIA
ADT/LANE 2921
S.N.
σ^2
S.N.
70
60
50
40
30
20
20.0
15.0
10.0
5.0
σ^2
ORIG. 11/69
1 8/70
2 2/71
3 9/71
4 3/72
5 8/72
6 2/73
7 11/73
8 2/74
RUN & DATE

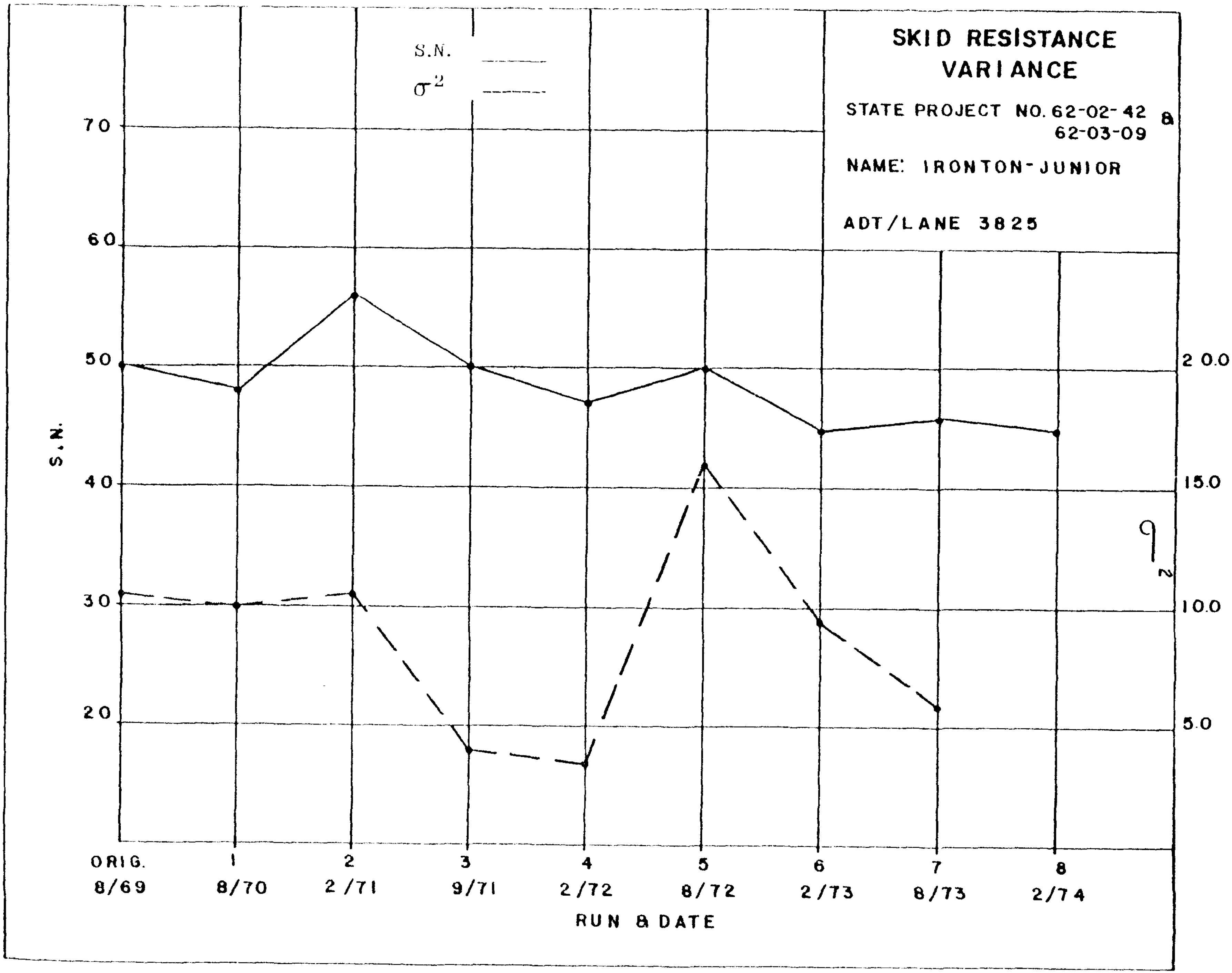

2 CYCLES X 28 DIVISIONS
VEHICLES X 10^6
SKID RESISTANCE VS. TRAFFIC
STATE PROJECT NO. 14-06-16
NAME: VORTEX SPUR — ALEXANDRIA
ADT/LANE 2921
S.N.40 X 10
0 VEHICLES
80

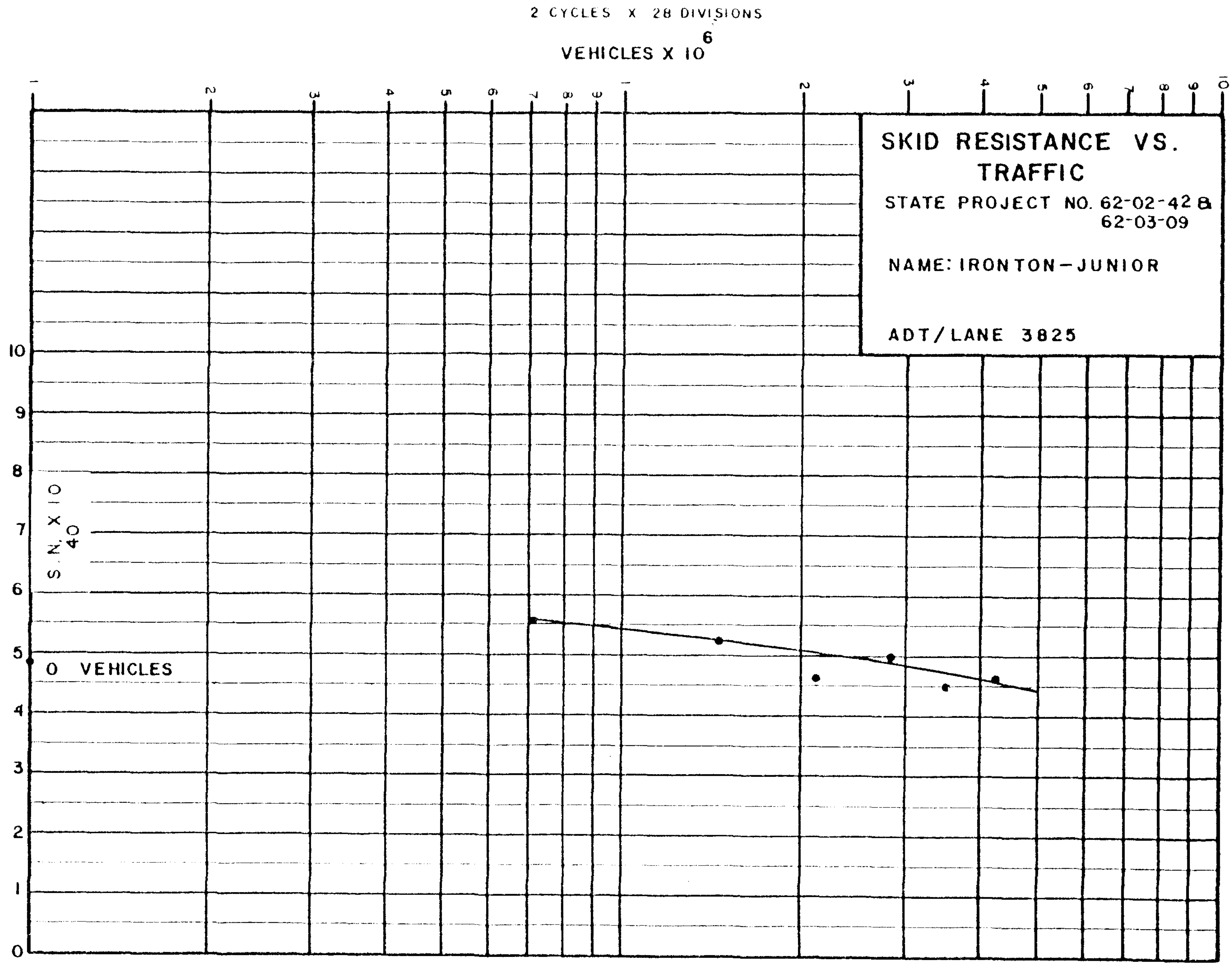

SKID RESISTANCE VARIANCE
STATE PROJECT NO.50-06-37 & 50-07-28
NAME: PLAQUEMINE - PORT ALLEN
ADT/ LANE 2195
S.N.
σ^2
70
60
50
40
30
20
S.N.
20.0
15.0
10.0
5.0
ORIG. 8/69
1 8/70
2 2/71
3 9/71
4 2/72
5 8/72
6 2/73
7 8/73
8 2/74
RUN & DATE

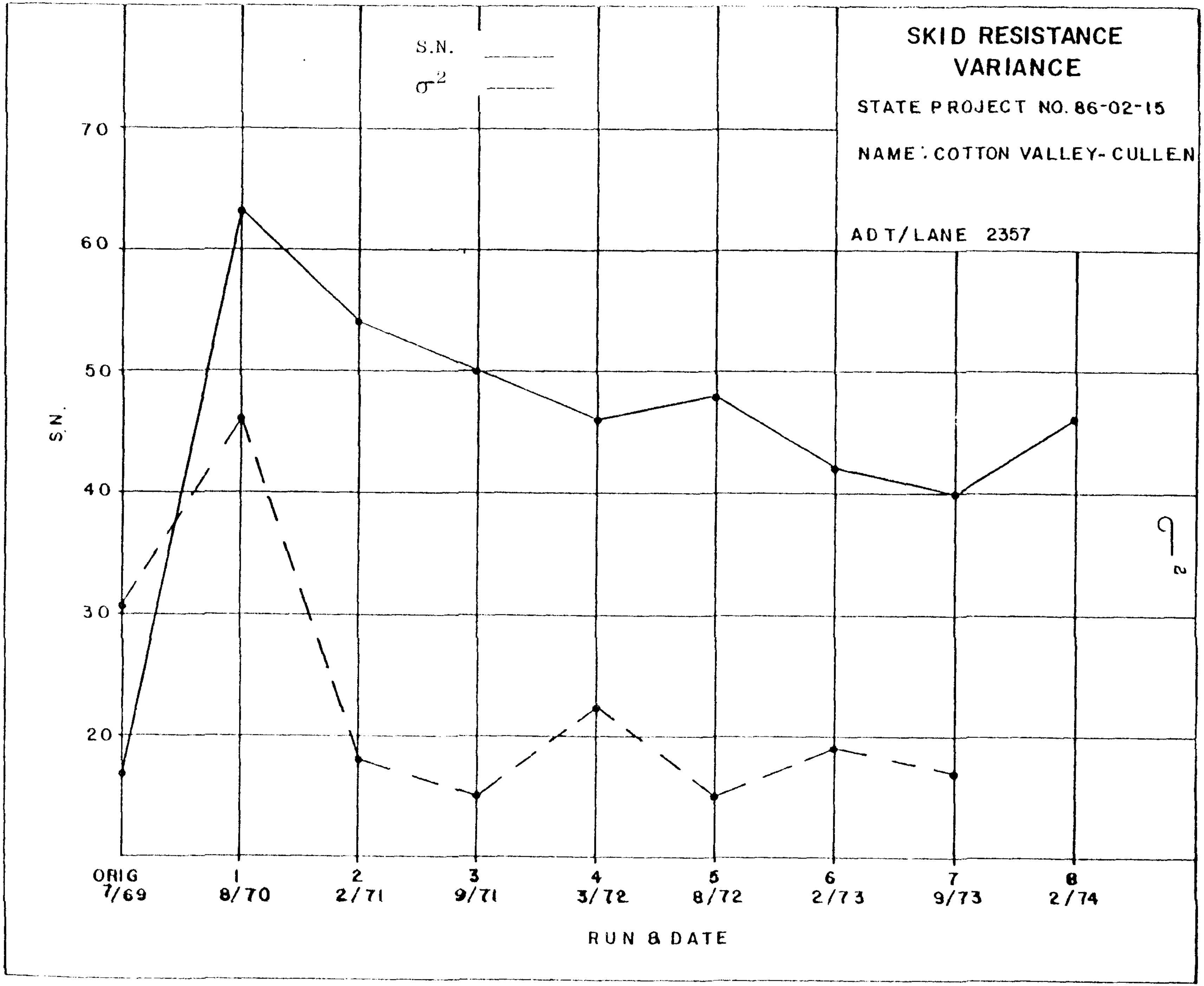

2 CYCLES X 28 DIVISIONS
VEHICLES X 10^6
SKID RESISTANCE VS. TRAFFIC
STATE PROJECT NO. 50-06-37 & 50-07-28
NAME: PLAQUEMINE - PORT ALLEN
ADT/LANE 2195
S.N.40 X 10
O VEHICLES

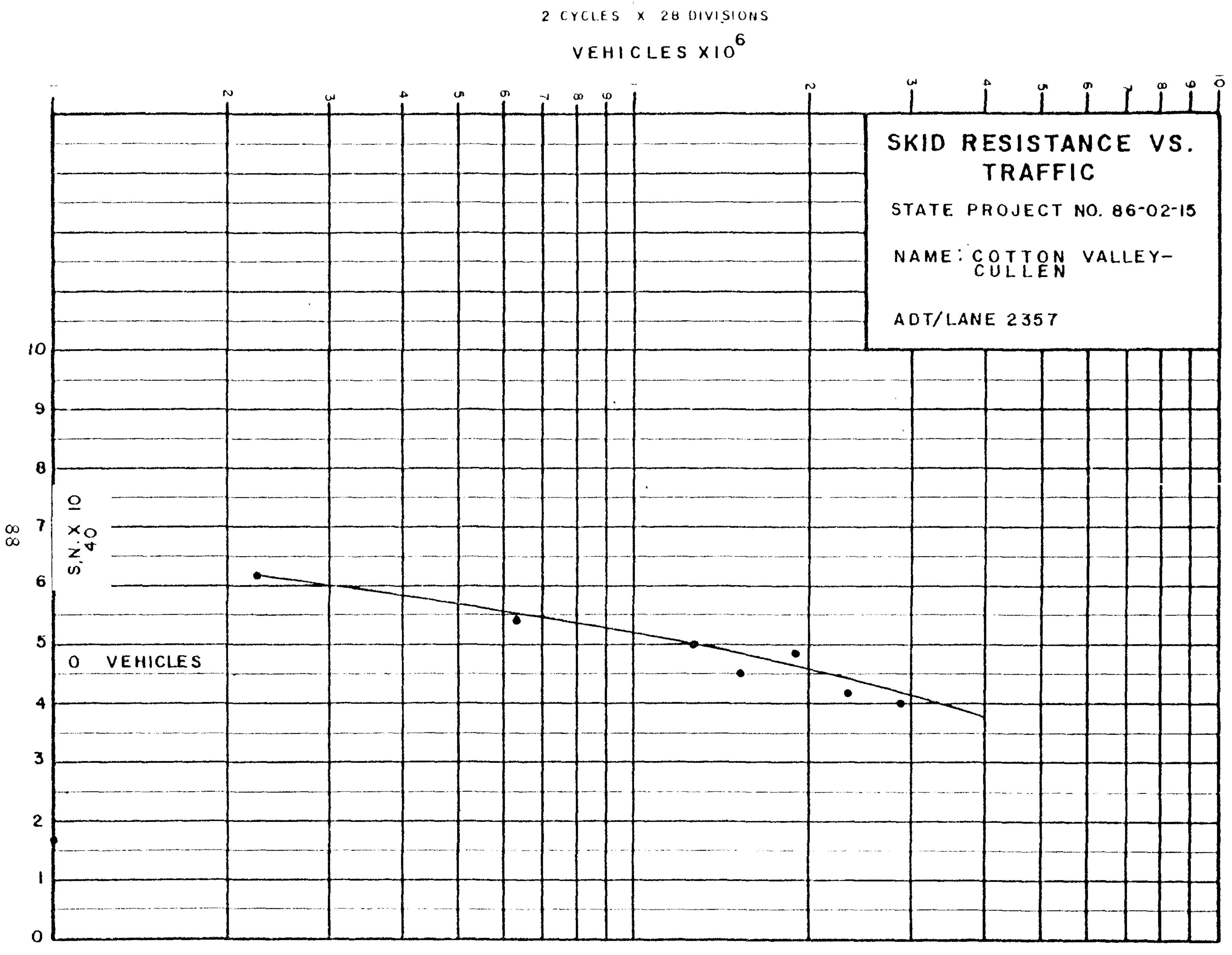

SKID RESISTANCE VARIANCE
STATE PROJECT NO.53-03-22
NAME: CLOUTIERVILLE - MONET FERRY
ADT/LANE 1719
S.N.
σ²
SN
70
60
50
40
30
20
20.0
15.0
10.0
5.0
σ²
ORIG. 7/69
1 12/69
2 8/70
3 2/71
4 9/71
5 3/72
6 8/72
7 2/73
8 11/73
9 2/74
RUN & DATE

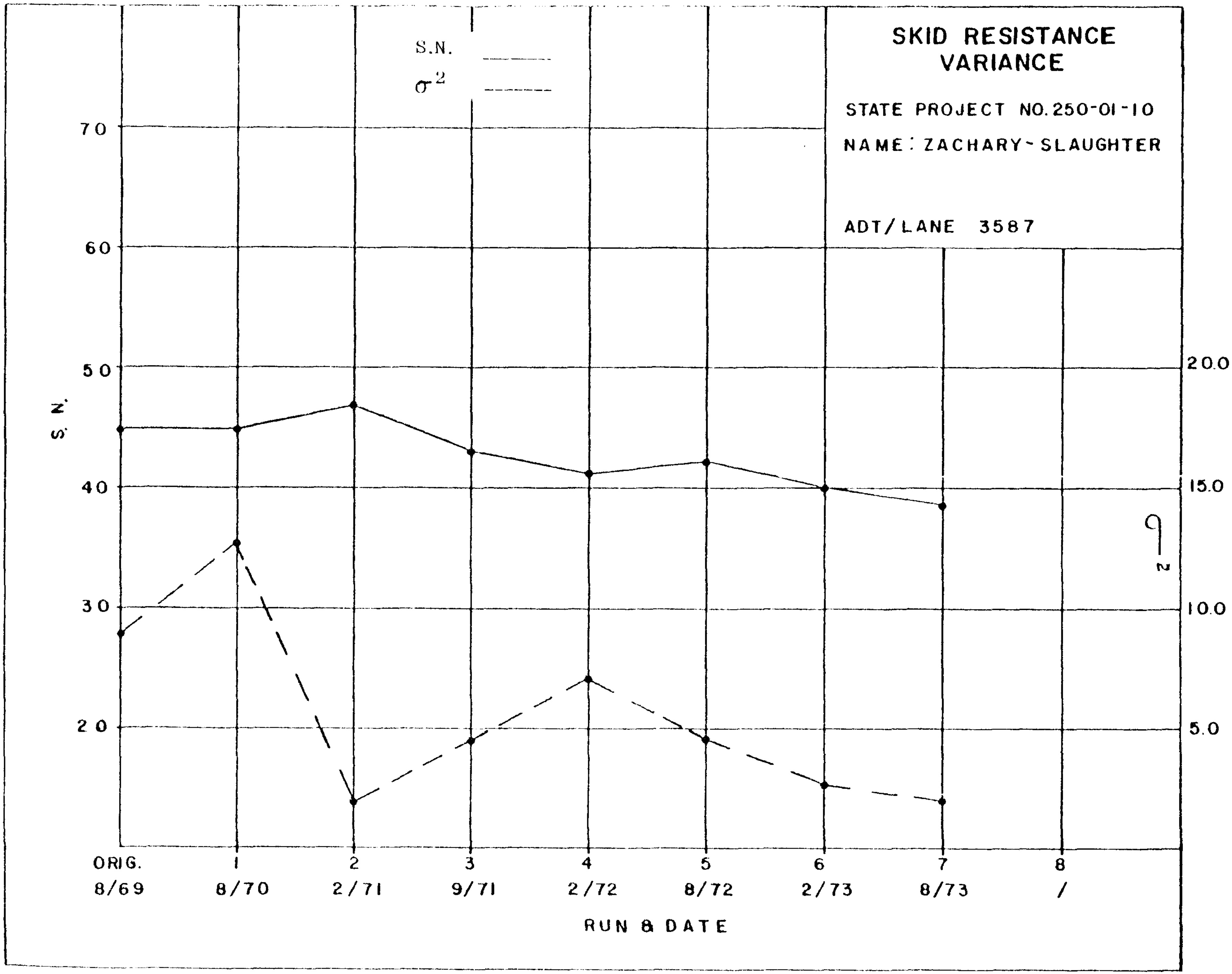

2 CYCLES X 28 DIVISIONS
VEHICLES X 10^6
SKID RESISTANCE VS. TRAFFIC
STATE PROJECT NO. 53-03-22
NAME: CLOUTIERVILLE-MONET FERRY
ADT/LANE 1719
S.N. X 10
40
0 VEHICLES

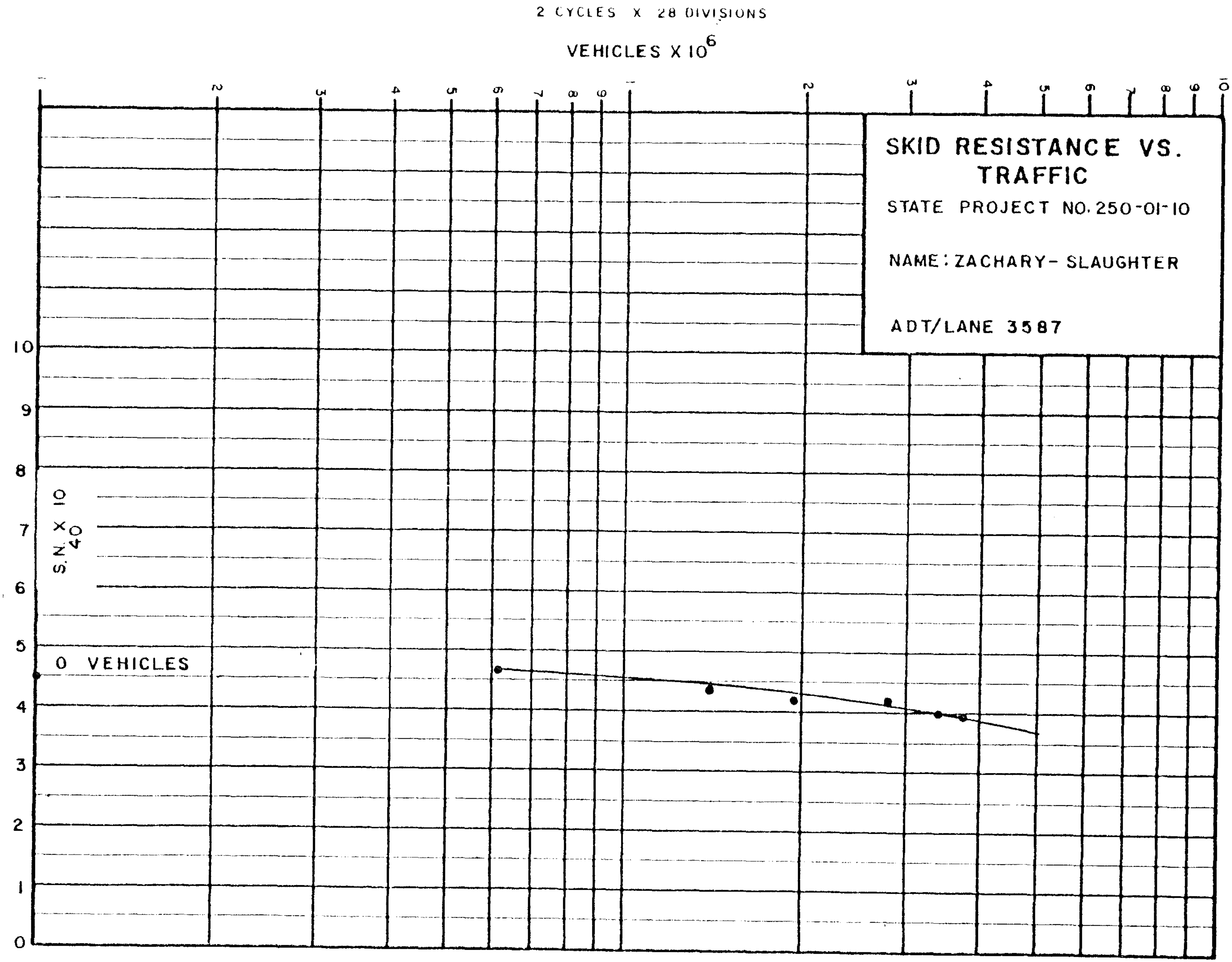

SKID RESISTANCE VARIANCE
STATE PROJECT NO. 62-02-42 & 62-03-09
NAME: IRONTON-JUNIOR
ADT/LANE 3825
S.N.
σ²
70
60
50
40
30
20
20.0
15.0
10.0
5.0
ORIG. 8/69
1 8/70
2 2/71
3 9/71
4 2/72
5 8/72
6 2/73
7 8/73
8 2/74
RUN & DATE

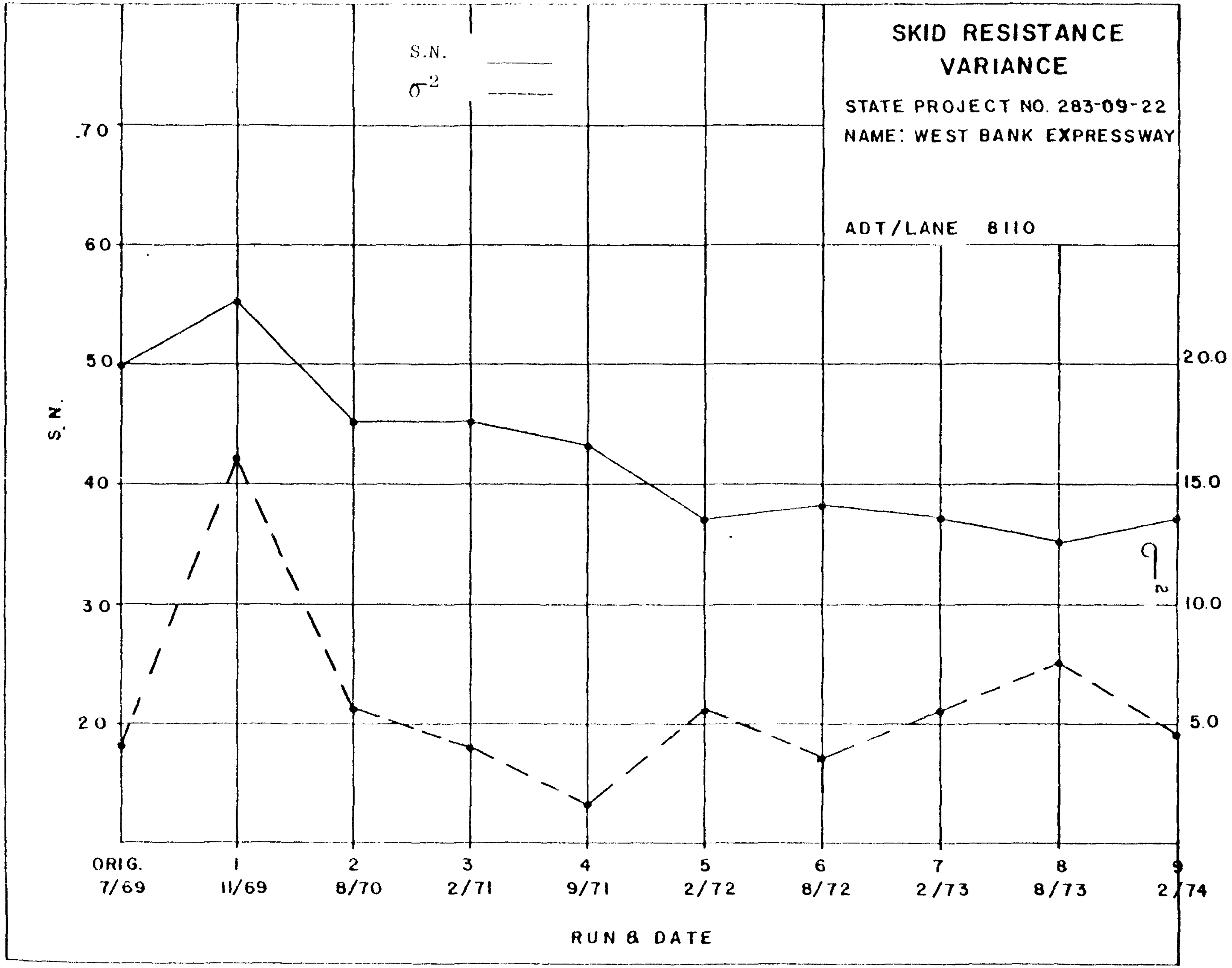

2 CYCLES X 28 DIVISIONS
VEHICLES X 10^6
SKID RESISTANCE VS. TRAFFIC
STATE PROJECT NO. 62-02-42 & 62-03-09
NAME: IRONTON-JUNIOR
ADT/LANE 3825
S.N. X 10
40
0 VEHICLES

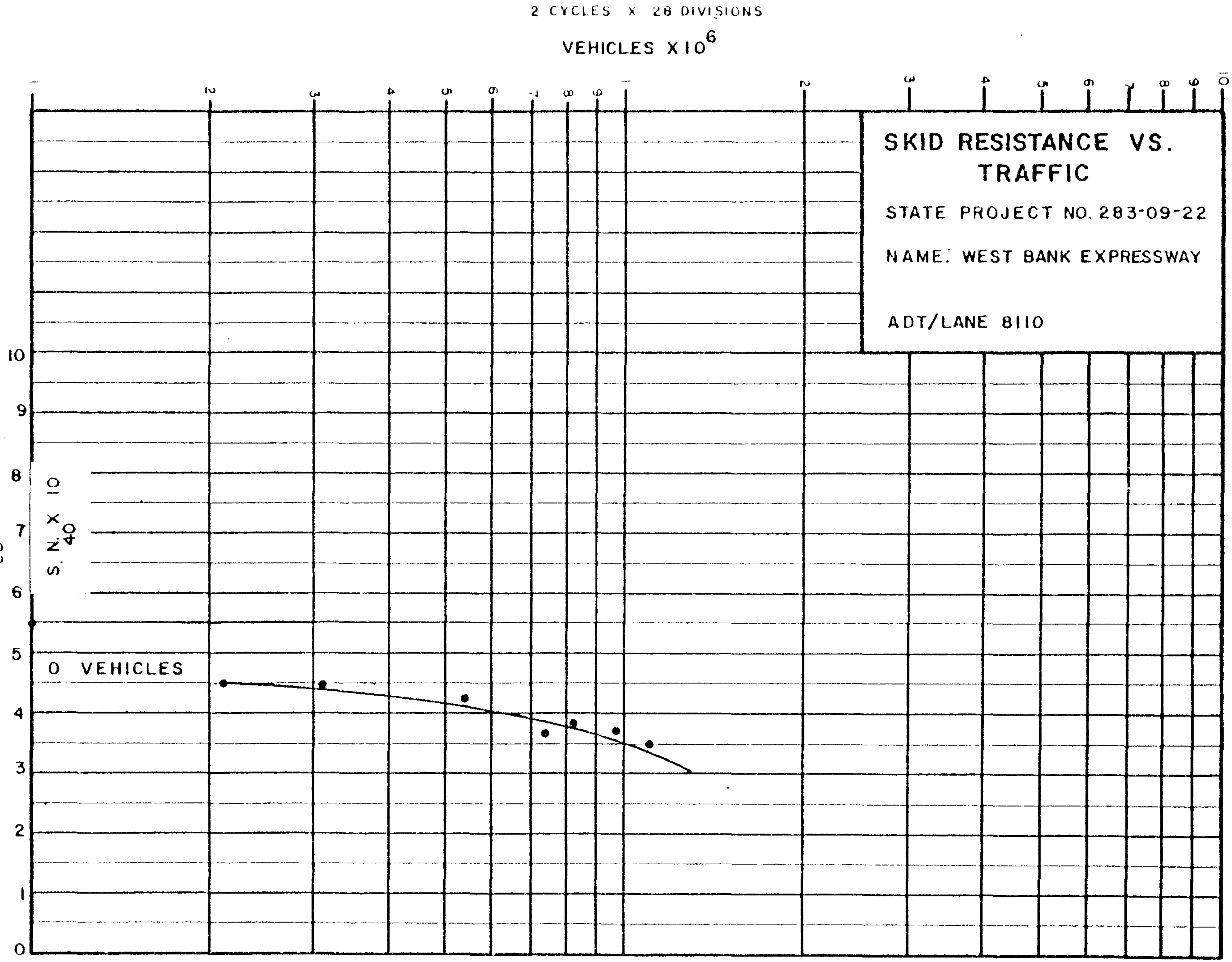

SKID RESISTANCE
VARIANCE
STATE PROJECT NO. 86-02-15
NAME: COTTON VALLEY-CULLEN
ADT/LANE 2357
S.N.
σ^2
70
60
50
40
30
20
S.N.
20.0
15.0
10.0
5.0
σ^2
ORIG 7/69
1 8/70
2 2/71
3 9/71
4 3/72
5 8/72
6 2/73
7 9/73
8 2/74
RUN & DATE


2 CYCLES X 28 DIVISIONS
VEHICLES X10^6
SKID RESISTANCE VS. TRAFFIC
STATE PROJECT NO. 86-02-15
NAME: COTTON VALLEY-CULLEN
ADT/LANE 2357
S.N. X 10
40
0 VEHICLES


SKID RESISTANCE VARIANCE
STATE PROJECT NO. 250-01-10
NAME: ZACHARY - SLAUGHTER
ADT/LANE 3587
S.N.
σ²
S.N.
70
60
50
40
30
20
20.0
15.0
10.0
5.0
ORIG. 8/69
1 8/70
2 2/71
3 9/71
4 2/72
5 8/72
6 2/73
7 8/73
8 /
RUN & DATE


2 CYCLES X 28 DIVISIONS
VEHICLES X 10^6
SKID RESISTANCE VS. TRAFFIC
STATE PROJECT NO. 250-01-10
NAME: ZACHARY- SLAUGHTER
ADT/LANE 3587
S.N. X 10/40
0 VEHICLES


SKID RESISTANCE
VARIANCE
STATE PROJECT NO. 283-09-22
NAME: WEST BANK EXPRESSWAY
ADT/LANE 8110
S.N.
σ^2
S.N.
.70
60
50
40
30
20
20.0
15.0
10.0
5.0
ORIG. 7/69
1 11/69
2 8/70
3 2/71
4 9/71
5 2/72
6 8/72
7 2/73
8 8/73
9 2/74
RUN & DATE


2 CYCLES X 28 DIVISIONS
VEHICLES X 10^6
SKID RESISTANCE VS. TRAFFIC
STATE PROJECT NO. 283-09-22
NAME: WEST BANK EXPRESSWAY
ADT/LANE 8110
S.N.40 X 10
0 VEHICLES
1
2
3
4
5
6
7
8
9
10