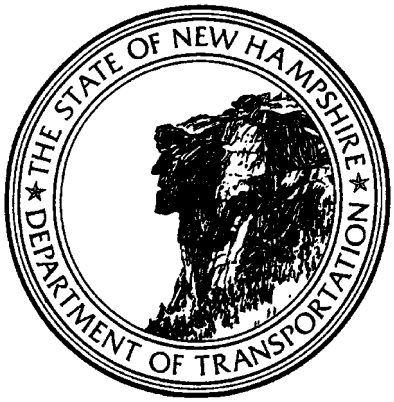

NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION
RIDE QUALITY STUDY

1995

Bureau of Materials & Research
PO Box 483, 11 Stickney Avenue
Concord, NH 03302-0483
Tel: (603) 271-1660

NH RIDE QUALITY STUDY

INTRODUCTION

The State of New Hampshire Department of Transportation performed a study in 1995 to investigate the relationship between the measured ride quality of bituminous pavements and the public perception of ride. The project involved the use of a panel to subjectively evaluate the ride quality of thirty-four bituminous pavement test sites. These same sites were then tested by the Department's KJLaw T6500 Profilometer. Results obtained by the Profilometer were compared and correlated to the average ride quality rating (MPR) from the panel.

OBJECTIVES

The research objectives of the project were:

- Verify the correlation between measured ride quality and the motoring public's perception of ride quality on New Hampshire roads.
- Determine the ride quality of a variety of roadway segments to assist in the development of pay limits for the Department's QC/QA specification for bituminous pavements.
- Build confidence in the data collected by the Profilometer and document results.

PROCEDURES

Procedures set up for the National Cooperative Highway Research Program (NCHRP) and documented in NCHRP Report 308 were followed. Thirty-four test sites were ridden over a two-day period by forty panel members. Profilometer data were collected over the following two-day period.

The test sites were comprised of 13 interstate, 5 primary and 16 secondary roadway segments. Test speeds were between 30 and 60 MPH. Test lengths were varied to provide a 25-second evaluation period at each site.

All panel members were driven over the sites in like vehicles with similar mileage. The drivers notified the raters of the start and stop points of each site. The speeds of the vehicles were consistent with each other.

Panel members were given a rater form for each test site. The form included a graduated scale from 0 (impassable) to 5 (perfect). (Neither end of the scale is obtainable in reality). Each panel member was asked to subjectively rate the ride quality of each test site. Completed forms were collected prior to arrival at each subsequent site.

The profilometer collected and reported ride quality data in terms of Ride Number, an index developed by NCHRP which is also based on a scale of 0 to 5. International Roughness Index (IRI) data were also calculated from the same profiles used to

determine Ride Number. The IRI data were then converted to a 0 to 5 scale by performing a linear regression of the Ride Number and IRI data sets. Both Ride Number and IRI results were correlated to the mean panel rating (MPR) at each site.

SUMMARY OF RESULTS

The Ride Number data correlated to the MPR's with a correlation coefficient of 0.97 and a standard error of 0.25. The IRI data correlated to the MPR's with a correlation coefficient of 0.92 and a standard error of 0.41. These results compare favorably with the findings of a previous study performed for the Ohio Department of Transportation by Spangler & Kelly.

CONCLUSIONS

The results of this study indicate that the New Hampshire Department of Transportation's KJLAW T6500 Profilometer correlates with subjective Mean Panel Ratings on New Hampshire roads. The Ride Number index correlated more closely than the International Roughness Index.

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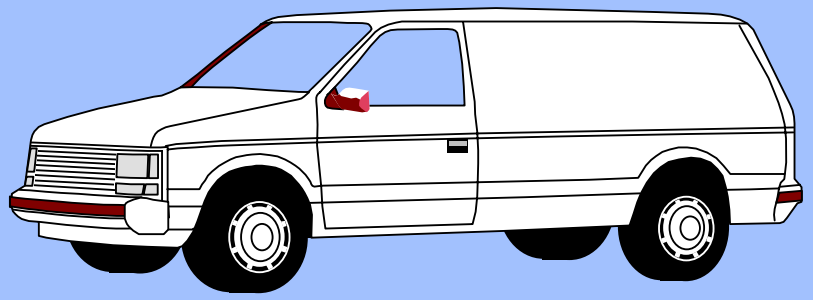
NHDOT Ride Quality Study

- **Background-QC/QA Specification for Asphalt Pavements**
- **Ride Quality**
- **Ride Number**
- **Correlation Between Measured Ride Quality and Public Perception of Ride**



NHDOT QC/QA Specification Asphalt Pavements

- **5 Year “Phased In” Schedule - Begin 1994**
- **Based on Random Sampling and Statistical Analysis**
- **Contractor’s Payment Based on Measured Quality of Pavement**
- **Bonus/Penalty Provisions**

QA Properties Measured for Payment

- **Gradation & Asphalt Cement Content**
- **Air Voids**
- **Pavement Thickness**
- **AC Viscosity**
- **Ride Quality**

RIDE QUALITY

- **Early 1993 - NHDOT Began Researching the State of the Art in Pavement Smoothness Measuring Devices**
- **Summer 1993 - Conducted Field Tests of Several Van-Based Profilers**
- **Winter 1993-94 - Ordered KJLaw T6500 Road Surveyor Profilometer**
- **Fall 1994 - Profilometer Delivered**

KJLaw T6500 Road Surveyor Profilometer

- **Based on GM Profiling Technology**
- **Utilizes Infrared Sensors and Accelerometers to Measure Road Profile**
- **In Addition to IRI, Calculates Ride Quality in Terms of "RIDE NUMBER"**

RIDE NUMBER

- **Developed under NCHRP Project 1-23 and 1-23(2) (NCHRP Reports 275 and 308) based on Subjective Panel Ratings**
- **Found by Spangler and Kelly to Have Closest Correlation to Subjective Panel Ratings when Compared to 4 Other Ride Indices.**
- **Currently in ASTM Balloting Process**

GOALS OF NHDOT RIDE QUALITY EXPERIMENT

- **Verify the Correlation Between Measured Ride Quality (Ride Number) and the Motoring Public's Perception of Ride Quality on New Hampshire Roads**
- **Determine the Ride Quality of a Variety of Roadway Segments to Assist in the Development of Specification Limits**
- **Build Confidence and Document Results**

TEST PROCEDURES

- **Follow Procedures Set up for NCHRP and Documented in Report 308.**
- **36 Test Sites**
- **40 Panel Members**
- **All Sites Ridden Over a 2-Day Period**
- **Profilometer Data Collected Over the Following 2-Day Period**

TEST SITES

NHDOT RIDE QUALITY STUDY

13 INTERSTATE

5 PRIMARY

16 SECONDARY

TEST SPEEDS 30 to 60 MPH

TEST SECTION LENGTHS VARIED TO

PROVIDE 25-SECOND EVALUATION PERIOD AT EACH SITE

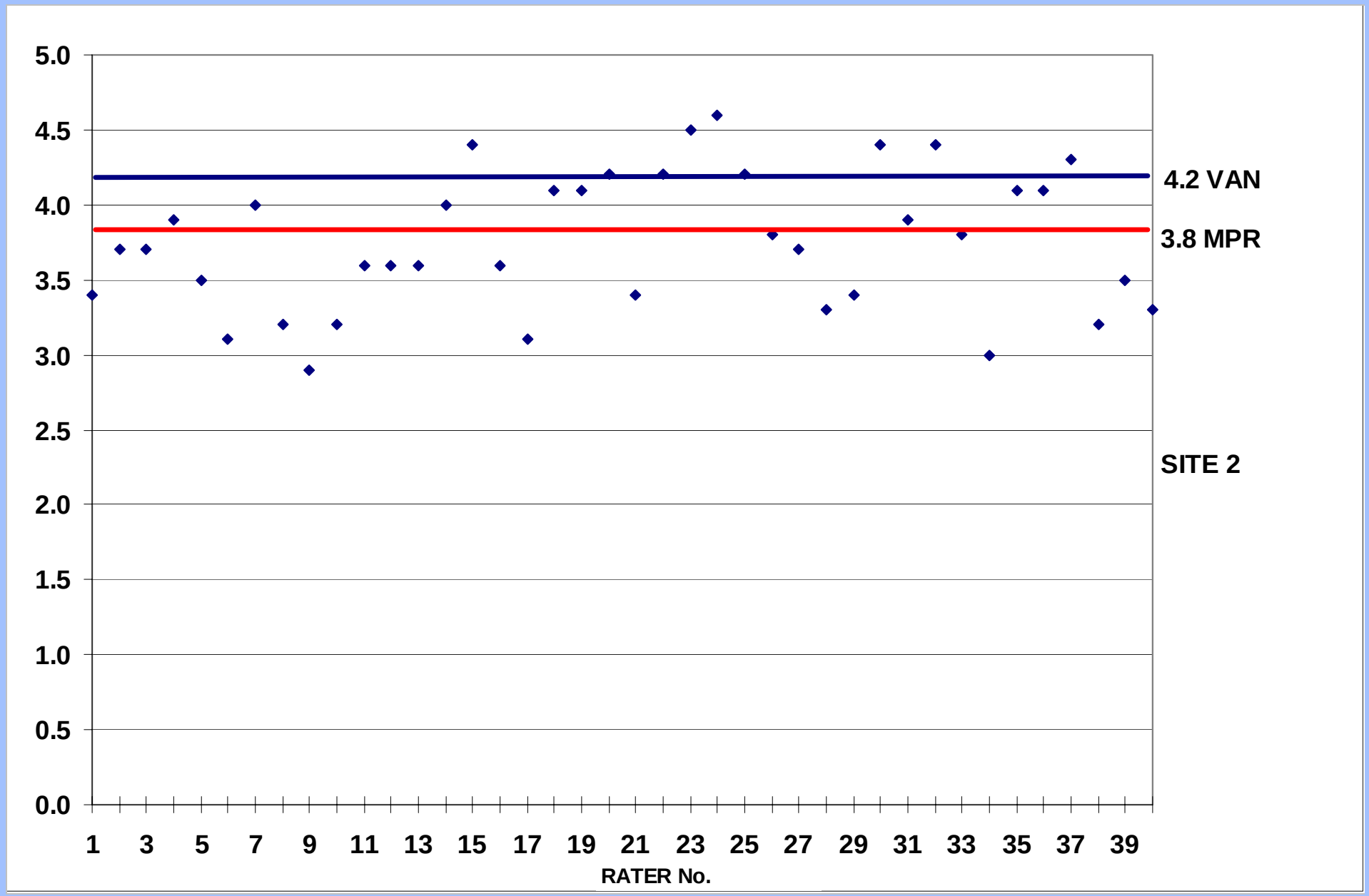
NHDOT RIDE QUALITY EXPERIMENT
RATER FORM

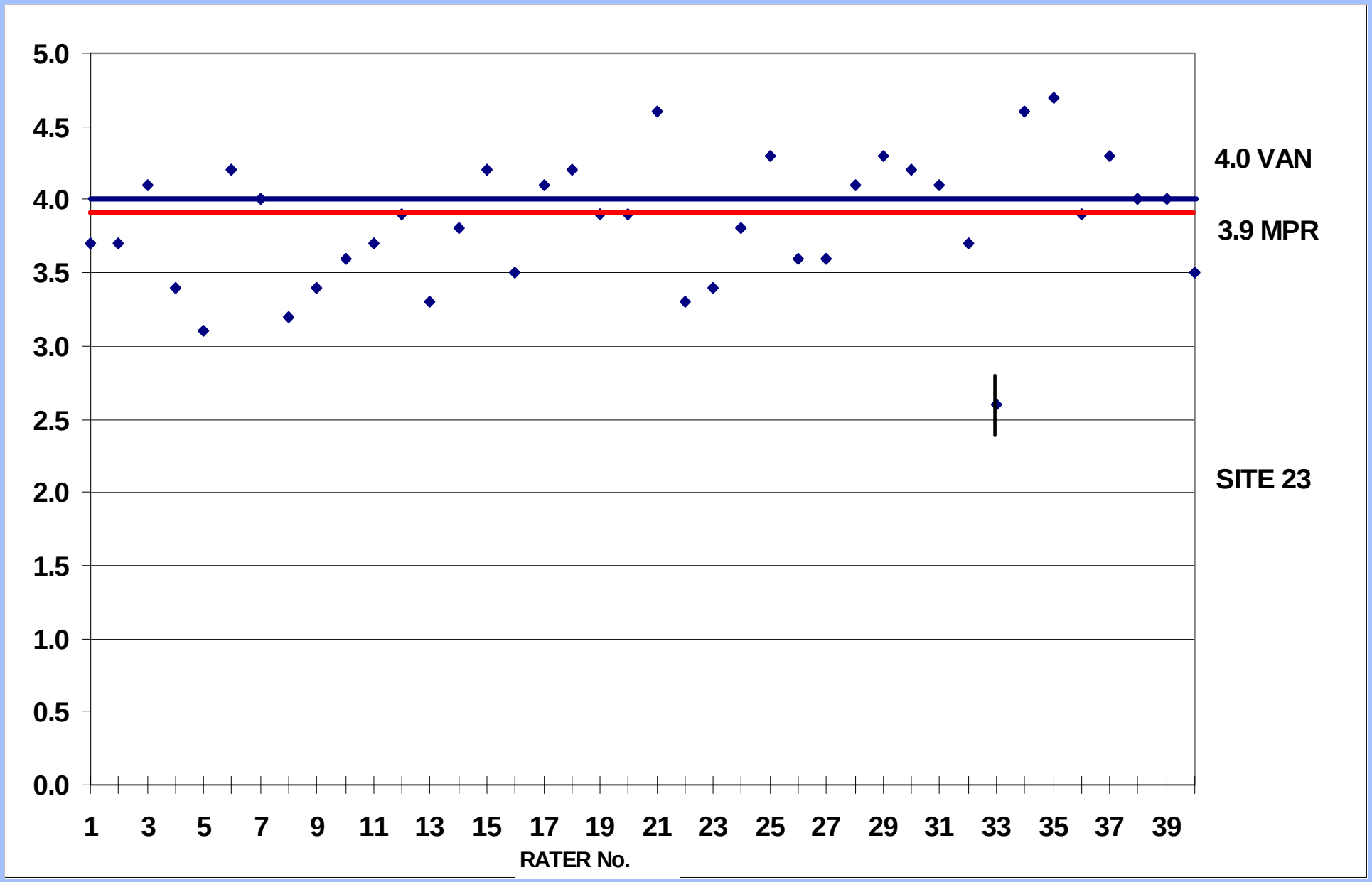
☐ Ride quality does not need improvement

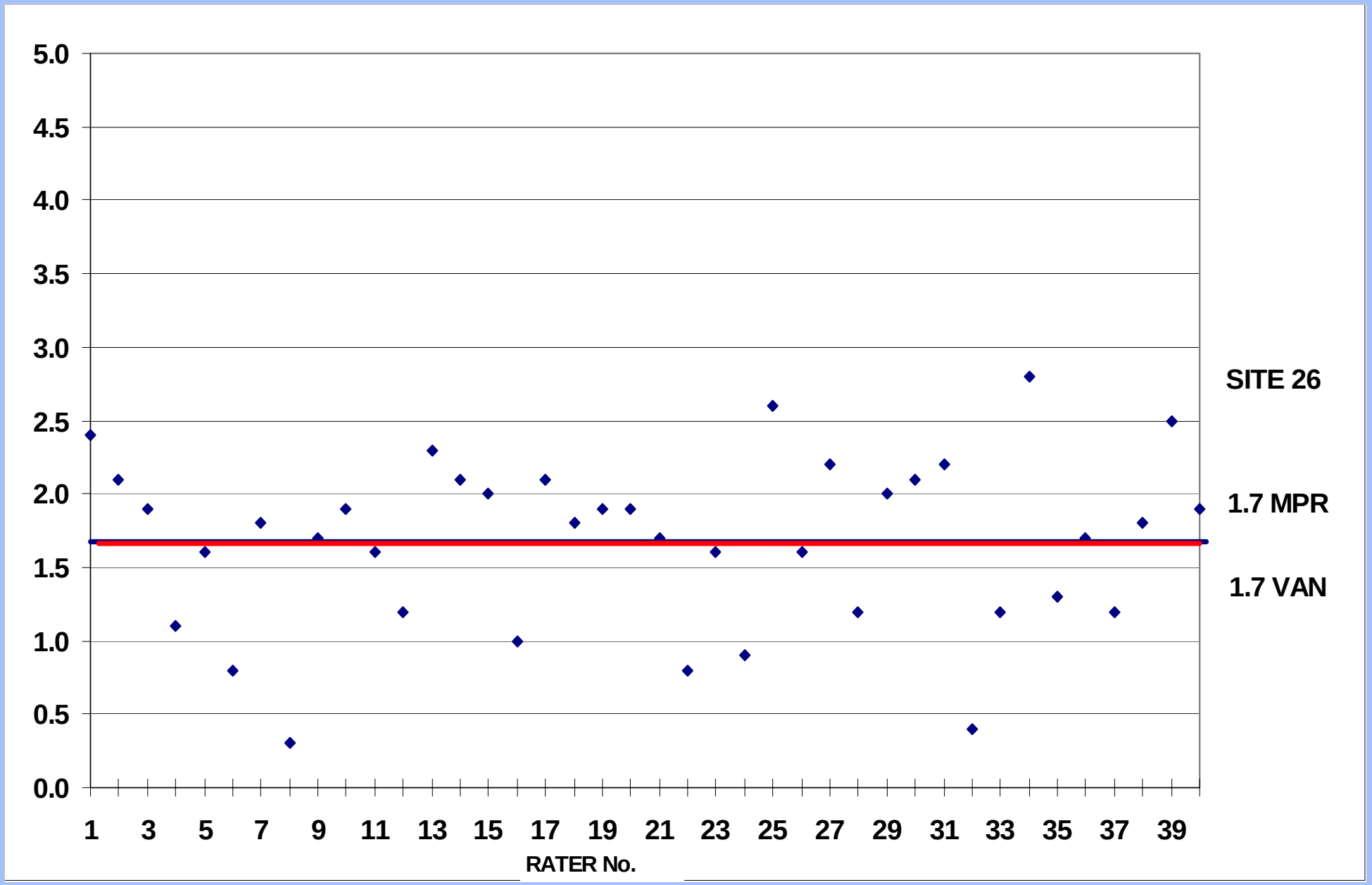
☐ Ride quality needs improvement

SPANGLER & KELLY

INDEX	CORREL. COEFF.	EST. ERROR
Ride Number	0.95	0.27
Mich. RQI	0.80	0.53
Texas SI	0.92	0.41
Mays RM	0.92	0.37
IRI	0.91	0.40


5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
RATER No.
4.2 VAN
3.8 MPR
SITE 2


5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
RATER No.
4.0 VAN
3.9 MPR
SITE 23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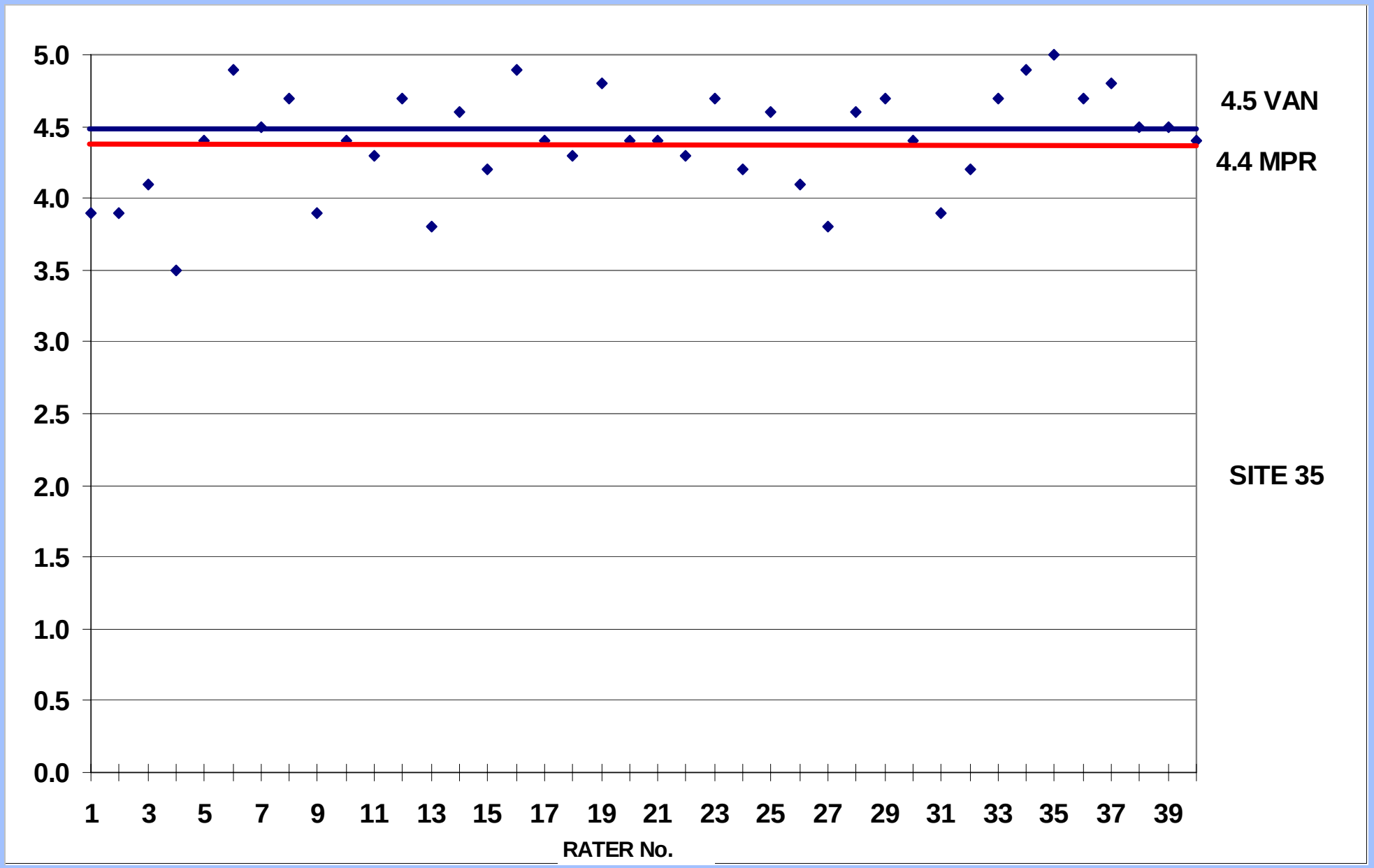
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39
RATER No.
SITE 26
1.7 MPR
1.7 VAN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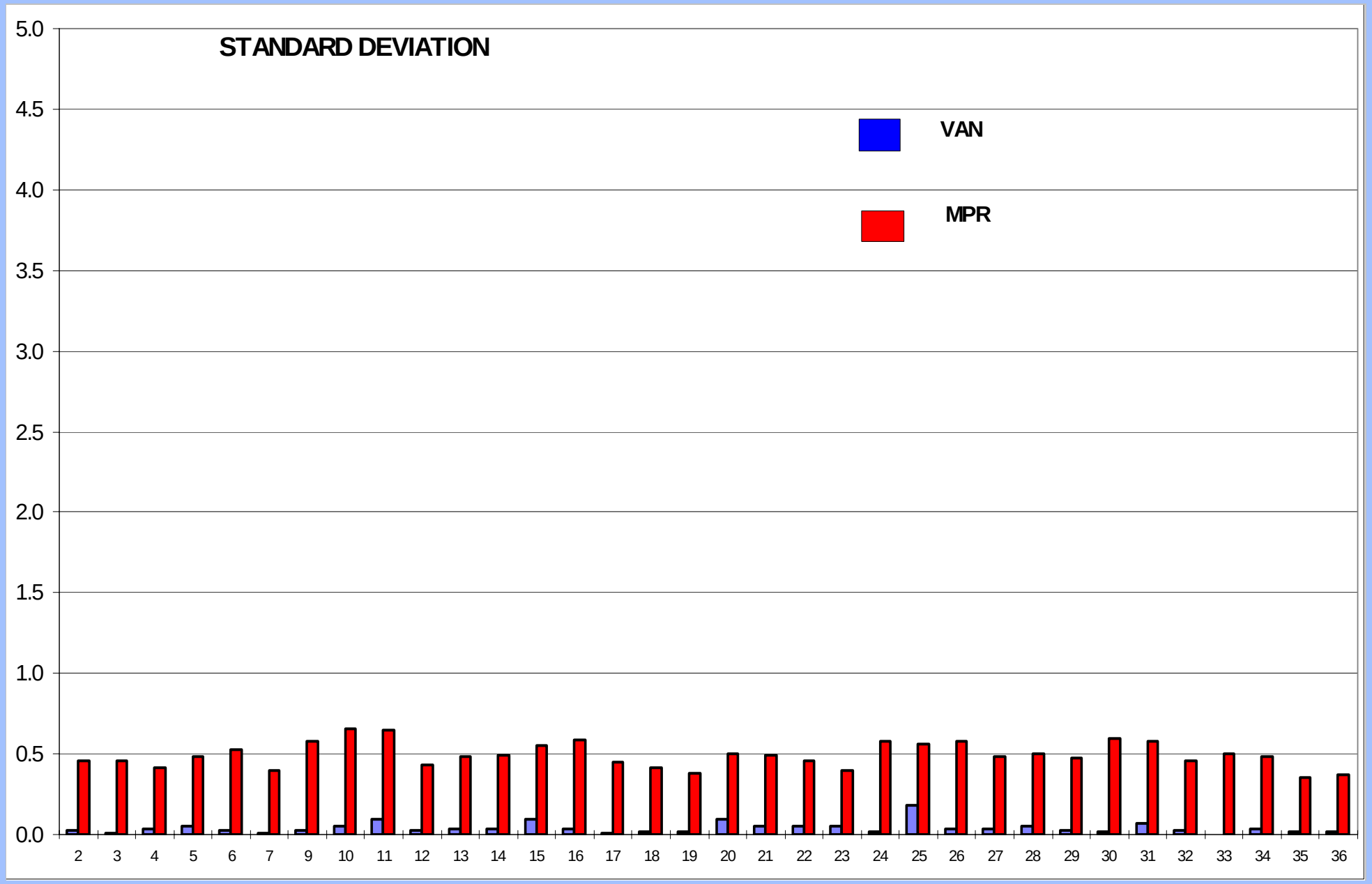
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39
RATER No.
4.5 VAN
4.4 MPR
SITE 35


STANDARD DEVIATION
VAN
MPR
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2
3
4
5
6
7
9
10
11
12
13
14
15
16
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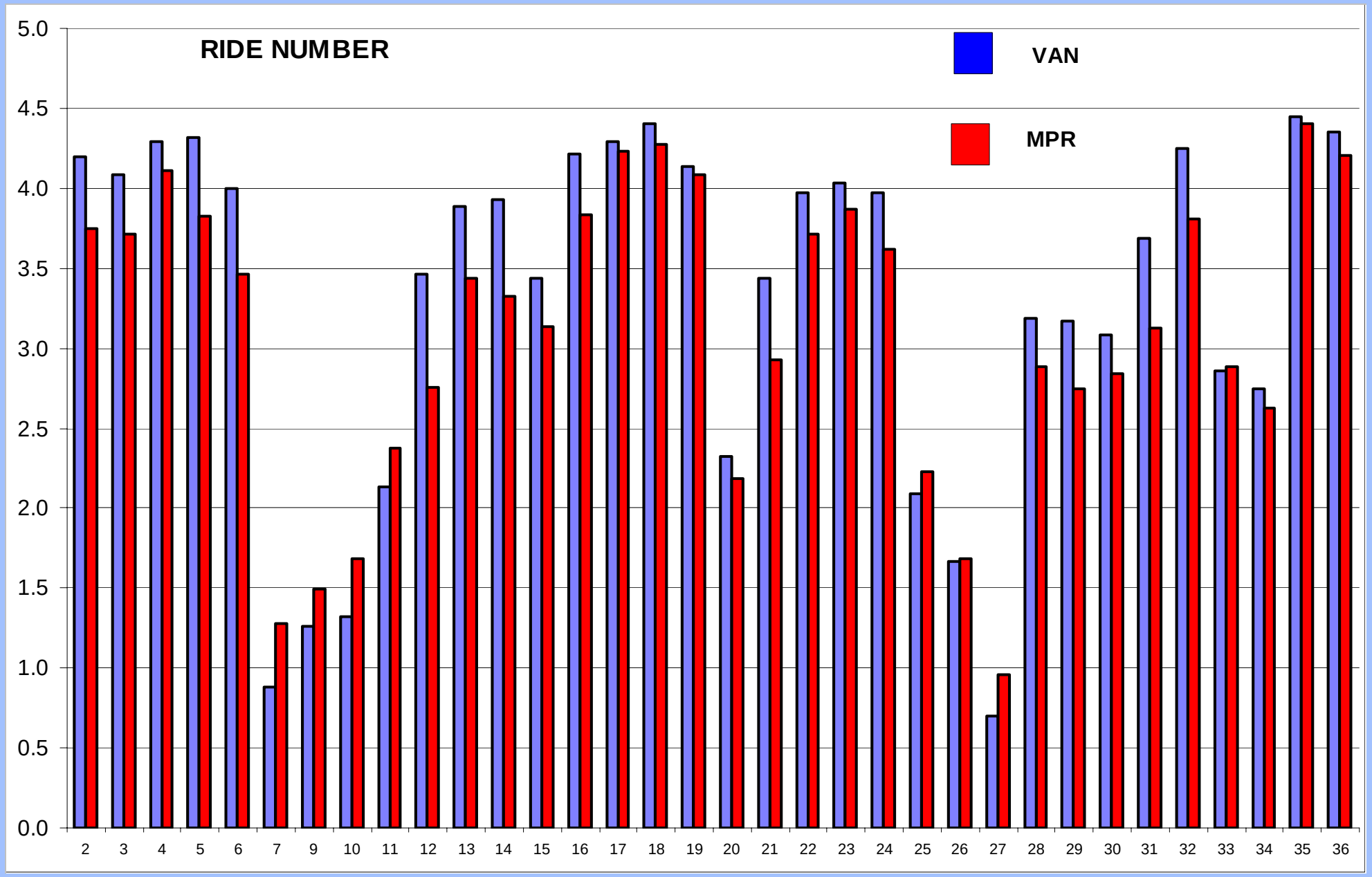
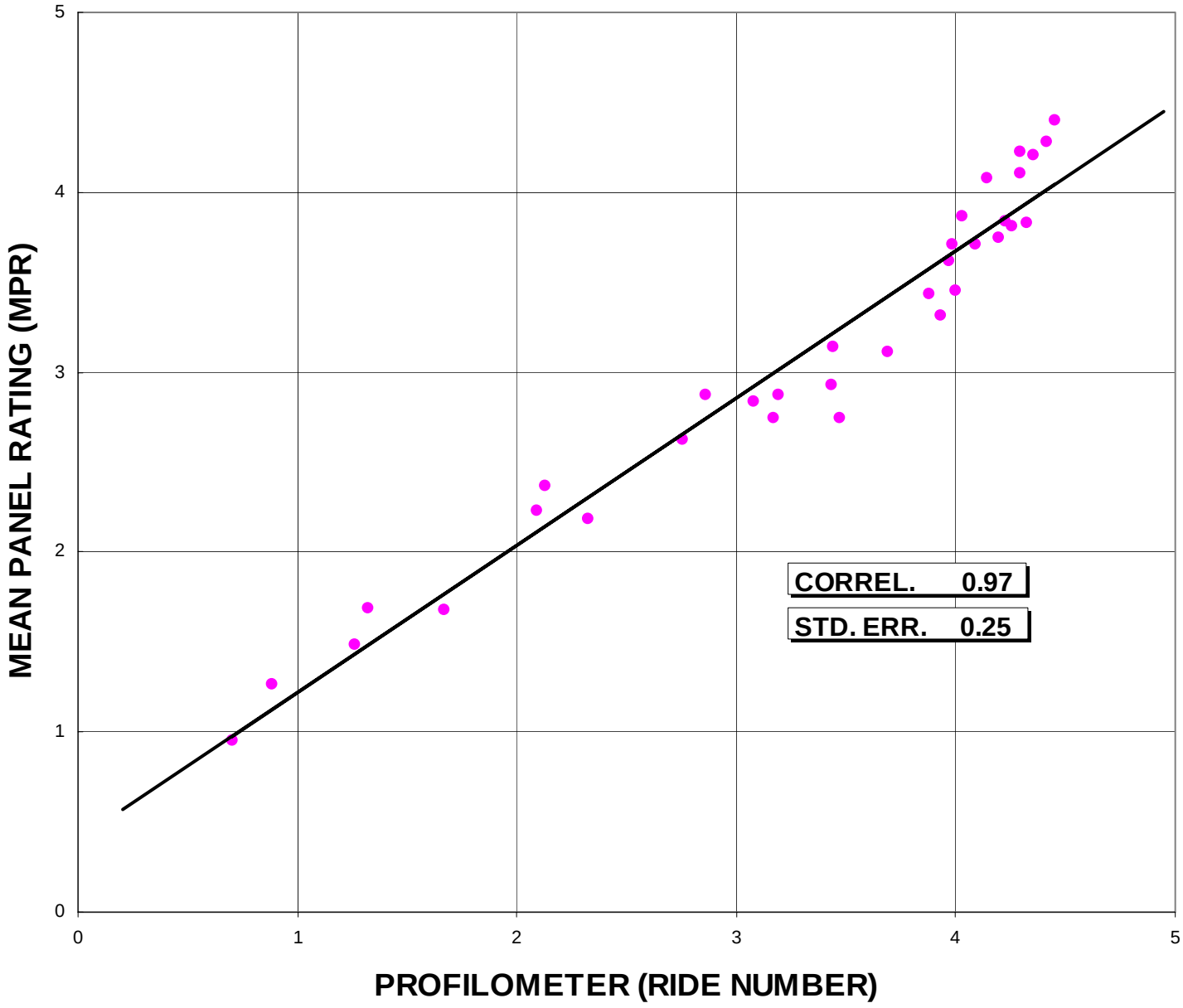
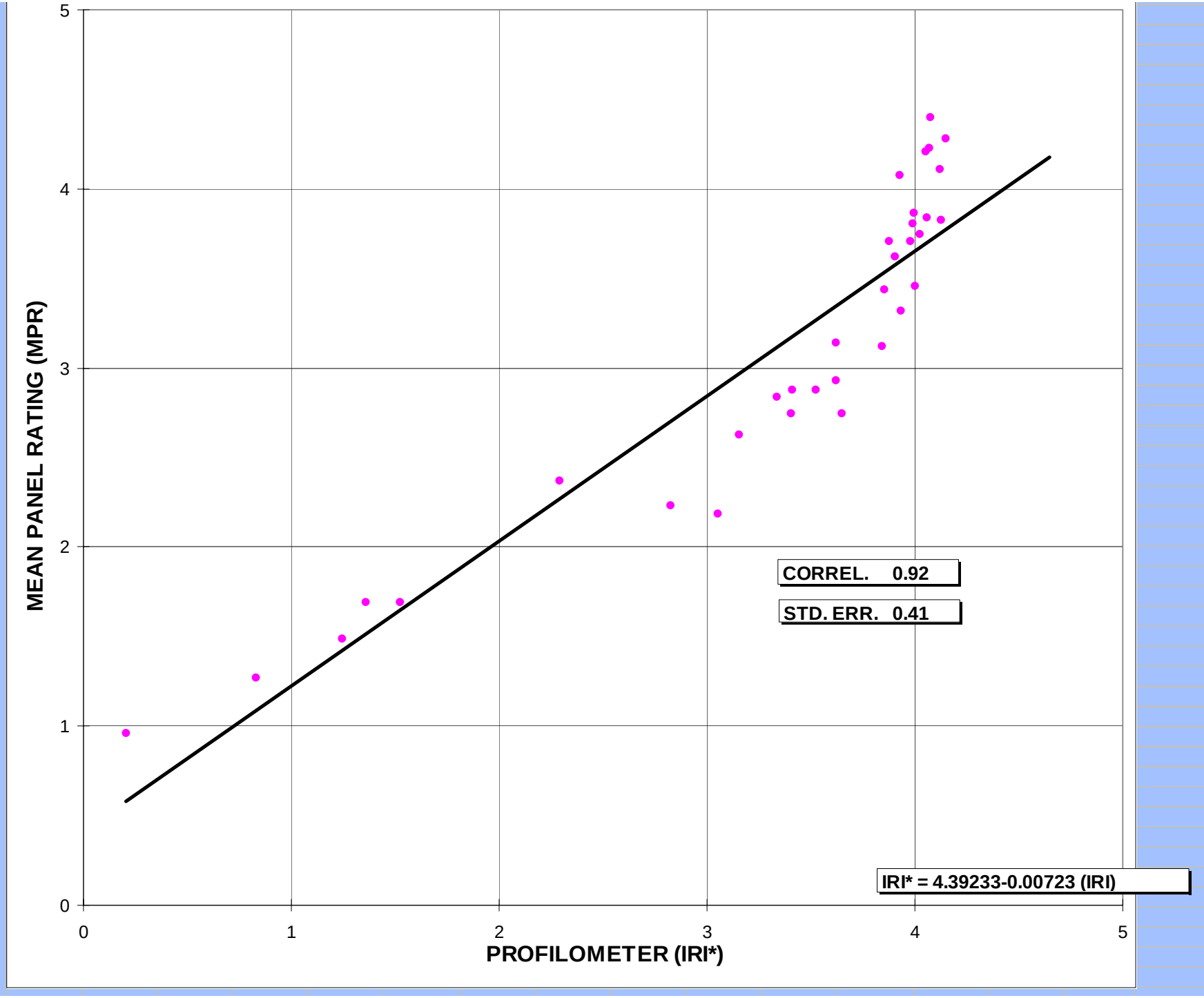
34
35
36


RIDE NUMBER
VAN
MPR
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2 3 4 5 6 7 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36


MEAN PANEL RATING (MPR)
PROFILOMETER (RIDE NUMBER)
0
1
2
3
4
5
CORREL. 0.97
STD. ERR. 0.25


MEAN PANEL RATING (MPR)
PROFILOMETER (IRI*)
0
1
2
3
4
5
CORREL. 0.92
STD. ERR. 0.41
IRI* = 4.39233-0.00723 (IRI)

EXAMPLES of PROJECTS

I 93 SANBORNTON-NEW HAMPTON

FULL RECLAMATION

AVERAGE 4.13

STD. DEVIATION .134

EXAMPLES of PROJECTS

NH 111 WINDHAM-HUDSON

PARTIAL RECLAMATION

AVERAGE 3.93

STD. DEVIATION .205

EXAMPLES of PROJECTS

NH 112 LIVERMORE

CHIPSEAL

AVERAGE 2.26

STD. DEVIATION .247

AFTER OVERLAY

AVERAGE 4.05

STD. DEVIATION .150

EXAMPLES of PROJECTS

DOVER POINT ROAD

3/8 PMST OVERLAY

AVERAGE 4.30

STD. DEVIATION .115

RIDE SMOOTHNESS

The price adjustment for ride smoothness per lot will be determined as follows.

$$PA = (PF - 1)(Q)(P)(0.40)$$

where:

PA = Price adjustment payment in dollars

PF = Pay factor based on statistical analysis on all sublots

Q = Quantity of the sum of all lots in tons

P = Contract unit price per ton

0.40 = Weight given to price adjustment for quality of ride smoothness

DOVER POINT ROAD

	EAST RUN NUMBER	WEST RUN NUMBER
528	3.15	3.68
1056	4.17	4.43
1584	4.18	4.38
2112	4.19	4.40
2640	4.26	4.39
3168	4.37	4.43
3696	4.23	4.28
4224	4.27	4.27
4752	4.16	4.36
5280	4.28	4.24
5808	4.02	4.33
6336	4.33	4.40
6864	4.29	4.37
7392	3.82	4.40
7920	4.41	4.40
8448	4.30	4.33
8976	4.18	4.36
9504	4.37	4.37
10032	4.33	4.27
10560	4.38	4.39
11088	4.35	3.97
11616	4.33	4.30
12144	4.16	4.34
12672	4.29	4.36
13200	4.25	4.31
13728	4.25	4.39
14256	4.25	4.41
14784	4.31	4.43
15312	4.32	4.40
15840	4.27	4.36
16368	4.28	4.40
16896	4.32	4.40
17424	4.28	4.04
17790	3.47	3.40
AVE.	4.25	4.30
STDEV	0.240	0.115
COUNT	68	64

PAY COMPUTATION FOR RES 12196 DOVER POINT ROAD

	WITH END JOINTS	WITHOUT END JOINTS
(+ OR -)		
USL	5.0	5.0
TARGET	4.3	4.3
LSL	4.0	4.0
COUNT N	68	64
MEAN X	4.25	4.30
STD DEV. S	0.240	0.115
QU (USL-X)/S	3.1	6.1
QL (X-LSL)/S	1.0	2.6
PU (TABLE 106-1)	100	100
PL (TABLE 106-1)	85	100
QUALITY LEVEL (PU+PL)-100	85	100
PAY FACTOR (TBL. 106-2)	0.97	1.05
PAY FACTOR COMPOSITE f ' FACTOR	1	1
PF * f '	0.97	1.05
CPF :	0.97	1.05
LOT SIZE	1308	1308
CONTRACT $/TON	$26.10	$26.10
PRICE ADJUSTMENT	($409.67)	$682.78

PAY COMPUTATION FOR RESURFACING 12196 DOVER POINT ROAD

CAN BE (+ OR -)	
USL = UPPER SPECIFICATION LIMIT	5.0
TARGET	4.3
LSL = LOWER SPECIFICATION LIMIT	4.0
NUMBER OF SUB-LOTS	64
AVERAGE RIDE NUMBER	4.30
STANDARD DEVIATION	0.115
QU = UPPER QUALITY INDEX (USL-X)/S	6.1
QL = LOWER QUALITY INDEX (X-LSL)/S	2.6
PU = % WITHIN UPPER LIMIT WHICH CORRESPONDS TO QU (TABLE 106-1)	100
PL = % WITHIN LOWER LIMIT WHICH CORRESPONDS TO QL (TABLE 106-1)	100
(PU+PL)-100	100
PAY FACTOR (TABLE 106-2)	1.05
LOT SIZE (TOTAL TONS USED)	1308
CONTRACT PRICE PER TON	$26.10
PRICE ADJUSTMENT	$682.78