Measuring Salt Retention

Center for Transportation
Research and Education

Final Report
March 2013

IOWA STATE UNIVERSITY
Institute for Transportation

Sponsored by
Iowa Department of Transportation
Federal Highway Administration
(InTrans Project 12-443)

About CTRE

The mission of the Center for Transportation Research and Education (CTRE) at Iowa State University is to develop and implement innovative methods, materials, and technologies for improving transportation efficiency, safety, and reliability while improving the learning environment of students, faculty, and staff in transportation-related fields.

Disclaimer Notice

Non-Discrimination Statement

Iowa Department of Transportation Statements

The preparation of this report was financed in part through funds provided by the Iowa Department of Transportation through its "Second Revised Agreement for the Management of Research Conducted by Iowa State University for the Iowa Department of Transportation" and its amendments.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.	
InTrans Project 12-443			
4. Title and Subtitle Measuring Salt Retention		**5. Report Date** March 2013 **6. Performing Organization Code**	
7. Author(s) Neal Hawkins, Omar Smadi, and Basak Aldemir Bektas		**8. Performing Organization Report No.** InTrans Project 12-443	
9. Performing Organization Name and Address Institute for Transportation Iowa State University 2711 South Loop Drive, Suite 4700 Ames, IA 50010-8664		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.**	
12. Sponsoring Organization Name and Address Iowa Department of Transportation 800 Lincoln Way Ames, IA 50010		**13. Type of Report and Period Covered** Final Report **14. Sponsoring Agency Code** SPR 90-00-RB02-013	
15. Supplementary Notes Visit www.intrans.iastate.edu for color pdfs of this and other research reports.			
16. Abstract This research developed and completed a field evaluation of salt distribution equipment. The evaluation provides a direct comparison of three different types of salt spreaders at three different truck speeds and brine rates. A rubber mat was divided into eight sample areas to measure the salt distribution across the lane by each variable combination. A total of 264 samples were processed and measured. These results will support future efforts to target areas of efficiencies specific to salt and brine delivery methods. These results support Iowa Department of Transportation efforts to progress winter maintenance efficiencies and ultimately motorist safety.			
17. Key Words brine rates—chute spreader—high-speed video—salt delivery methods—salt retention—salt spreader comparison—salt truck application speeds—winter road maintenance—zero-velocity spreader		**18. Distribution Statement** No restrictions.	
19. Security Classification (of this report) Unclassified.	**20. Security Classification (of this page)** Unclassified.	**21. No. of Pages** 33	**22. Price** NA

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

MEASURING SALT RETENTION

Final Report
March 2013

Principal Investigator
Neal Hawkins
Director
Center for Transportation Research and Education, Iowa State University

Co-Principal Investigators
Omar Smadi
Director
Roadway Infrastructure Management and Operations Systems, Iowa State University

Basak Aldemir Bektas
Research Scientist
Center for Transportation Research and Education, Iowa State University

Authors
Neal Hawkins, Omar Smadi, and Basak Aldemir Bektas

Sponsored by
the Iowa Department of Transportation and
the Federal Highway Administration
State Planning and Research Funding
(SPR 90-00-RB02-013)

Preparation of this report was financed in part
through funds provided by the Iowa Department of Transportation
through its research management agreement with the
Institute for Transportation
(InTrans Project 12-443)

A report from
Institute for Transportation
Iowa State University
2711 South Loop Drive, Suite 4700
Ames, IA 50010-8664
Phone: 515-294-8103 Fax: 515-294-0467
www.intrans.iastate.edu

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

The authors want to thank the dedicated professionals from the Iowa Department of Transportation Office of Maintenance for their sponsorship and contributions toward the completion of this research and the Federal Highway Administration for State Planning and Research (SPR) funding for this project. We also gratefully appreciate the support received from numerous district staff.

EXECUTIVE SUMMARY

This research developed and completed a field evaluation of salt distribution equipment. The three salt spreaders were compared in terms of the amount of salt delivered across the roadway.

Each spreader was evaluated at different speeds (20, 30, and 40 mph) and brine rates (10, 20, and 30 gal. per lane mile). A full-factorial experimental design was used to study the three variables distinctly at three levels with a total of 27 runs. Six additional runs with no brine at 25 and 40 mph for each spreader type were added at the request of a district staff person for comparative purposes and not as a comparative variable for this study. Overall, a total of 33 truck runs were completed.

To measure salt distribution laterally, a 3 x 24 ft wide rubber mat was installed to allow for the salt and brine to be removed from the mat after each run. The mat was segmented into eight 3 x 3 ft squares. All samples were labeled by run number, (identifying spreader, truck speed, and brine rate) and sample for each 3 x 3 ft square. The trucks followed a paint line on the roadway to travel over the mat at the same location each time.

A total of 264 samples were processed and measured. These results compare each spreader by total salt delivered, delivery by sample square on the mat, and the combinations of speed and brine rates.

These results will support future efforts to target areas of efficiencies specific to salt and brine delivery methods. These results support Iowa Department of Transportation efforts to progress winter maintenance efficiencies and ultimately motorist safety.

INTRODUCTION

The Iowa Department of Transportation (DOT) is addressing winter maintenance efficiency through a variety of activities. This project involves measuring and reporting the retention of salt and brine on the roadway as a result of using different salt spreaders, application speeds, and brine quantities.

OBJECTIVE

This research develops an evaluation methodology, directs the field collection effort and compliance, provides the laboratory facilities for the measurement and dehydration of samples, and documents the findings in a final report. Results from this study will support Iowa DOT efforts to progress winter maintenance efficiencies and ultimately motorist safety.

PROJECT METHODOLOGY

The project methodology included key components as described below.

Project Technical Advisory Committee (TAC)

The research team worked with Iowa DOT staff who served as the project TAC for input and feedback throughout the duration of the project. This included several work sessions to refine field collection procedures and a final meeting, held after the laboratory measurements were finalized, to discuss the results.

Study Methodology

The researchers worked with the TAC to develop an overall study methodology, which provided the organizational details to ensure a clear and efficient approach for all field collection and laboratory measurement activities.

In general, this project involved driving different salt spreading equipment over a rubber mat that allowed the deposited salt and brine to be collection and analyzed specific to lane position. The 3 ft long by 24 ft wide mat, shown in Figure 1, was divided into eight equal squares and each truck drove over the mat at the same location.

Each grid is identified by sample number, 1 through 8, and trucks drove over sample squares 4, 3, and 2 (which was about the width of the truck/spreader) each pass with sample square 4 being on the driver’s side. After each truck pass, the remaining salt and brine for each of the eight squares were removed, contained, and labeled.

Figure 1. Rubber mat used to capture salt by grid sample

Experimental Design

Thirty-three truck passes were made under different variable settings as shown in Table 1. The methodology included the number of passes per variable such as speed, equipment, and brine quantity, as well as labeling and measurement details. In addition, a high-speed video camera was used to record the salt distribution for each run. The variables within Table 1 are discussed below.

Table 1. Experimental design

Run Number	Salt Spreader Type	Salt Application Rate* (pounds per lane mile)	Brine Rate (gallons per lane mile)	Truck Speed (mph)
1	Zero Velocity	200	0	25
2	Zero Velocity	200	0	40
3	Zero Velocity	200	10	20
4	Zero Velocity	200	10	30
5	Zero Velocity	200	10	40
6	Zero Velocity	200	20	20
7	Zero Velocity	200	20	30
8	Zero Velocity	200	20	40
9	Zero Velocity	200	30	20
10	Zero Velocity	200	30	30
11	Zero Velocity	200	30	40
12	Standard	200	0	25
13	Standard	200	0	40
14	Standard	200	10	20
15	Standard	200	10	30
16	Standard	200	10	40
17	Standard	200	20	20
18	Standard	200	20	30
19	Standard	200	20	40
20	Standard	200	30	20
21	Standard	200	30	30
22	Standard	200	30	40
23	Chute	200	0	25
24	Chute	200	0	40
25	Chute	200	10	20
26	Chute	200	10	30
27	Chute	200	10	40
28	Chute	200	20	20
29	Chute	200	20	30
30	Chute	200	20	40
31	Chute	200	30	20
32	Chute	200	30	30
33	Chute	200	30	40

*Trucks could account for speed to maintain a constant rate of application.

Spreader Type

Three different salt spreaders were used for the evaluation. An image for each spreader is shown in Figure 2. Iowa DOT staff use the three spreaders routinely during winter maintenance operations. The same truck was used for the standard spreader and chute.

Figure 2. Salt spreaders evaluated (standard on the left, chute in the middle, and zero-velocity on the right)

Salt Application Rate

Each truck was calibrated to distribute salt at the rate of 200 lbs per lane mile. The trucks were equipped with a ground speed adjustment that accounted for the truck speed and either increased or decreased the salt delivery to maintain the constant application rate.

Brine Rate

Four different brine rates were used. A rate of zero indicated that the run was dry. For all other runs, 5 gallons per lane mile were applied directly on the salt at delivery and varying rates of 10, 20, and 30 gallons per lane mile were applied through a truck-width spray bar. Both trucks were expected to pre-wet the salt with brine; however, the truck with the chute and standard spreader had only water. The truck with the zero-velocity spreader did use brine for the pre-wetting.

Truck Speed

The primary truck speeds evaluated were at 20, 30, and 40 mph. Two additional runs were made for each spreader type at speeds of 25 and 40 mph under dry (no brine) conditions. These additional runs were at the request of a district staff person for comparative purposes and not as a comparative variable for this study.

Field Collection and Laboratory Measurement

On October 3, 2012, the research team and Iowa DOT staff conducted the field collection effort on a closed Iowa DOT weigh station roadway. As shown in Figure 3, the remaining salt was retrieved and labeled by run and grid number.

Figure 4 shows the position of the high-speed video camera and the process of cleaning the roadway area of salt after each run.

Figure 3. Salt sample collection per run and grid square

Figure 4. High-speed video camera position and clean up between truck passes

Laboratory Measurements

A total of 264 samples (33 runs with 8 grids per run) from the field evaluation were containerized and the water was removed using sublimation laboratory equipment. Following this, the samples were weighed with the results provided in Appendix A.

OBSERVATIONS

The project results by run and sample were presented to the project TAC along with a series of pivot tables, which show the amount of salt content by spreader type, brine rate, truck speed, and so forth. This discussion led to several observations including the following.

Spreader Type

Figure 5 shows that the chute spreader delivered the most salt followed by the zero-velocity and standard spreaders.

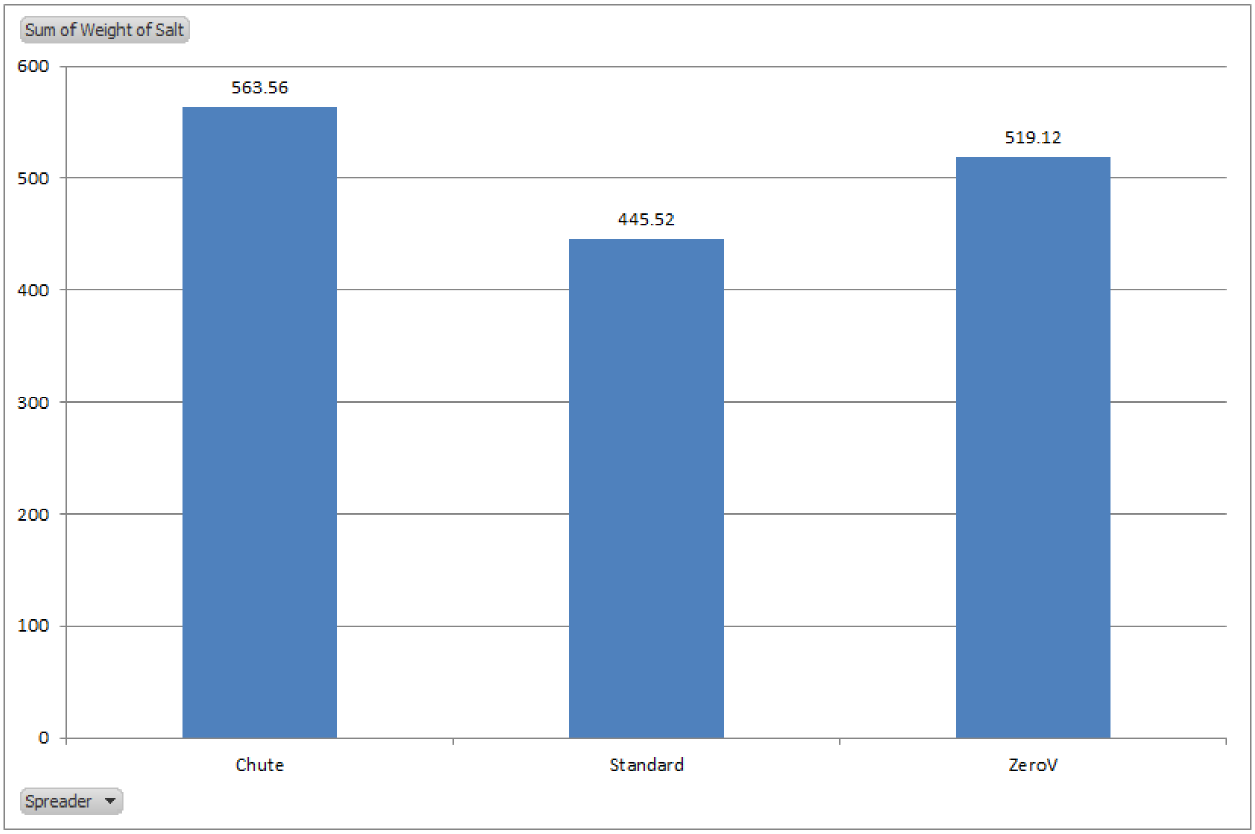


Figure 5. Salt (grams) by spreader type

Figure 6 shows the retained salt by sample number (or square) and spreader type. The distribution across a lane can be envisioned given that the truck driver side crosses sample square 4 and the passenger side crosses over sample square 2. As shown, the distribution pattern for the chute and zero-velocity spreaders resemble each other as opposed to the flatter pattern of the standard spreader.

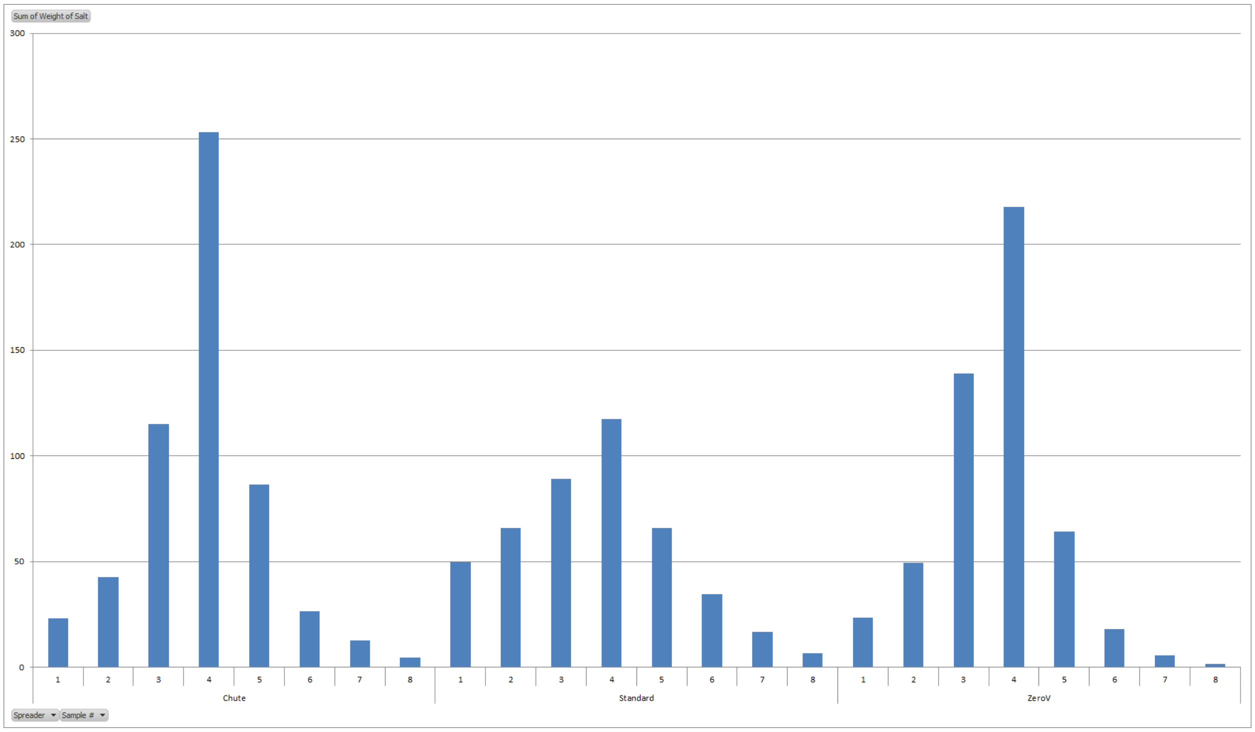


Figure 6. Salt (grams) by spreader type and sample number

Salt by Spreader, Speed, and Brine

Using 200 lbs per lane mile of salt, no brine included, the maximum weight per run should be 51.54 grams. Figure 7 shows this value (straight red line across bar chart) compared to the actual measured salt for each run.

As shown, the chute spreader exceeded 51.54 grams three times (one at 20 mph and two at 30 mph) and the zero-velocity spreader exceeded the limit twice, both at 30 mph. These values hint toward a need to verify that the spreaders are calibrated and delivering consistent quantities at varying truck speeds.

Additional comparisons are provided in Appendix B.

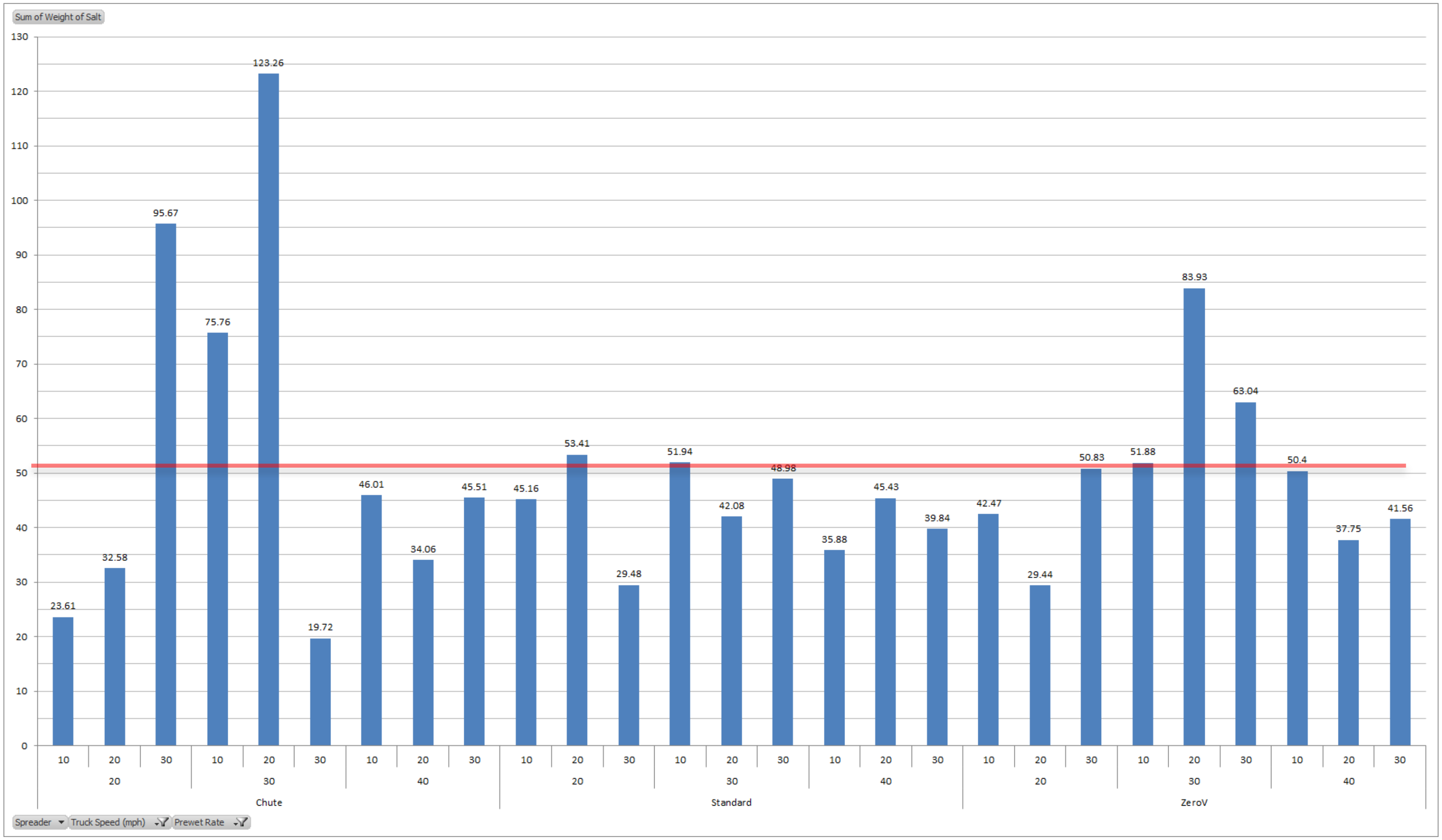


Figure 7. Salt (grams) by spreader, speed, and brine rate compared to expected maximum per run

IMPLEMENTATION

The TAC discussion resulted in several opportunities for implementation as follows:

- These results will assist the Iowa DOT in understanding the performance of each of the three salt spreader types in terms of truck speed and brine rates.

- The results will guide future investigations toward more-detailed comparisons such as material loss, material migration after application, truck calibration by speed, and the effectiveness of varied brine rates.

- The high-speed video enhanced DOT abilities to see each of the three salt spreaders in motion and to observe salt placement and loss across the lane.

- These results will help target future investigations specific to speed of application and salt and brine delivery methods.

SUMMARY

This research developed and completed a field evaluation of salt distribution equipment. The evaluation provides a direct comparison of three different types of salt spreaders at three different truck speeds and brine rates.

A rubber mat was divided into eight sample areas to measure salt distribution across the lane by each variable combination. A total of 264 samples were processed and measured.

These results will support future efforts to target areas of efficiencies specific to salt and brine delivery methods. These results support Iowa DOT efforts to progress winter maintenance efficiencies and ultimately motorist safety.

APPENDIX A. WEIGHT RESULTS FOR SAMPLES

Run Number	Sample Number	Spreader Type	Brine Rate (gal/lane mile)	Truck Speed (mph)	Weight of Salt (grams)
R01	1	ZeroV	0	25	0.11
R01	2	ZeroV	0	25	2.00
R01	3	ZeroV	0	25	8.60
R01	4	ZeroV	0	25	18.32
R01	5	ZeroV	0	25	1.78
R01	6	ZeroV	0	25	0.28
R01	7	ZeroV	0	25	0.00
R01	8	ZeroV	0	25	0.00
R02	1	ZeroV	0	40	1.13
R02	2	ZeroV	0	40	3.40
R02	3	ZeroV	0	40	7.98
R02	4	ZeroV	0	40	12.17
R02	5	ZeroV	0	40	7.50
R02	6	ZeroV	0	40	2.26
R02	7	ZeroV	0	40	1.55
R02	8	ZeroV	0	40	0.74
R03	1	ZeroV	10	20	0.46
R03	2	ZeroV	10	20	1.10
R03	3	ZeroV	10	20	4.01
R03	4	ZeroV	10	20	29.47
R03	5	ZeroV	10	20	6.60
R03	6	ZeroV	10	20	0.83
R03	7	ZeroV	10	20	0.00
R03	8	ZeroV	10	20	0.00
R04	1	ZeroV	10	30	2.49
R04	2	ZeroV	10	30	4.65
R04	3	ZeroV	10	30	6.07
R04	4	ZeroV	10	30	23.93
R04	5	ZeroV	10	30	11.42
R04	6	ZeroV	10	30	2.35
R04	7	ZeroV	10	30	0.97
R04	8	ZeroV	10	30	0.00
R05	1	ZeroV	10	40	5.30
R05	2	ZeroV	10	40	7.85

Run Number	Sample Number	Spreader Type	Brine Rate (gal/lane mile)	Truck Speed (mph)	Weight of Salt (grams)
R05	3	ZeroV	10	40	10.71
R05	4	ZeroV	10	40	12.14
R05	5	ZeroV	10	40	6.60
R05	6	ZeroV	10	40	6.36
R05	7	ZeroV	10	40	1.08
R05	8	ZeroV	10	40	0.36
R06	1	ZeroV	20	20	0.07
R06	2	ZeroV	20	20	0.37
R06	3	ZeroV	20	20	9.81
R06	4	ZeroV	20	20	17.95
R06	5	ZeroV	20	20	1.24
R06	6	ZeroV	20	20	0.00
R06	7	ZeroV	20	20	0.00
R06	8	ZeroV	20	20	0.00
R07	1	ZeroV	20	30	5.85
R07	2	ZeroV	20	30	9.93
R07	3	ZeroV	20	30	36.27
R07	4	ZeroV	20	30	21.65
R07	5	ZeroV	20	30	8.84
R07	6	ZeroV	20	30	0.98
R07	7	ZeroV	20	30	0.41
R07	8	ZeroV	20	30	0.00
R08	1	ZeroV	20	40	2.39
R08	2	ZeroV	20	40	2.81
R08	3	ZeroV	20	40	13.63
R08	4	ZeroV	20	40	10.71
R08	5	ZeroV	20	40	6.08
R08	6	ZeroV	20	40	1.67
R08	7	ZeroV	20	40	0.46
R08	8	ZeroV	20	40	0.00
R09	1	ZeroV	30	20	0.06
R09	2	ZeroV	30	20	2.31
R09	3	ZeroV	30	20	8.19
R09	4	ZeroV	30	20	33.88
R09	5	ZeroV	30	20	6.08
R09	6	ZeroV	30	20	0.31

Run Number	Sample Number	Spreader Type	Brine Rate (gal/lane mile)	Truck Speed (mph)	Weight of Salt (grams)
R09	7	ZeroV	30	20	0.00
R09	8	ZeroV	30	20	0.00
R10	1	ZeroV	30	30	2.98
R10	2	ZeroV	30	30	7.03
R10	3	ZeroV	30	30	19.47
R10	4	ZeroV	30	30	24.17
R10	5	ZeroV	30	30	5.51
R10	6	ZeroV	30	30	2.20
R10	7	ZeroV	30	30	1.10
R10	8	ZeroV	30	30	0.58
R11	1	ZeroV	30	40	2.48
R11	2	ZeroV	30	40	8.01
R11	3	ZeroV	30	40	14.32
R11	4	ZeroV	30	40	13.37
R11	5	ZeroV	30	40	2.63
R11	6	ZeroV	30	40	0.75
R11	7	ZeroV	30	40	0.00
R11	8	ZeroV	30	40	0.00
R12	1	Standard	0	25	2.15
R12	2	Standard	0	25	2.83
R12	3	Standard	0	25	5.39
R12	4	Standard	0	25	6.57
R12	5	Standard	0	25	3.66
R12	6	Standard	0	25	2.50
R12	7	Standard	0	25	0.44
R12	8	Standard	0	25	0.46
R13	1	Standard	0	40	4.96
R13	2	Standard	0	40	3.45
R13	3	Standard	0	40	5.28
R13	4	Standard	0	40	7.09
R13	5	Standard	0	40	4.72
R13	6	Standard	0	40	2.13
R13	7	Standard	0	40	1.12
R13	8	Standard	0	40	0.57
R14	1	Standard	10	20	2.88
R14	2	Standard	10	20	9.83
R14	3	Standard	10	20	14.05

Run Number	Sample Number	Spreader Type	Brine Rate (gal/lane mile)	Truck Speed (mph)	Weight of Salt (grams)
R14	4	Standard	10	20	11.07
R14	5	Standard	10	20	2.34
R14	6	Standard	10	20	3.48
R14	7	Standard	10	20	0.98
R14	8	Standard	10	20	0.53
R15	1	Standard	10	30	3.62
R15	2	Standard	10	30	6.30
R15	3	Standard	10	30	15.09
R15	4	Standard	10	30	11.94
R15	5	Standard	10	30	6.76
R15	6	Standard	10	30	3.01
R15	7	Standard	10	30	4.24
R15	8	Standard	10	30	0.98
R16	1	Standard	10	40	4.15
R16	2	Standard	10	40	4.38
R16	3	Standard	10	40	6.09
R16	4	Standard	10	40	8.02
R16	5	Standard	10	40	5.17
R16	6	Standard	10	40	4.59
R16	7	Standard	10	40	1.93
R16	8	Standard	10	40	1.55
R17	1	Standard	20	20	1.51
R17	2	Standard	20	20	5.81
R17	3	Standard	20	20	7.65
R17	4	Standard	20	20	21.81
R17	5	Standard	20	20	10.94
R17	6	Standard	20	20	2.92
R17	7	Standard	20	20	1.55
R17	8	Standard	20	20	1.22
R18	1	Standard	20	30	9.35
R18	2	Standard	20	30	3.64
R18	3	Standard	20	30	5.12
R18	4	Standard	20	30	10.11
R18	5	Standard	20	30	7.09
R18	6	Standard	20	30	4.23
R18	7	Standard	20	30	2.54
R18	8	Standard	20	30	0.00
R19	1	Standard	20	40	6.83
R19	2	Standard	20	40	7.89

Run Number	Sample Number	Spreader Type	Brine Rate (gal/lane mile)	Truck Speed (mph)	Weight of Salt (grams)
R19	3	Standard	20	40	7.05
R19	4	Standard	20	40	11.25
R19	5	Standard	20	40	6.83
R19	6	Standard	20	40	3.86
R19	7	Standard	20	40	1.17
R19	8	Standard	20	40	0.55
R20	1	Standard	30	20	2.94
R20	2	Standard	30	20	6.16
R20	3	Standard	30	20	8.84
R20	4	Standard	30	20	4.62
R20	5	Standard	30	20	5.05
R20	6	Standard	30	20	0.98
R20	7	Standard	30	20	0.42
R20	8	Standard	30	20	0.47
R21	1	Standard	30	30	7.36
R21	2	Standard	30	30	7.30
R21	3	Standard	30	30	8.23
R21	4	Standard	30	30	15.33
R21	5	Standard	30	30	5.00
R21	6	Standard	30	30	4.19
R21	7	Standard	30	30	1.57
R21	8	Standard	30	30	0.00
R22	1	Standard	30	40	3.88
R22	2	Standard	30	40	8.23
R22	3	Standard	30	40	6.33
R22	4	Standard	30	40	9.46
R22	5	Standard	30	40	8.21
R22	6	Standard	30	40	2.76
R22	7	Standard	30	40	0.79
R22	8	Standard	30	40	0.18
R23	1	Chute	0	25	1.46
R23	2	Chute	0	25	2.38
R23	3	Chute	0	25	5.41
R23	4	Chute	0	25	9.98
R23	5	Chute	0	25	1.60
R23	6	Chute	0	25	0.74
R23	7	Chute	0	25	0.38
R23	8	Chute	0	25	0.00
R24	1	Chute	0	40	6.32

Run Number	Sample Number	Spreader Type	Brine Rate (gal/lane mile)	Truck Speed (mph)	Weight of Salt (grams)
R24	2	Chute	0	40	5.89
R24	3	Chute	0	40	12.78
R24	4	Chute	0	40	13.79
R24	5	Chute	0	40	4.79
R24	6	Chute	0	40	0.58
R24	7	Chute	0	40	1.28
R24	8	Chute	0	40	0.00
R25	1	Chute	10	20	0.98
R25	2	Chute	10	20	0.80
R25	3	Chute	10	20	4.84
R25	4	Chute	10	20	14.18
R25	5	Chute	10	20	2.81
R25	6	Chute	10	20	0.00
R25	7	Chute	10	20	0.00
R25	8	Chute	10	20	0.00
R26	1	Chute	10	30	2.07
R26	2	Chute	10	30	4.64
R26	3	Chute	10	30	13.80
R26	4	Chute	10	30	40.93
R26	5	Chute	10	30	12.08
R26	6	Chute	10	30	2.24
R26	7	Chute	10	30	0.00
R26	8	Chute	10	30	0.00
R27	1	Chute	10	40	1.42
R27	2	Chute	10	40	5.82
R27	3	Chute	10	40	8.07
R27	4	Chute	10	40	7.64
R27	5	Chute	10	40	9.24
R27	6	Chute	10	40	8.45
R27	7	Chute	10	40	4.45
R27	8	Chute	10	40	0.92
R28	1	Chute	20	20	0.00
R28	2	Chute	20	20	3.47
R28	3	Chute	20	20	11.77
R28	4	Chute	20	20	12.16
R28	5	Chute	20	20	4.89
R28	6	Chute	20	20	0.29
R28	7	Chute	20	20	0.00
R28	8	Chute	20	20	0.00

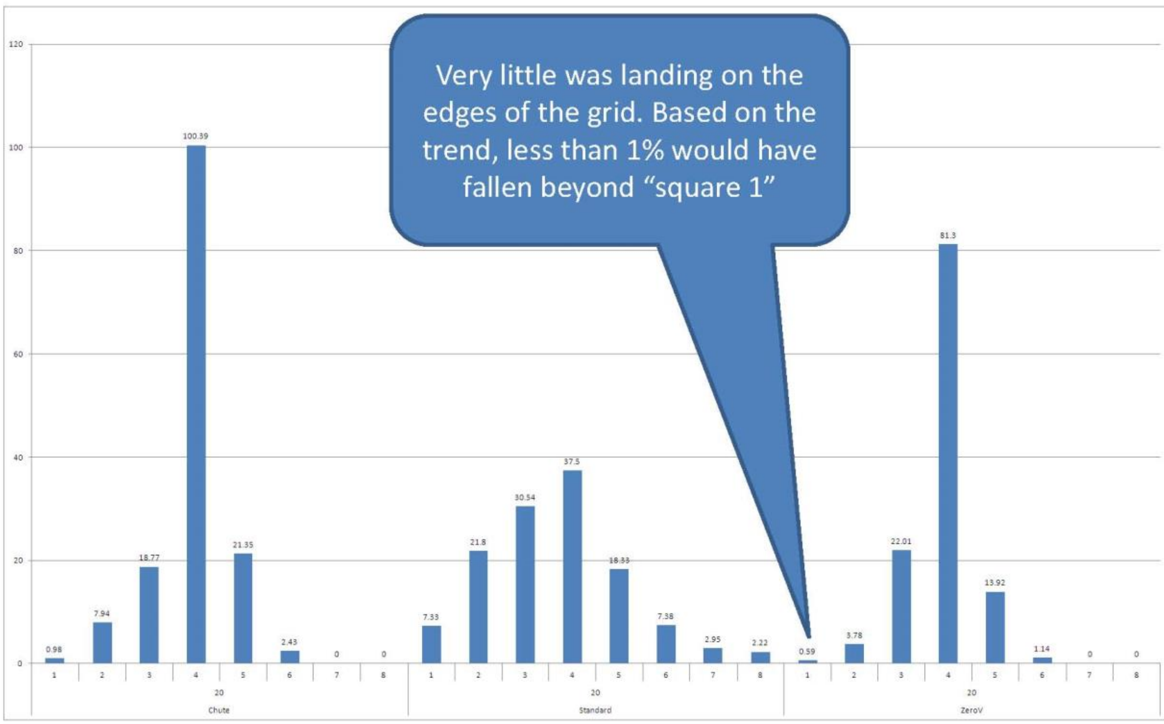
Run Number	Sample Number	Spreader Type	Brine Rate (gal/lane mile)	Truck Speed (mph)	Weight of Salt (grams)
R29	1	Chute	20	30	2.30
R29	2	Chute	20	30	6.94
R29	3	Chute	20	30	29.08
R29	4	Chute	20	30	53.68
R29	5	Chute	20	30	22.61
R29	6	Chute	20	30	5.57
R29	7	Chute	20	30	2.39
R29	8	Chute	20	30	0.69
R30	1	Chute	20	40	3.28
R30	2	Chute	20	40	3.13
R30	3	Chute	20	40	11.34
R30	4	Chute	20	40	10.36
R30	5	Chute	20	40	3.19
R30	6	Chute	20	40	0.86
R30	7	Chute	20	40	1.38
R30	8	Chute	20	40	0.52
R31	1	Chute	30	20	0.00
R31	2	Chute	30	20	3.67
R31	3	Chute	30	20	2.16
R31	4	Chute	30	20	74.05
R31	5	Chute	30	20	13.65
R31	6	Chute	30	20	2.14
R31	7	Chute	30	20	0.00
R31	8	Chute	30	20	0.00
R32	1	Chute	30	30	0.55
R32	2	Chute	30	30	0.76
R32	3	Chute	30	30	4.30
R32	4	Chute	30	30	6.64
R32	5	Chute	30	30	5.89
R32	6	Chute	30	30	0.85
R32	7	Chute	30	30	0.37
R32	8	Chute	30	30	0.36
R33	1	Chute	30	40	4.82
R33	2	Chute	30	40	5.02
R33	3	Chute	30	40	11.44
R33	4	Chute	30	40	9.73
R33	5	Chute	30	40	5.55
R33	6	Chute	30	40	4.64
R33	7	Chute	30	40	2.36

Run Number	Sample Number	Spreader Type	Brine Rate (gal/lane mile)	Truck Speed (mph)	Weight of Salt (grams)
R33	8	Chute	30	40	1.95

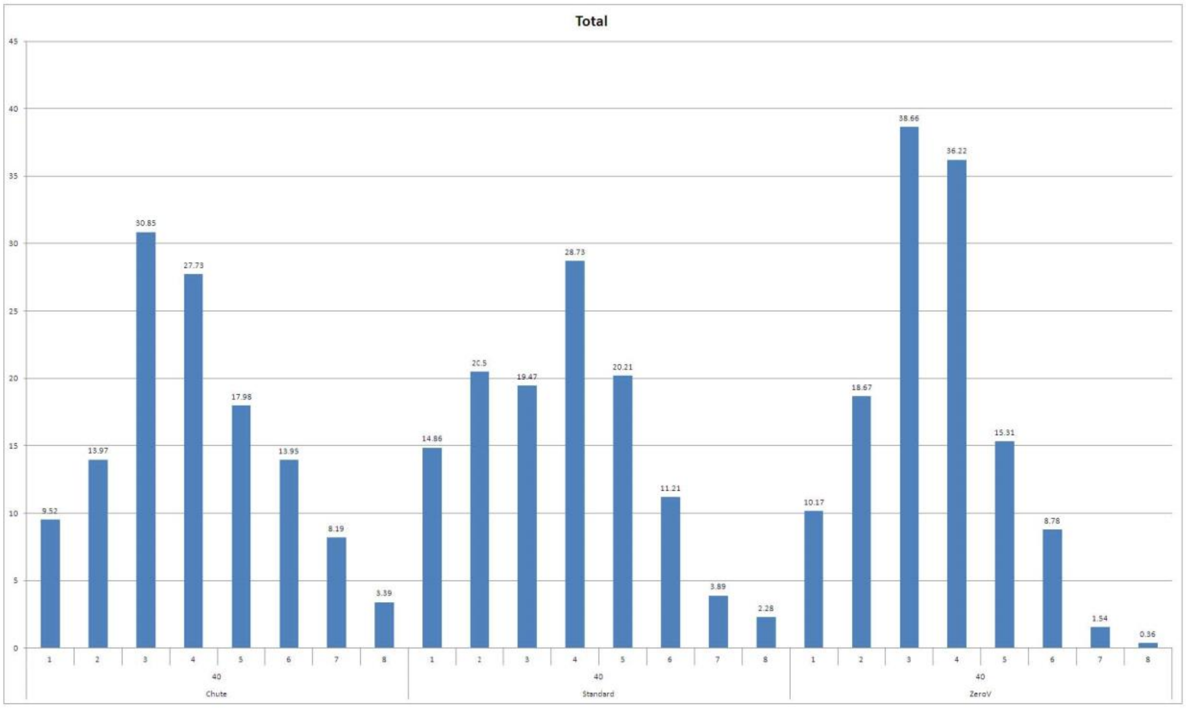
APPENDIX B. ADDITIONAL COMPARISONS

Tina Greenfield with the Iowa DOT Office of Maintenance provided the information included in this appendix.

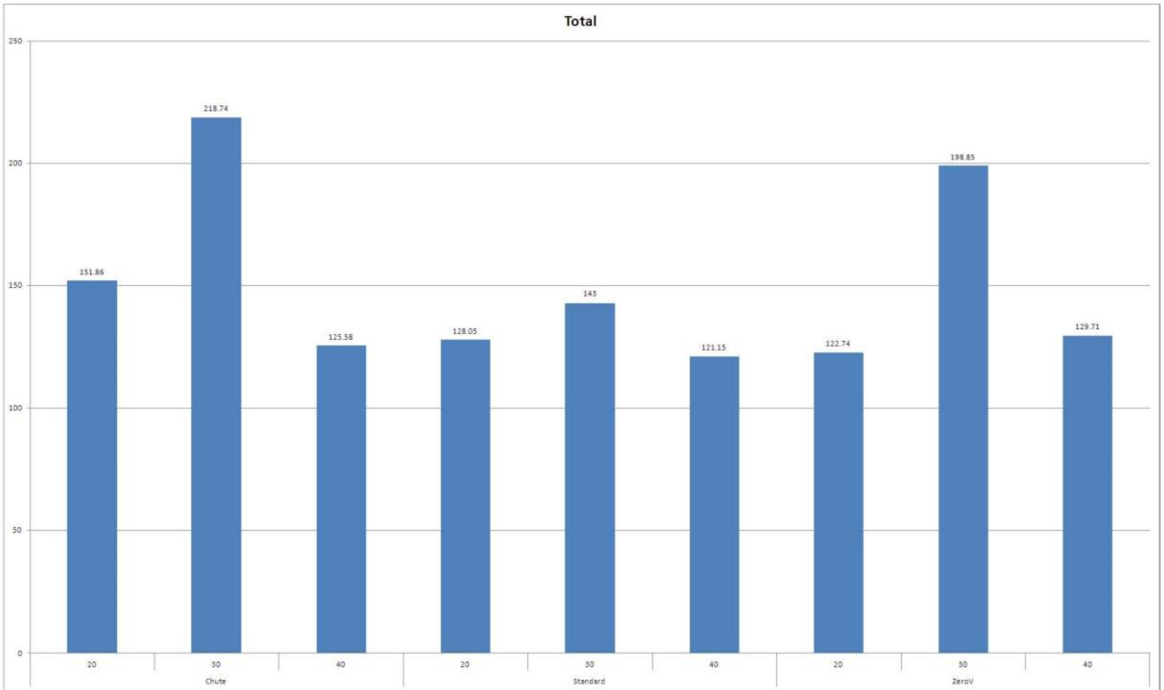
In total amounts recovered, the ZV was the lowest even at 20mph when loss was very low, which indicates the difference is more likely due to calibration than “material loss”



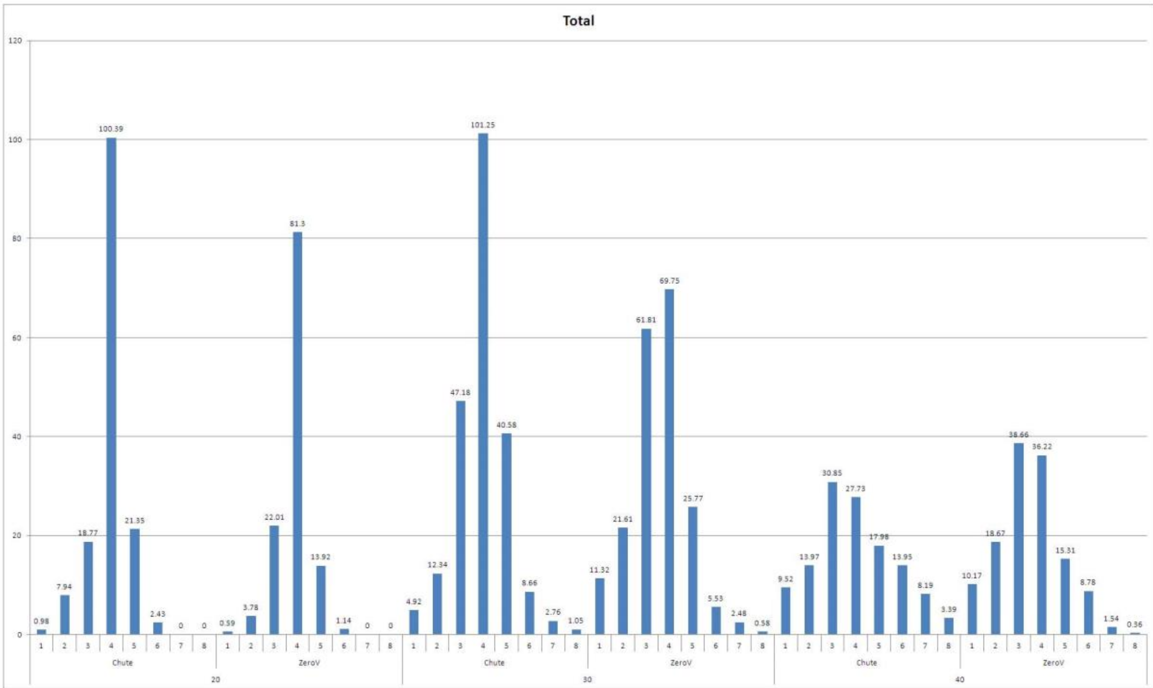
As Speed increased, the distribution widened.
Estimated loss beyond 'box 1' became more significant.
@40 mph, ~10% for ZV or Chute, more for standard.



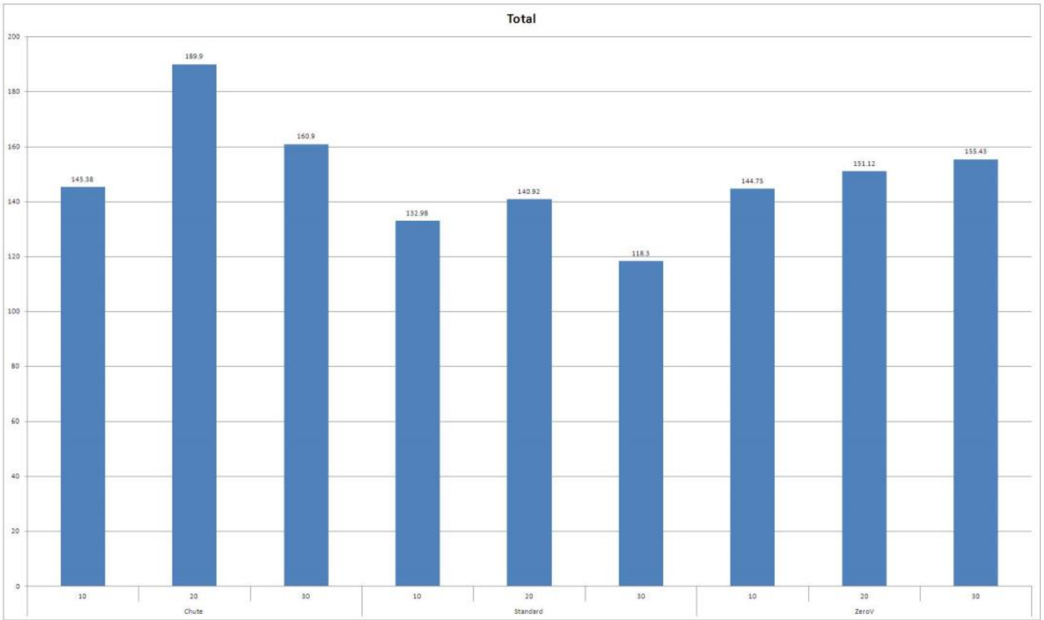
Although the expected loss increased with speed, the amount recovered at 30 mph was oddly high. The ground-speed control function of the spreaders may need investigated.



In pattern of distribution, ZV and Chute were very similar.



Anti-ice bar rate did not have a clear impact on salt retention. Rate at prewet nozzles was constant.



At 40 mph, advantage of prewet over dry was evident for the standard spreader, but not as obvious for ZV or Chute