Salt Bounce and Scatter Study

PROJECT SUMMARY REPORT

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Introduction

Adverse winter weather influences transportation systems by increasing the likelihood of traffic accidents and decreasing mobility, potentially decreasing economic activity during and after a winter storm event. A study, conducted by the Salt Institute to simulate the loss of economic activity that would accompany a shutdown of activities in Michigan due to a snowstorm, concluded that the state would lose $258 million/day in direct and derived costs. However, it should be noted that it is unlikely that a winter storm event would cause a complete shutdown of transportation facilities across the state. The Michigan Department of Transportation (MDOT) and local agencies plow and apply chemical deicers before, during and after winter storm events in order to achieve the prescribed level of service.

Sodium chloride (salt) has been used by road agencies across Michigan for controlling snow and ice on roadways for nearly a century. Salt is a very effective deicer, widely available and less expensive than other deicing options. However, the use of salt does have its drawbacks. Excessive application can adversely affect bodies of water and vegetation, and salt is corrosive to vehicles, bridges and other structures on or near the roadway. While salt is the cheapest deicer, its price has gone up significantly over the past decade. This puts even more emphasis on the need to use salt as efficiently as possible, and apply it at the lowest effective rate possible.

One way to reduce the amount of salt used is to ensure that as much salt as possible stays within the target area of the traveling lane, which is approximately four feet on either side of the roadway centerline. This is best accomplished by reducing the amount of bounce and scatter of the salt during application. Many factors influence the amount of bounce and scatter of salt, including the current road conditions, moisture content of the salt, type of distribution equipment and truck speed. MDOT puts a lot of effort into limiting the amount of salt that bounces off the road by using effective application equipment and enforcing a maximum speed for trucks applying salt. MDOT's current winter operations policy states that salt should be applied at speeds of 35 mph or slower if possible. MDOT also promotes pre-treating (pre-wetting) salt before it is applied.

MDOT is continually looking for ways to deliver services better, faster, cheaper, safer and smarter by applying the right material in the right place at the right time. By initiating a study to measure the bounce and scatter of salt, the objective was to demonstrate how much material drifts from the intended target area of the road. For this study, treated and untreated road salt was utilized. The intent was to determine precisely where the salt disperses after it leaves the truck and measure how much material is landing inside and outside of the target area. This data will be used to demonstrate how much salt scatters from the centerline into the target areas and beyond. The ultimate goal is to reduce costs and environmental impacts by understanding how truck speed, salt-delivering equipment and salt type (treated versus untreated) affect salt displacement during application.

Background

In the early 1970s, MDOT experimented by treating salt with a liquid deicer before it was applied to the roadway. The results of this study concluded that “pre-wetting” (treating) of ice control salt with liquid calcium chloride is an effective tool to increase the salt efficiency and improve the application pattern. The addition of the chloride accelerates the melting action and reduces salt loss because of better control of the salt application. These two factors will reduce the period that the adverse road condition exists. The additional chloride will extend the temperature range that salt can be used efficiently.” The final report from the “Pre-wetted Salt Report” study is still referenced today as the model for determining the effectiveness of utilizing treated salt.

To build upon prior work, this new study tested the bounce and scatter of salt from two different delivery systems, using untreated salt and pre-treated salt. The test was also done at three different speeds (25 mph, 35 mph, and 45 mph) that provided a good range of possible application speeds. MDOT’s current policy states that operators should not exceed 35 mph while applying salt. However, many operators feel that an application speed of 45 mph is more efficient and perceive it to be safer. The support for slower speed analysis was warranted by the MDOT Southwest Region’s pilot project during the winter of 2011-2012, which limited salting speeds to 25 mph.

All testing was conducted on an unused section of US-31 in Benton Harbor, Michigan. This location provided a controlled setting where the existing 48-foot-wide section of concrete roadway could simulate a two-lane road with paved 12-foot shoulders. This site allowed for multiple tests to be performed without traffic influencing where the material landed.

Figure 1: Test Site Location

MDOT uses a wide variety of salt distribution systems throughout the state. For the purpose of limiting the amount of testing scenarios, the Office of Field Services (OFS) chose to measure the bounce and scatter of the two most common distribution systems, Y-chutes and rear-cross conveyers.

Y-chutes are attached to the rear of winter maintenance trucks. These units have virtually no moving components and are relatively inexpensive to purchase and maintain. They also perform well at applying material along the centerline (crown) of the roadway. Some Y-chutes have an added drop chute which give the operator the option to place material on the high side of a ramp or to “play the wind” while applying salt.

The rear-cross conveyers also attach to the rear of winter maintenance trucks. They utilize a hydraulic unit that allows the operators to apply material to the left or right side of the truck or

utilize a rear center-mounted spinner. Rear-cross conveyors are more versatile, and can be left on the trucks and used for summer maintenance activities.

Distribution Systems Tested

Figure 2: Y –Chute
Truck Number: 04-1636
Chute Height: 16 inches
Gate Height: 3 inches

Figure 3: Rear-Cross Conveyer
Truck Number: 04-4015
Chute Height 12 inches
Gate Height 2 inches

Evaluation Procedure

The salt bounce and scatter tests were conducted at three different speeds: 25 mph, 35 mph, and 45 mph. To get more accurate results, three runs of each scenario were performed and the results averaged. The material was applied to the test section at an application rate of 350 pounds per two lane miles. Two different heavy winter maintenance trucks were used. (See Figures 2 and 3 above for specifications.) Both trucks were calibrated prior to testing by the Paw Paw Central Repair Facility.

Figure 4: Grid Layout

Prior to testing, a grid was painted onto the test area surface. The test area was 100 feet long and 48 feet wide, and was divided up into 12 four-foot collection lanes. Each four-foot collection lane was assigned a letter so the amount of salt collected in each lane could easily be documented. After the grid was laid out on the concrete, the test section was cleaned with brooms and blowers to remove any dirt and debris from the pavement that could otherwise influenced the testing.

Figure 5: Salt Collection (Vacuuming)

Cones were set 200 feet before the test grid to signal the truck operator to turn on the delivery system. This provided plenty of time for the truck's hydraulic systems to engage before the start of test. Similarly, cones were placed 20 feet after the test section to signal the operator to turn off the delivery system. Truck operators were instructed to keep the truck at the same RPM for each test scenario, in order to maintain consistency throughout the test. After each test run, material was collected by vacuuming up each four-foot collection lane with wet/dry vacuums.

Each vacuum was then weighed with a digital hanging scale (the scale was calibrated and zeroed out prior to each run). A two-person team was assigned to document all of the information collected on the bounce and scatter field sheets to help ensure it was recorded accurately. A full list of equipment utilized for this study can be found in Appendix A.

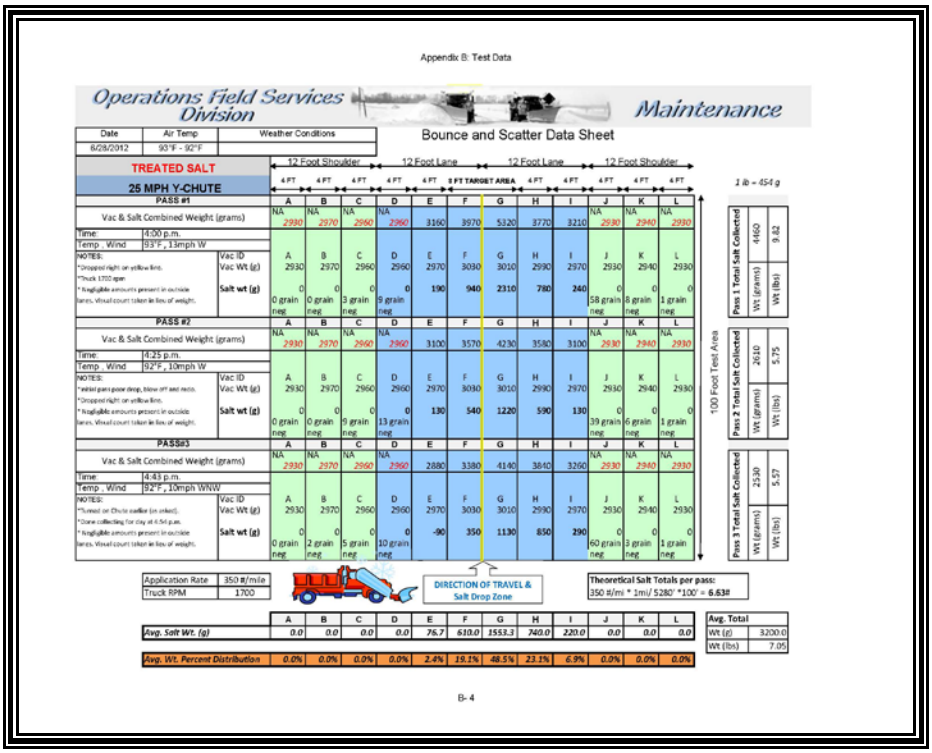
All salt used in this study was standard specification road salt conforming to ASTM D 632 and the MDOT specifications for road salt. To verify the results of the work MDOT did in the early 1970s on treated salt, both standard dry salt and salt treated with a liquid deicer were utilized. The particular liquid deicer used was a blend of liquid calcium chloride, an agricultural byproduct, and a corrosion inhibitor additive, which gives the treated salt a brown tint. MDOT's Coloma Maintenance Garage treated the salt by injecting the liquid deicer into a stockpile of untreated salt at a rate of 8 gallons per ton.

Figure 6: Collection Vacuum
Untreated Road Salt

Figure 7: Collection Vacuum
Pre-treated Road Salt

Data Analysis: Comments on Data Collection/Data Tables

Before graphical results from the study can be discussed, the data collection process and corresponding data sheets should be reviewed. The 12 data sheets for the study (one for each unique test scenario) can be found in Appendix B. Each sheet contains information (time of test, notes, collected weights, etc.) regarding the three passes conducted for each test condition. A total of 36 truck passes were utilized for collecting data.


Appendix B: Test Data

Operations Field Services Division — Maintenance

Bounce and Scatter Data Sheet

Date	Air Temp	Weather Conditions
6/28/2012	93°F - 92°F	

TREATED SALT
25 MPH Y-CHUTE

12 Foot Shoulder | 12 Foot Lane | 12 Foot Lane | 12 Foot Shoulder
4 FT | 4 FT | 4 FT | 4 FT | 4 FT | 8 FT TARGET AREA | 4 FT | 4 FT | 4 FT | 4 FT | 4 FT

1 lb = 454 g

	A	B	C	D	E	F	G	H	I	J	K	L
PASS #1												
Vac & Salt Combined Weight (grams)	NA 2930	NA 2970	NA 2960	NA 2960	3160	3970	5320	3770	3210	NA 2930	NA 2940	NA 2930
Time: 4:00 p.m.												
Temp . Wind 93°F , 13mph W												
NOTES: *Dropped right on yellow line. *Truck 1700 rpm * Negligible amounts present in outside lanes. Visual count taken in lieu of weight.	Vac ID											
	Vac Wt (g) 2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
	Salt wt (g) 0	0	0	0	190	940	2310	780	240	0	0	0
	0 grain neg	0 grain neg	3 grain neg	9 grain neg						58 grain neg	8 grain neg	1 grain neg
PASS #2												
Vac & Salt Combined Weight (grams)	NA 2930	NA 2970	NA 2960	NA 2960	3100	3570	4230	3580	3100	NA 2930	NA 2940	NA 2930
Time: 4:25 p.m.												
Temp . Wind 92°F , 10mph W												
NOTES: *Wind gusts gone drop, blow off and recs. *Dropped right on yellow line. * Negligible amounts present in outside lanes. Visual count taken in lieu of weight.	Vac ID											
	Vac Wt (g) 2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
	Salt wt (g) 0	0	0	0	130	540	1220	590	130	0	0	0
	0 grain neg	0 grain neg	9 grain neg	13 grain neg						39 grain neg	6 grain neg	1 grain neg
PASS#3												
Vac & Salt Combined Weight (grams)	NA 2930	NA 2970	NA 2960	NA 2960	2880	3380	4140	3840	3260	NA 2930	NA 2940	NA 2930
Time: 4:43 p.m.												
Temp . Wind 92°F , 10mph WNW												
NOTES: *Turned on Chute outlet (on video). *Done collecting for day at 4:54 p.m. * Negligible amounts present in outside lanes. Visual count taken in lieu of weight.	Vac ID											
	Vac Wt (g) 2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
	Salt wt (g) 0	0	0	0	-90	350	1130	850	290	0	0	0
	0 grain neg	2 grain neg	5 grain neg	10 grain neg						60 grain neg	3 grain neg	1 grain neg

100 Foot Test Area

	Pass 1 Total Salt Collected	
	Wt (grams)	4460
	Wt (lbs)	9.82

	Pass 2 Total Salt Collected	
	Wt (grams)	2610
	Wt (lbs)	5.75

	Pass 3 Total Salt Collected	
	Wt (grams)	2530
	Wt (lbs)	5.57

Application Rate	350 #/mile
Truck RPM	1700

DIRECTION OF TRAVEL & Salt Drop Zone

Theoretical Salt Totals per pass:
350 #/mi * 1mi/ 5280' *100' = 6.63#

	A	B	C	D	E	F	G	H	I	J	K	L
Avg. Salt Wt. (g)	0.0	0.0	0.0	0.0	76.7	610.0	1553.3	740.0	220.0	0.0	0.0	0.0
Avg. Wt. Percent Distribution	0.0%	0.0%	0.0%	0.0%	2.4%	19.1%	48.5%	23.1%	6.9%	0.0%	0.0%	0.0%

Avg. Total	
Wt (g)	3200.0
Wt (lbs)	7.05

B- 4

Figure 8: Sample Data Sheet (Appendix B).

To determine the actual weight of the salt collected for each four-foot wide collection lane, the empty weight of the shop vacuum bucket needed to be subtracted (only the combined salt and vacuum weight could be recorded in the field). While the study utilized brand new shop vacs of the same model number, prior to testing it was discovered that the empty weights of the shop vac buckets varied in range from 2,930 to 3,030 grams. Each individual bucket weight was recorded and marked on the unit. Each vacuum identifier also was noted on the field sheets, so that the proper salt weights could be calculated.

For all the 25 mph tests and some of the 35 mph tests, the outside collection lanes contained a negligible amount of salt (based on visual observation). For these instances, the lanes were not vacuumed and “0” was entered on the data sheets for the collection lane. Visible grains of salt were counted, for information purposes only, and lanes were swept or blown clear before the next test run.

Converse to the slower speeds, passes at the 45 mph speed provided instances where some salt bounced completely off of the 48-foot-wide collection grid. These occurrences were noted in the pass notes on the test data sheets. Whenever this occurred, the amounts did not appear to be excessive. If salt did not land on the 48-foot collection grid, it could not be collected. Ultimately, graphed results show the percent weight distribution of all the salt collected for a pass.

The collection and weighing process for lane "K" varied from that of the other lanes. In order to obtain a full 48-foot-wide collection grid, the paved shoulder along the test segment needed to be utilized. The area enclosed by lane "K" included the longitudinal paving joint between concrete and asphalt sections, as well as the rumble strips in the asphalt shoulder. This proved to be problematic during collection, as pieces of HMA would occasionally get vacuumed up with the salt. Pieces of HMA were picked out of the buckets before weighing the sample. However, weights accounted for in lane "K" could be slightly inflated due to foreign material being present.

At the end of Appendix B is a data summary sheet that includes the information from the data tables used to compile the collection graphs. It should be noted that some of the data collected was not included in the average weight percent distribution calculations. These omissions are listed on the Data Summary sheet, and are highlighted on the specific data sheet.

Data Analysis: Graphing Process/Methodology

When interpreting the data collected from the bounce and scatter tests, a graphical representation summarizing each test scenario (based on delivery system, salt type and truck speed) for comparison was desired. The biggest challenge was to diminish the effects of the minor, inevitable variations that might occur. These variations could include, but are not limited to, the driver's ability to exactly match the prescribed speed and RPMs, drop zone placement consistency, reaction time and driving characteristic variations between drivers, and minor differences between the trucks other than the different delivery systems. For this reason, three passes were made to create an average for each scenario.

While averaging the collected weights for each scenario eliminates some of the variability, comparisons based on average collected weights are not necessarily equal. In theory, the total amount of salt collected across all collection lanes for a pass on our 100-foot-long collection grid at a rate of 350 pounds per mile should yield 6.63 pounds or 3010 grams:

Eq. 1) Theoretical Weight = $350\frac{lbs}{mi} * \frac{1}{5280}\frac{mi}{ft}$ * 100 *ft.* = **6.63 *lbs.*** $* 454\frac{grams}{lbs} = \mathbf{3010}\ grams$

From viewing the bounce and scatter data sheets in Appendix B, the total weight of salt collected does not match the theoretical amounts for any pass. When comparing the 12 different test scenarios, the average total salt weight collected ranged from 5.73 pounds (2,603 grams) to 11.80 pounds (5,357 grams). Graphing this data would not yield the best comparative charts due to the different magnitudes of salt collected with each scenario. For example, a collection lane in the target zone could contain a higher weight of salt than the same lane retained from a different method. However, it could still be considered less effective if the total amount of salt collected for that pass was higher.

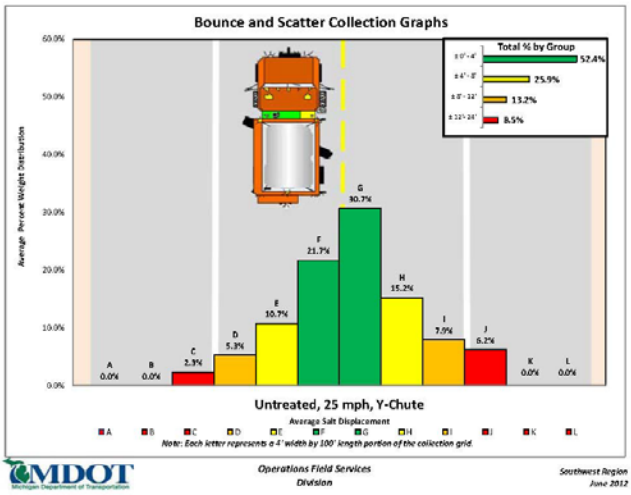
To eliminate this potential issue and provide a more accurate comparison, the average weight percent distribution was calculated for each four-foot-wide collection lane on the grid.

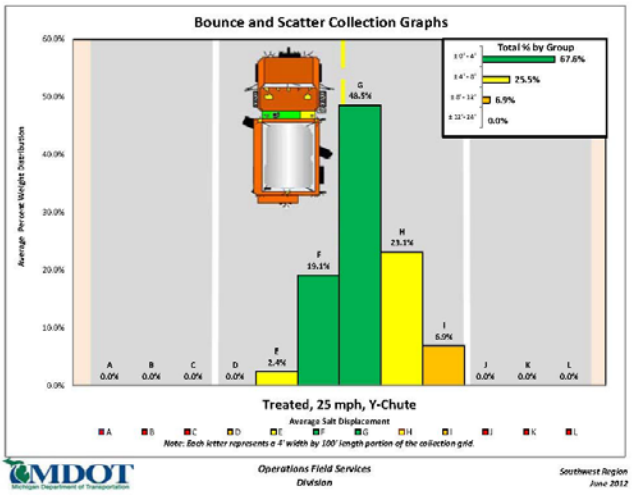
Eq. 2) Avg. Wt. Percent Distribution $= \frac{Average\ "Lane"\ Salt\ Wt.\ Collected}{Average\ "Total"\ Salt\ Wt.\ Collected}$

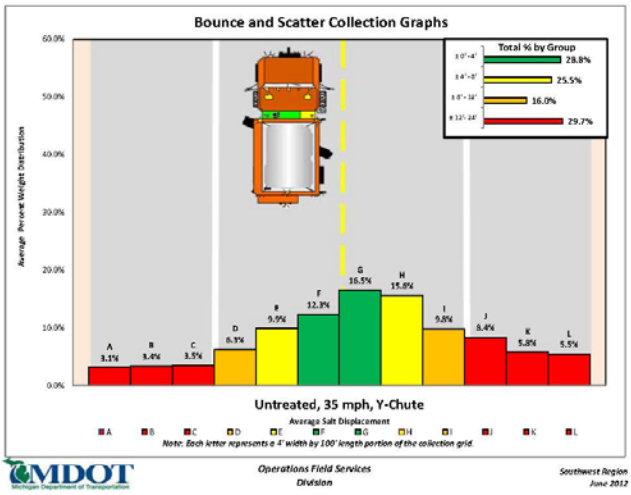
Graphing this information provides the salt displacement concentrations for each collection lane, which are directly comparable to corresponding zones in the other graphs.

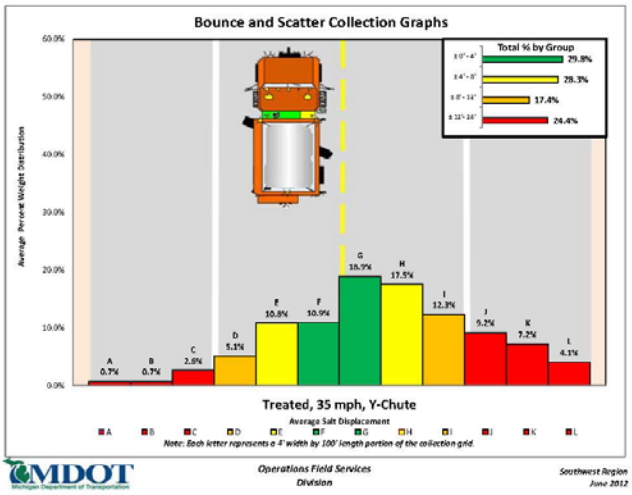
For presentation purposes, the graphs depict the 48-foot-wide collection grid as two 12-foot lanes with two 12-foot shoulders. Since each collection lane maintained a uniform four-foot width, the data collected can still be used to depict other configurations where the drop zone is at the crown point of the roadway. For example, four 12-foot lanes, two lanes with a four-foot median shoulder and eight-foot outside shoulder, etc. No matter what the lane configuration of a roadway, salt effectiveness is maximized if it can begin working close to the crown point. For this reason, the color green was used to depict the eight-foot target area (collection lanes F and G on either side of the crown). Beyond the target area, it is assumed that salt effectiveness diminishes as it gets further away from the crown. Salt is considered non effective if it lands beyond the traveled roadway. For our depiction, salt effectiveness diminishes beyond the target area from yellow to orange to red. Please note that larger, single-sheet copies of the graphs are located in Appendix C.

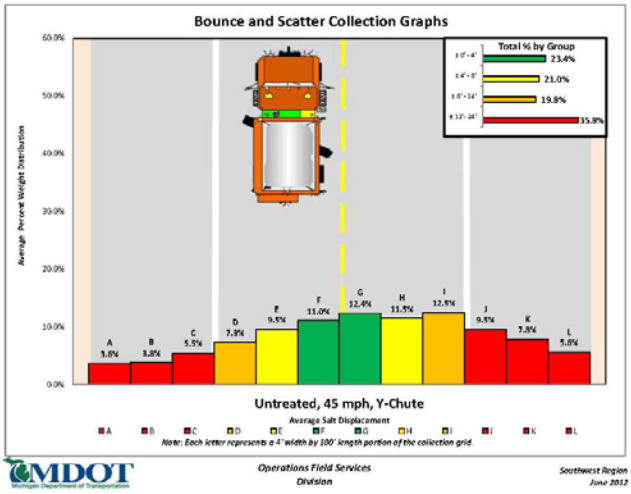
Data Analysis: Collection Graphs

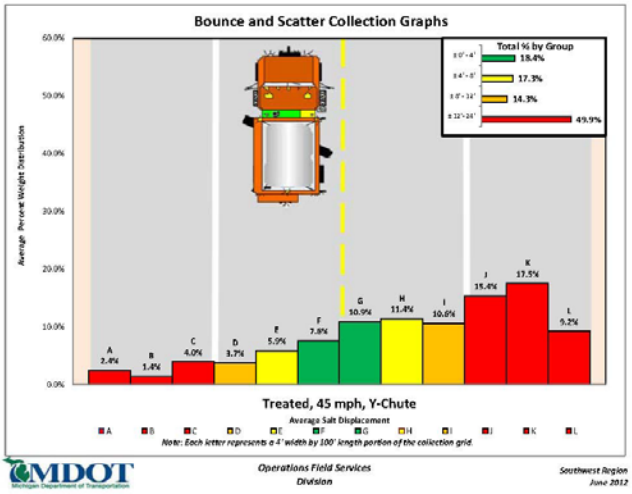




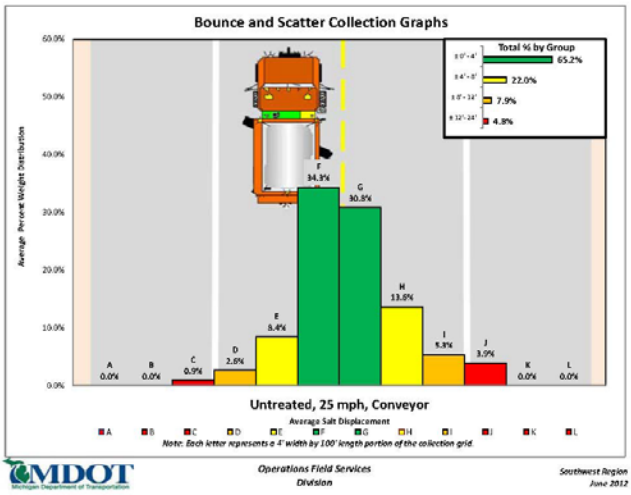


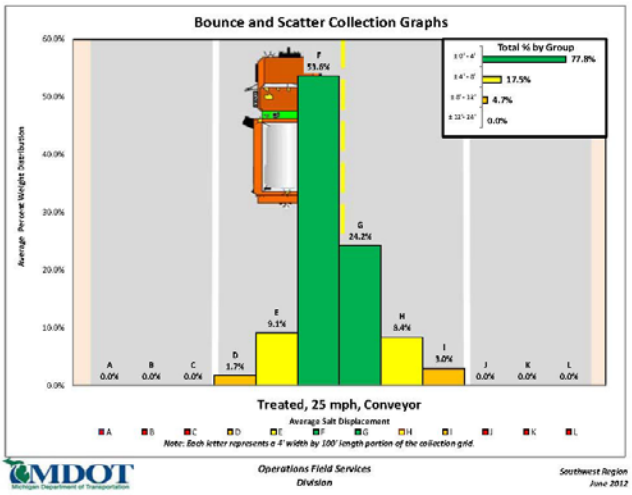


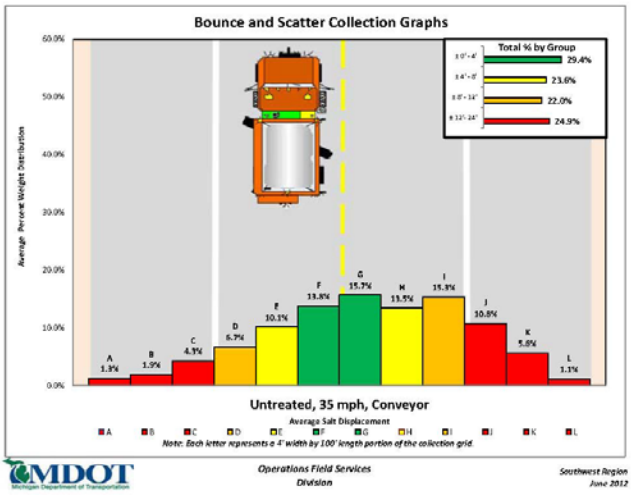


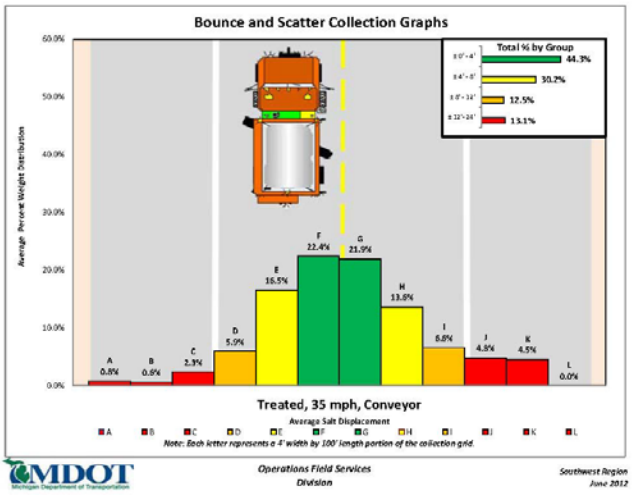


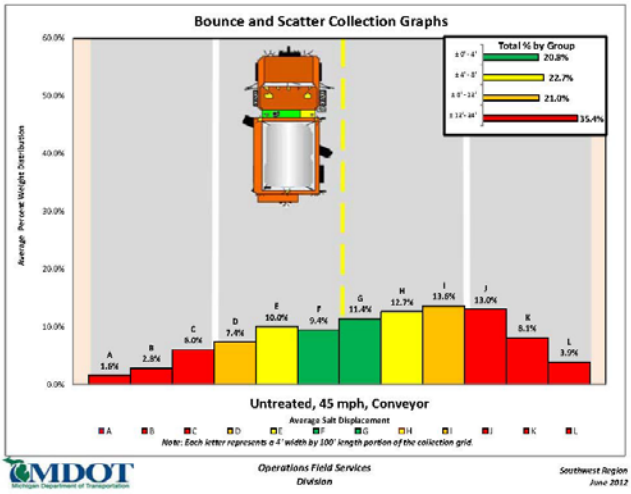
Data Analysis: Collection Graphs

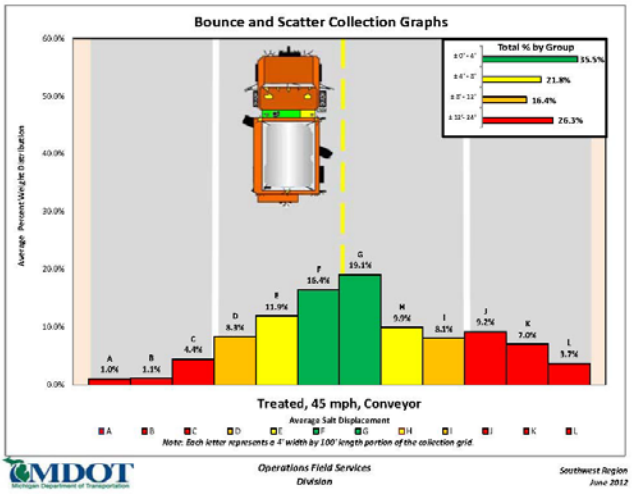












Data Analysis: Interpretations from Collection Graphs

After viewing the collection graphs, differences between the delivery techniques are evident. The most obvious of these is the effect that truck speed has on salt bounce and scatter, regardless of delivery system or salt type used. Results show there is less scatter of salt when it is applied at a 25 mph speed. The percentage of salt that remains in the target area at 25 mph is close to, if not more than, double of correlating graphs at 35 mph. What is also interesting with the speed analysis is that there is a more dramatic spike in salt scatter going from 25 mph to 35 mph than there is from 35 mph to 45 mph.

When focusing ones attention on the differences between treated and untreated salt for a particular speed and delivery type, the differences do not appear as drastic but are still present. Five of these six comparisons support the conviction that treated salt scatters less than untreated salt. This is evinced by viewing the "Total percent by group" portion of the graphs. "Treated" tests show a larger percent in the green area (target zone), as well as lower totals in the red area (outlying areas) versus untreated salt of the same speed and delivery type. The anomaly to this trend is in the comparison of the Y-chute delivery system at 45 mph.

Further investigation into this situation points towards the "Treated 45 mph Y-chute" test scenario being at fault. The salt displacement for this test shows a significant unevenness shifted towards the outlying areas toward the right side of the drop zone. A review of the field notes did not suggest that the driver dropped the salt outside of the area anticipated. The data recorded on the field sheets match the data entered on the data sheets. The issues discussed above with lane "K" could have had a role in this skew but would not explain the higher concentrations in lane "J" and lane "L". While every effort was made to assure uniformity was kept with the vacuuming and weighing process, deviations could have occurred for this scenario which yielded the non-typical data. If this study is to be replicated, it would be worthwhile to recollect information for this scenario.

The last direct comparison to make is the comparison between the Y-chute and cross-conveyor delivery systems. This comparison is the least distinctive of the three single-variable comparisons but did show an overall sway towards one delivery system. To make this realization, one must again look at the "Total % by Group" portion of the graphs. Five of the six direct comparisons here suggest that a conveyor delivery system retains more salt in the target area and disperses less salt in the outlying areas than a Y-chute delivery system. The data contradicts this, however slightly, for the comparison of untreated salt at 45 mph. In practical terms, these two graph scenarios were equal to each other.

By comparing all 12 graphs against each other, the statistical values in Tables 1 and 2 lead to the following generalizations for the parameters measured in this study:

1) The most effective treatment for reducing salt bounce and scatter is to apply a treated salt product, with a cross conveyor delivery system, from a truck traveling at 25 mph.

2) Salt bounce and scatter is at its highest, when applied from a Y-chute delivery system, from a truck traveling at 45 mph.

Data presented in Table 1 highlights the test scenarios that contained the five largest percent totals for each of the four collection zones. This was obtained from the "Total % by Group" portion of the collection graphs.

Table 1: Salt Concentrations per Group

Highest Total Percent in Target Area (Green):		
	77.8%	**Treated, 25 mph, Conveyor**
	67.5%	Treated, 25 mph, Y-Chute
	65.2%	Untreated, 25 mph, Conveyor
	52.4%	Untreated, 25 mph, Y-Chute
	44.3%	Treated, 35 mph, Conveyor
Highest Total Percent in Intermediate Area (Yellow):		
	30.2%	**Treated, 35 mph, Conveyor**
	28.3%	Treated, 35 mph, Y-Chute
	25.9%	Untreated, 25 mph, Y-Chute
	25.5%	Treated, 25 mph, Y-Chute
	25.5%	Untreated, 35 mph, Y-Chute
Highest Total Percent in Intermediate Area (Orange):		
	22.0%	**Untreated, 35 mph, Conveyor**
	21.0%	Untreated, 45 mph, Conveyor
	19.8%	Untreated, 45 mph, Y-Chute
	17.4%	Treated, 35 mph, Y-Chute
	16.4%	Treated, 45 mph, Conveyor
Highest Total Percent in Outlying Area (Red):		
	49.9%	***Treated, 45 mph, Y-Chute****
	35.8%	**Untreated, 45 mph, Y-Chute**
	35.4%	Untreated, 45 mph, Conveyor
	29.7%	Treated, 35 mph, Y-Chute
	26.4%	Treated, 45 mph, Conveyor
	** data trends do not correlate with other test info.*	

Data presented in Table 2 expands beyond the target zone (green area from the collection graphs) to include the additional zone(s) within the driving lanes (yellow, then orange). Table 2 rates all 12 test scenarios by total percent retained for each expansion.

Table 2: Retained Salt (Cumulative)

Total Percent Retained ± 8' (Green + Yellow):	
95.3%	**Treated, 25 mph, Conveyor**
93.1%	Treated, 25 mph, Y-Chute
87.2%	Untreated, 25 mph, Conveyor
78.3%	Untreated, 25 mph, Y-Chute
74.4%	Treated, 35, Conveyor
58.2%	Treated, 35 mph, Y-Chute
57.3%	Treated, 45, Conveyor
54.3%	Untreated, 35 mph, Y-Chute
53.0%	Untreated, 35 mph, Conveyor
44.4%	Untreated, 45 mph, Y-Chute
43.5%	Untreated, 45 mph, Conveyor
35.7%	*Treated, 45 mph, Y-Chute**
Total Percent Retained ± 12' (Green + Yellow + Orange):	
100.0%	**Treated, 25 mph, Conveyor**
100.0%	**Treated, 25 mph, Y-Chute**
95.2%	Untreated, 25 mph, Conveyor
91.5%	Untreated, 25 mph, Y-Chute
86.9%	Treated, 35, Conveyor
75.6%	Treated, 35 mph, Y-Chute
75.1%	Untreated, 35 mph, Conveyor
73.7%	Treated, 45, Conveyor
70.3%	Untreated, 35 mph, Y-Chute
64.6%	Untreated, 45 mph, Conveyor
64.2%	Untreated, 45 mph, Y-Chute
50.1%	*Treated, 45 mph, Y-Chute**
	** data trends do not correlate with other test info.*

Data Analysis: Potential Cost Savings

To give an idea on how the data collected from this bounce and scatter study can lead to cost saving measures for winter operations, OFS examined historical usage information from one of MDOT's seven regions. The Southwest Region's historical 5-year salt-use average equates to 66,000 tons of salt per year, and includes treated and untreated salt. The 2011-2012 average unit price of salt was approximately $60.00 per ton. For this scenario, the Southwest Region spends $3,960,000 on salt for a season.

Since truck speed plays the biggest role in how far salt will bounce and scatter, Table 3 compares speeds costs by using data collected from the rear cross conveyor that applied the treated salt (data supports that most effective method is a conveyor applying treated salt at 25 mph). When assessing the cost benefits it is assumed that the green "target" zone is 100 percent effective, the yellow zone is 67 percent effective, the orange zone 33 percent effective, and the red zone is 100 percent non-effective. All non-effective portions are considered waste.

Table 3: Speed Example Cost Comparison

MDOT Southwest Region Data			5-yr Avg Use (tons)	2011-2012 Avg Unit Cost	Avg Year Costs
Speed Cost Comparison			***66000***	***$60.00***	***$3,960,000.00***
25 mph, Conveyor, Treated Salt					
Graph Data		**% Effective**	**Benefit Cost**	**% Non-Effective**	**Waste Cost**
green	77.80%	100.00%	$3,080,880.00	0.00%	$0.00
yellow	17.50%	66.67%	$462,000.00	33.33%	$231,000.00
orange	4.70%	33.33%	$62,040.00	66.67%	$124,080.00
red	0.00%	0.00%	$0.00	100.00%	$0.00
		Totals:	**$3,604,920.00**		**$355,080.00**
35 mph, Conveyor, Treated Salt					
Graph Data		**% Effective**	**Benefit Cost**	**% Non-Effective**	**Waste Cost**
green	44.30%	100.00%	$1,754,280.00	0.00%	$0.00
yellow	30.20%	66.67%	$797,280.00	33.33%	$398,640.00
orange	12.50%	33.33%	$165,000.00	66.67%	$330,000.00
red	13.10%	0.00%	$0.00	100.00%	$518,760.00
		Totals:	**$2,716,560.00**		**$1,247,400.00**
45 mph, Conveyor, Treated Salt					
Graph Data		**% Effective**	**Benefit Cost**	**% Non-Effective**	**Waste Cost**
green	35.50%	100.00%	$1,405,800.00	0.00%	$0.00
yellow	21.80%	66.67%	$575,520.00	33.33%	$287,760.00
orange	16.40%	33.33%	$216,480.00	66.67%	$432,960.00
red	26.30%	0.00%	$0.00	100.00%	$1,041,480.00
		Totals:	**$2,197,800.00**		**$1,762,200.00**

The information in Table 3 suggests that applying salt at a 45 mph speed yields over four times as much waste then applying salt at 25 mph. However, it should be noted that the data presented in this report takes into account only the cost of salt and does not factor in additional staff time, fuel usage or other costs associated with applying salt at a slower speed. Other relevant decision making factors such as mobility/user delay costs, route length (time) and staffing costs need to be considered when choosing a salt application speed.

Using a similar approach, Table 4 examines how the use of treated salt promotes more effective cost savings versus untreated salt.

Table 4: Salt Type Example Cost Comparison

MDOT Southwest Region Data			5-yr Avg Use (tons)	2011-2012 Avg Unit Cost	Avg Year Costs
Salt Type Cost Comparison			*66000*	*$60.00*	*$3,960,000.00*
Untreated Salt, 25 mph, Conveyor					
Graph Data		**% Effective**	**Benefit Cost**	**% Non-Effective**	**Waste Cost**
green	65.20%	100.00%	$2,581,920.00	0.00%	$0.00
yellow	22.00%	66.67%	$580,800.00	33.33%	$290,400.00
orange	7.90%	33.33%	$104,280.00	66.67%	$208,560.00
red	4.80%	0.00%	$0.00	100.00%	$190,080.00
		Totals:	**$3,267,000.00**		**$689,040.00**
Treated Salt, 25 mph, Conveyor					
Graph Data		**% Effective**	**Benefit Cost**	**% Non-Effective**	**Waste Cost**
green	77.80%	100.00%	$3,080,880.00	0.00%	$0.00
yellow	17.50%	66.67%	$462,000.00	33.33%	$231,000.00
orange	4.70%	33.33%	$62,040.00	66.67%	$124,080.00
red	0.00%	0.00%	$0.00	100.00%	$0.00
		Totals:	**$3,604,920.00**		**$355,080.00**
Untreated Salt, 35 mph, Conveyor					
Graph Data		**% Effective**	**Benefit Cost**	**% Non-Effective**	**Waste Cost**
green	29.40%	100.00%	$1,164,240.00	0.00%	$0.00
yellow	23.60%	66.67%	$623,040.00	33.33%	$311,520.00
orange	22.00%	33.33%	$290,400.00	66.67%	$580,800.00
red	24.90%	0.00%	$0.00	100.00%	$986,040.00
		Totals:	**$2,077,680.00**		**$1,878,360.00**
Treated Salt, 35 mph, Conveyor					
Graph Data		**% Effective**	**Benefit Cost**	**% Non-Effective**	**Waste Cost**
green	44.30%	100.00%	$1,754,280.00	0.00%	$0.00
yellow	30.20%	66.67%	$797,280.00	33.33%	$398,640.00
orange	12.50%	33.33%	$165,000.00	66.67%	$330,000.00
red	13.10%	0.00%	$0.00	100.00%	$518,760.00
		Totals:	**$2,716,560.00**		**$1,247,400.00**

MDOT Southwest Region Data			5-yr Avg Use (tons)	2011-2012 Avg Unit Cost	Avg Year Costs
Salt Type Cost Comparison			*66000*	*$60.00*	*$3,960,000.00*
Untreated Salt, 35 mph, Y-Chute					
Graph Data		**% Effective**	**Benefit Cost**	**% Non-Effective**	**Waste Cost**
green	28.80%	100.00%	$1,140,480.00	0.00%	$0.00
yellow	25.50%	66.67%	$673,200.00	33.33%	$336,600.00
orange	16.00%	33.33%	$211,200.00	66.67%	$422,400.00
red	29.70%	0.00%	$0.00	100.00%	$1,176,120.00
		Totals:	**$2,024,880.00**		**$1,935,120.00**
Treated Salt, 35 mph, Y-Chute					
Graph Data		**% Effective**	**Benefit Cost**	**% Non-Effective**	**Waste Cost**
green	29.80%	100.00%	$1,180,080.00	0.00%	$0.00
yellow	28.30%	66.67%	$747,120.00	33.33%	$373,560.00
orange	17.40%	33.33%	$229,680.00	66.67%	$459,360.00
red	24.40%	0.00%	$0.00	100.00%	$966,240.00
		Totals:	**$2,156,880.00**		**$1,799,160.00**

Conclusions

The data presented in this report shows there are significant differences in the amount of bounce and scatter of salt between the scenarios tested. The most obvious of these differences is the effect truck speed has on salt bounce and scatter, regardless of delivery system or salt type used. Results show that, by far, there is less scatter of salt, when it is applied at a 25 mph speed. The percentage of salt that remains in the target area at 25 mph is close to, if not more than, double than the amount retained at 35 mph. What also is interesting is that a more dramatic spike in salt scatter occurs when comparing results at 25 mph to 35 mph than when comparing results at 35 mph to 45 mph. The data presented in this report also validates the

conclusions presented in the “Pre-wetted Salt Report” released by MDOT in the early 1970s, which concluded that pre-wetting salt reduces salt loss due to bounce and scatter because of better control of the salt application. Treated salt at all speeds and with both types of distribution systems performed better than dry salt.

The most effective scenario of the 12 tested in this study to reduce salt bounce and scatter, occurs when a treated salt product is applied with a cross conveyor from a truck traveling at 25 mph. Conversely, salt bounce and scatter is at its highest when applied from a Y-chute delivery system in a truck traveling at 45 mph.

While these tests were not performed in winter-like conditions, the consensus is that the results are still valid. The amount of salt retained on the pavement would likely change if the pavement was snow-covered and influenced by traffic. However, OFS believes this would have the same effect on all scenarios equally, negating the fact that the tests were performed on a dry road without traffic.

Utilizing the results of this study, OFS has developed the following recommendations:

- Salt should be applied at the lowest reasonable speed possible and every attempt should be made to follow the MDOT guideline that all salt must applied at speeds of 35 mph or below. Salt should be applied at 25 mph whenever possible.
- All salt applied by MDOT and its contract agency partners should be treated with a liquid deicer, using one of the common pre-wetting strategies.
- Additional testing of other types of delivery systems and at various heights off the pavement should be performed so more accurate conclusions of the most effective types of delivery systems can be made. Additional testing should include at a minimum: a zero velocity spreader, salt slurry generator and Y-chutes with varying chute heights.

Recommendations

For the safety of operators and the motoring public, the OFS recommends that operators follow the current MDOT 2011-2012 Winter Maintenance Manual guidelines that states “operators should never exceed 35 mph while applying material and sometimes even slower speeds are necessary."

Due to the proven reduction of the bounce and scatter of salt that has been treated, it is recommended that all of the salt being applied to the Michigan trunklines be pre-wet with a liquid deicer, utilizing any of the following methods; stock pile injecting, batching, pre-wetting a loaded truck, pre-wetting with an onboard spray system or purchasing pre-mixed “enhanced” salt.

OFS also recommends that this study be expanded, and that future research should include testing other types of material distribution systems, such as zero velocity and salt slurry type application equipment.

Appendix A

List of miscellaneous equipment:

Description	QTY	Model
1. Shop Vac	12	Rigid WD1270
2. Generator	6	2500-5000W Gas Powered
3. Samsonite digital scale	1	Hanging Digital
4. 100 ft. extension cord	12	12 Ga.
5. Broom	3	
6. Dust pan	1	
7. Camera	1	
8. Tractor w/broom	1	John Deere w/front broom
9. Backpack blower	1	
10. Marking paint	10	
11. 500 ft. retractable string line	1	
12. Cooler with water and ice	1	

Operations Field Services Division — Maintenance

Bounce and Scatter Data Sheet

Date	Air Temp	Weather Conditions
6/21/2012	79°F - 81°F	Mostly Cloudy

UNTREATED SALT

25 MPH Y-CHUTE

12 Foot Shoulder | 12 Foot Lane | 12 Foot Lane | 12 Foot Shoulder

4 FT | 4 FT | 4 FT | 4 FT | 4 FT | **8 FT TARGET AREA** | 4 FT | 4 FT | 4 FT | 4 FT | 4 FT

1 lb = 454 g

100 Foot Test Area

PASS #1

	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	NA *3010*	NA *2990*	3220	3360	3430	3900	4610	3880	3340	3180	NA *2940*	NA *2930*
Vac ID	A/G	B/H	C/I	D/J	E/K	F/L	A/G	B/H	C/I	D/J	E/K	F/L
Vac Wt (g)	3010	2990	2970	2930	2940	2930	3010	2990	2970	2930	2940	2930
Salt wt (g)	0	0	250	430	490	970	1600	890	370	250	0	0
	6 grain neg	12 grain neg									12 grain neg	4 grain neg

Time: 8:22 a.m.
Temp , Wind: 79°F , 13mph SW
NOTES:
*Negligible amounts in outside lanes (counted grains then cleared lanes).
*This pass not included in Avg due to heavier weights (1st pass of day included dirt).

Pass 1 Total Salt Collected	5250	11.56
	Wt (grams)	Wt (lbs)

PASS #2

	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	NA *3010*	NA *2990*	3050	3140	3400	3660	4000	3550	3290	3130	NA *2940*	NA *2930*
Vac ID	A/G	B/H	C/I	D/J	E/K	F/L	A/G	B/H	C/I	D/J	E/K	F/L
Vac Wt (g)	3010	2990	2970	2930	2940	2930	3010	2990	2970	2930	2940	2930
Salt wt (g)	**0**	**0**	**80**	**210**	**460**	**730**	**990**	**560**	**320**	**200**	**0**	**0**
	4 grain neg	9 grain neg									12 grain neg	5 grain neg

Time: 9:38 a.m.
Temp , Wind: 80°F, 15mph SW
NOTES:
*Chute dropped on yellow line.
*Negligible amounts in outside lanes (counted grains then cleared lanes).

Pass 2 Total Salt Collected	3550	7.82
	Wt (grams)	Wt (lbs)

PASS#3

	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	NA *3010*	NA *2990*	3040	3060	3170	3600	4000	3410	3180	3130	NA *2940*	NA *2930*
Vac ID	A/G	B/H	C/I	D/J	E/K	F/L	A/G	B/H	B/H	D/J	E/K	F/L
Vac Wt (g)	3010	2990	2970	2930	2940	2930	3010	2990	2990	2930	2940	2930
Salt wt (g)	**0**	**0**	**70**	**130**	**230**	**670**	**990**	**420**	**190**	**200**	**0**	**0**
	3 grain neg	2 grain neg									8 grain neg	3 grain neg

Time: 10:20 a.m.
Temp , Wind: 81°F, 16mph WSW
NOTES:
*Chute dropped on yellow line.
*Negligible amounts in outside lanes (counted grains then cleared lanes).
*Vacuum B/H used in lane I.

Pass 3 Total Salt Collected	2900	6.39
	Wt (grams)	Wt (lbs)

Application Rate	350 #/mile
Truck RPM	1650

DIRECTION OF TRAVEL & Salt Drop Zone

Theoretical Salt Totals per pass:
350 #/mi * 1mi/ 5280' *100' = **6.63#**

	A	B	C	D	E	F	G	H	I	J	K	L
Avg. Salt Wt. (g) (Pass 2&3)	***0.0***	***0.0***	***75.0***	***170.0***	***345.0***	***700.0***	***990.0***	***490.0***	***255.0***	***200.0***	***0.0***	***0.0***
Avg. Wt. Percent Distribution	***0.0%***	***0.0%***	***2.3%***	***5.3%***	***10.7%***	***21.7%***	***30.7%***	***15.2%***	***7.9%***	***6.2%***	***0.0%***	***0.0%***

Avg. Total	
Wt (g)	3225.0
Wt (lbs)	7.10

Operations Field Services Division

Maintenance

Bounce and Scatter Data Sheet

Date	Air Temp	Weather Conditions
6/21/2012	81°F - 71°F	Mostly Cloudy/ Overcast

UNTREATED SALT

35 MPH Y-CHUTE

12 Foot Shoulder | 12 Foot Lane | 12 Foot Lane | 12 Foot Shoulder

4 FT | 4 FT | 4 FT | 4 FT | 4 FT | **8 FT TARGET AREA** | 4 FT | 4 FT | 4 FT | 4 FT | 4 FT

1 lb = 454 g

PASS #1		**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Vac & Salt Combined Weight (grams)		3120	3040	3050	3090	3250	3290	3430	3310	3230	3200	3100	3100
Time:	10:58 a.m.												
Temp , Wind	81°F , 17mph WSW												
NOTES:	Vac ID	A/G	B/H	C/I	D/J	E/K	F/L	A/G	B/H	C/I	D/J	E/K	F/L
*Chute dropped on yellow line.	Vac Wt (g)	3010	2990	2970	2930	2940	2930	3010	2990	2970	2930	2940	2930
*Speed seemed faster than 25pmh runs.													
* Few grains bounced outside test are (neg)	**Salt wt (g)**	**110**	**50**	**80**	**160**	**310**	**360**	**420**	**320**	**260**	**270**	**160**	**170**
* First time lanes A, B, K, L vacummed.													
*Break for Lunch @ 11:45 a.m.													

PASS #2		**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Vac & Salt Combined Weight (grams)		3110	3140	3110	3110	3240	3290	3380	3340	3210	3180	3140	3060
Time:	12:58 p.m.												
Temp , Wind	76°F, 14mph NNW												
NOTES:	Vac ID	A/G	B/H	C/I	C/I	E/K	F/L	A/G	B/H	D/J	D/J	E/K	F/L
*Chute dropped approx 6" left of yellow line "F".	Vac Wt (g)	3010	2990	2970	2970	2940	2930	3010	2990	2930	2930	2940	2930
*brief rain sprinkles @ 1:18 p.m.	**Salt wt (g)**	**100**	**150**	**140**	**140**	**300**	**360**	**370**	**350**	**280**	**250**	**200**	**130**
*Vac C/I used in Lane D.													
*Vac D/J used in lane I.													

PASS#3		**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Vac & Salt Combined Weight (grams)		3070	3080	3050	3170	3180	3270	3640	3660	3270	3130	3080	3100
Time:	1:39 p.m.												
Temp , Wind	71°F, 5mph N												
NOTES:	Vac ID	A/G	B/H	C/I	D/J	E/K	F/L	A/G	B/H	C/I	D/J	E/K	F/L
*Chute dropped approx 6" left of yellow line "F".	Vac Wt (g)	3010	2990	2970	2930	2940	2930	3010	2990	2970	2930	2940	2930
	Salt wt (g)	**60**	**90**	**80**	**240**	**240**	**340**	**630**	**670**	**300**	**200**	**140**	**170**

100 Foot Test Area

Pass 1 Total Salt Collected	Wt (grams)	2670	5.88
	Wt (lbs)		

Pass 2 Total Salt Collected	Wt (grams)	2770	6.10
	Wt (lbs)		

Pass 3 Total Salt Collected	Wt (grams)	3160	6.96
	Wt (lbs)		

Application Rate	350 #/mile
Truck RPM	1600

DIRECTION OF TRAVEL & Salt Drop Zone

Theoretical Salt Totals per pass:
350 #/mi * 1mi/ 5280' *100' = **6.63#**

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Avg. Salt Wt. (g)	***90.0***	***96.7***	***100.0***	***180.0***	***283.3***	***353.3***	***473.3***	***446.7***	***280.0***	***240.0***	***166.7***	***156.7***
Avg. Wt. Percent Distribution	***3.1%***	***3.4%***	***3.5%***	***6.3%***	***9.9%***	***12.3%***	***16.5%***	***15.6%***	***9.8%***	***8.4%***	***5.8%***	***5.5%***

Avg. Total	
Wt (g)	2866.7
Wt (lbs)	6.31

Bounce and Scatter Data Sheet

Date	Air Temp	Weather Conditions
6/21/2012	70°F - 74°F	Mostly Cloudy/ Overcast/ Rain

UNTREATED SALT

45 MPH Y-CHUTE

12 Foot Shoulder | 12 Foot Lane | 12 Foot Lane | 12 Foot Shoulder

4 FT | 4 FT | 4 FT | 4 FT | 4 FT | **8 FT TARGET AREA** | 4 FT | 4 FT | 4 FT | 4 FT | 4 FT

1 lb = 454 g

PASS #1	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	3080	3070	3120	3180	3400	3520	3720	3610	3460	3220	3220	3090
Time: 2:16 p.m.												
Temp , Wind 70°F , 5mph NNW												
NOTES: *Chute dropped within 6" left of yellow line "F". *Speed seemed extremely fast. Done Vaccuming @ 2:50. Start Rain and Break. *picked out pieces of HMA from lane K before weighing.	Vac ID	A/G	B/H	C/I	D/J	E/K	F/L	A/G	B/H	C/I	D/J	E/K	F/L
	Vac Wt (g)	3010	2990	2970	2930	2940	2930	3010	2990	2970	2930	2940	2930
	Salt wt (g)	**70**	**80**	**150**	**250**	**460**	**590**	**710**	**620**	**490**	**290**	**280**	**160**

PASS #2	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	3180	2990	3140	3190	3200	3200	3250	3240	3040	3210	3160	3140
Time: 4:47 p.m.												
Temp , Wind 68°F, Calm												
NOTES: *Rain Stop 4:00. Broom and dry out track. *Chute dropped within 6" left of yellow line "F". *picked out pieces of HMA from lane K before weighing	Vac ID	A/G	B/H	C/I	D/J	E/K	F/L	A/G	B/H	C/I	D/J	E/K	F/L
	Vac Wt (g)	3010	2990	2970	2930	2940	2930	3010	2990	2970	2930	2940	2930
	Salt wt (g)	**170**	**0**	**170**	**260**	**260**	**270**	**240**	**250**	**70**	**280**	**220**	**210**

PASS#3	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	3130	3160	3190	3140	3160	3160	3280	3250	3300	3300	3210	3110
Time: 5:27 p.m.												
Temp , Wind 74°F, Calm												
NOTES: *Chute dropped within 6" left of yellow line "F". *Done for Day at 6:03 p.m. *picked out pieces of HMA from lane K before weighing	Vac ID	A/G	B/H	C/I	D/J	E/K	F/L	A/G	B/H	C/I	D/J	E/K	F/L
	Vac Wt (g)	3010	2990	2970	2930	2940	2930	3010	2990	2970	2930	2940	2930
	Salt wt (g)	**120**	**170**	**220**	**210**	**220**	**230**	**270**	**260**	**330**	**370**	**270**	**180**

100 Foot Test Area

Pass 1 Total Salt Collected	Wt (grams)	Wt (lbs)
	4150	9.14

Pass 2 Total Salt Collected	Wt (grams)	Wt (lbs)
	2400	5.29

Pass 3 Total Salt Collected	Wt (grams)	Wt (lbs)
	2850	6.28

Application Rate	350 #/mile
Truck RPM	1600

DIRECTION OF TRAVEL & Salt Drop Zone

Theoretical Salt Totals per pass:
350 lbs/mi * 1mi/ 5280' *100' : **6.63 lbs**

	A	B	C	D	E	F	G	H	I	J	K	L
Avg. Salt Wt. (g)	***120.0***	***125.0***	***180.0***	***240.0***	***313.3***	***363.3***	***406.7***	***376.7***	***410.0***	***313.3***	***256.7***	***183.3***
Avg. Wt. Percent Distribution	***3.6%***	***3.8%***	***5.5%***	***7.3%***	***9.5%***	***11.0%***	***12.4%***	***11.5%***	***12.5%***	***9.5%***	***7.8%***	***5.6%***

Avg. Total	
Wt (g)	3288.3
Wt (lbs)	7.24

Operations Field Services Division — Maintenance

Bounce and Scatter Data Sheet

Date	Air Temp	Weather Conditions
6/28/2012	93°F - 92°F	

TREATED SALT

25 MPH Y-CHUTE

12 Foot Shoulder | 12 Foot Lane | 12 Foot Lane | 12 Foot Shoulder

4 FT | 4 FT | 4 FT | 4 FT | 4 FT | **8 FT TARGET AREA** | 4 FT | 4 FT | 4 FT | 4 FT | 4 FT

1 lb = 454 g

100 Foot Test Area

PASS #1

	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	NA *2930*	NA *2970*	NA *2960*	NA *2960*	3160	3970	5320	3770	3210	NA *2930*	NA *2940*	NA *2930*
Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
Salt wt (g)	0	0	0	**0**	**190**	**940**	**2310**	**780**	**240**	0	0	0
	0 grain neg	0 grain neg	3 grain neg	9 grain neg						58 grain neg	8 grain neg	1 grain neg

Time: 4:00 p.m.
Temp , Wind 93°F , 13mph W

NOTES:
*Dropped right on yellow line.
*Truck 1700 rpm
* Negligible amounts present in outside lanes. Visual count taken in lieu of weight.

Pass 1 Total Salt Collected: Wt (grams) 4460 | Wt (lbs) 9.82

PASS #2

	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	NA *2930*	NA *2970*	NA *2960*	NA *2960*	3100	3570	4230	3580	3100	NA *2930*	NA *2940*	NA *2930*
Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
Salt wt (g)	0	0	0	**0**	**130**	**540**	**1220**	**590**	**130**	0	0	0
	0 grain neg	0 grain neg	9 grain neg	13 grain neg						39 grain neg	6 grain neg	1 grain neg

Time: 4:25 p.m.
Temp , Wind 92°F , 10mph W

NOTES:
*Initial pass poor drop, blow off and redo.
*Dropped right on yellow line.
* Negligible amounts present in outside lanes. Visual count taken in lieu of weight.

Pass 2 Total Salt Collected: Wt (grams) 2610 | Wt (lbs) 5.75

PASS#3

	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	NA *2930*	NA *2970*	NA *2960*	NA *2960*	2880	3380	4140	3840	3260	NA *2930*	NA *2940*	NA *2930*
Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
Salt wt (g)	0	0	0	**0**	**-90**	**350**	**1130**	**850**	**290**	0	0	0
	0 grain neg	2 grain neg	5 grain neg	10 grain neg						60 grain neg	3 grain neg	1 grain neg

Time: 4:43 p.m.
Temp , Wind 92°F , 10mph WNW

NOTES:
*Turned on Chute earlier (as asked).
*Done collecting for day at 4:54 p.m.
* Negligible amounts present in outside lanes. Visual count taken in lieu of weight.

Pass 3 Total Salt Collected: Wt (grams) 2530 | Wt (lbs) 5.57

Application Rate	350 #/mile
Truck RPM	1700

DIRECTION OF TRAVEL & Salt Drop Zone

Theoretical Salt Totals per pass:
350 #/mi * 1mi/ 5280' *100' = **6.63#**

	A	B	C	D	E	F	G	H	I	J	K	L
Avg. Salt Wt. (g)	***0.0***	***0.0***	***0.0***	***0.0***	***76.7***	***610.0***	***1553.3***	***740.0***	***220.0***	***0.0***	***0.0***	***0.0***
Avg. Wt. Percent Distribution	***0.0%***	***0.0%***	***0.0%***	***0.0%***	***2.4%***	***19.1%***	***48.5%***	***23.1%***	***6.9%***	***0.0%***	***0.0%***	***0.0%***

Avg. Total	
Wt (g)	3200.0
Wt (lbs)	7.05

Operations Field Services Division

Maintenance

Bounce and Scatter Data Sheet

Date	Air Temp	Weather Conditions
6/28/2012	93°F - 91°F	

TREATED SALT

35 MPH Y-CHUTE

12 Foot Shoulder | 12 Foot Lane | 12 Foot Lane | 12 Foot Shoulder

4 FT | 4 FT | 4 FT | 4 FT | 4 FT | **8 FT TARGET AREA** | 4 FT | 4 FT | 4 FT | 4 FT | 4 FT

1 lb = 454 g

PASS #1		A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)		NA *2930*	2970	3000	3140	3270	3270	3650	3560	3250	3200	3140	3090
Time:	12:03 p.m.												
Temp , Wind	93°F , 15mph W												
NOTES:	Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
	Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
	Salt wt (g)	**0** 4 grain neg	**0** few grain	**40**	**180**	**300**	**240**	**640**	**570**	**280**	**270**	**200**	**160**

PASS #2		A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)		*2930*	2990	2730	3060	3380	3440	3600	3530	3430	3220	3160	2990
Time:	12:21 p.m.												
Temp , Wind	91°F , 14mph WSW												
NOTES:	Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
*Dropped right on yellow line.	Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
	Salt wt (g)	**0** 3 grain	**20**	**-230**	**100**	**410**	**410**	**590**	**540**	**460**	**290**	**220**	**60**

PASS#3		A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)		2990	3010	3070	3120	3190	3320	3410	3390	3290	3160	3140	3060
Time:	12:39 p.m.												
Temp , Wind	92°F , 14mph WSW												
NOTES:	Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
*Done collecting at 12:53. next is 45mph conveyor.	Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
	Salt wt (g)	**60**	**40**	**110**	**160**	**220**	**290**	**400**	**400**	**320**	**230**	**200**	**130**

100 Foot Test Area

Pass 1 Total Salt Collected	Wt (grams)	2880	Wt (lbs)	6.34
Pass 2 Total Salt Collected	Wt (grams)	2870	Wt (lbs)	6.32
Pass 3 Total Salt Collected	Wt (grams)	2560	Wt (lbs)	5.64

Application Rate	350 #/mile
Truck RPM	1600

DIRECTION OF TRAVEL & Salt Drop Zone

Theoretical Salt Totals per pass:
350 #/mi * 1mi/ 5280' *100' = **6.63#**

	A	B	C	D	E	F	G	H	I	J	K	L
Avg. Salt Wt. (g)	***20.0***	***20.0***	***75.0***	***146.7***	***310.0***	***313.3***	***543.3***	***503.3***	***353.3***	***263.3***	***206.7***	***116.7***
Avg. Wt. Percent Distribution	***0.7%***	***0.7%***	***2.6%***	***5.1%***	***10.8%***	***10.9%***	***18.9%***	***17.5%***	***12.3%***	***9.2%***	***7.2%***	***4.1%***

Avg. Total	
Wt (g)	2871.7
Wt (lbs)	6.33

Operations Field Services Division

Maintenance

Bounce and Scatter Data Sheet

Date	Air Temp	Weather Conditions
6/28/2012	84°F - 86°F	

TREATED SALT

45 MPH Y-CHUTE

12 Foot Shoulder | 12 Foot Lane | 12 Foot Lane | 12 Foot Shoulder

4 FT | 4 FT | 4 FT | 4 FT | 4 FT | **8 FT TARGET AREA** | 4 FT | 4 FT | 4 FT | 4 FT | 4 FT

1 lb = 454 g

PASS #1	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	2980	3020	3080	3060	3090	3150	3300	3340	3360	3580	3620	3210
Time: 10:26 a.m.												
Temp , Wind 84°F , 16mph WSW												
NOTES: *Dropped within 6" left of yellow line. — Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
Salt wt (g)	**50**	**50**	**120**	**100**	**120**	**120**	**290**	**350**	**390**	**650**	**680**	**280**

PASS #2	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	3020	3020	3070	3100	3150	3270	3290	3230	3220	3170	3170	3090
Time: 10:48 a.m.												
Temp , Wind 85°F , 17mph WSW												
NOTES: — Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
Salt wt (g)	**90**	**50**	**110**	**140**	**180**	**240**	**280**	**240**	**250**	**240**	**230**	**160**

PASS#3	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	2980	2980	3040	3010	3130	3260	3290	3290	3160	3240	3400	3210
Time: 11:10 a.m.												
Temp , Wind 86°F , 17mph WSW												
NOTES: *Done collecting at 11:25. — Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
Salt wt (g)	**50**	**10**	**80**	**50**	**160**	**230**	**280**	**300**	**190**	**310**	**460**	**280**

100 Foot Test Area

Pass 1 Total Salt Collected	3200	7.05
	Wt (grams)	Wt (lbs)
Pass 2 Total Salt Collected	2210	4.87
	Wt (grams)	Wt (lbs)
Pass 3 Total Salt Collected	2400	5.29
	Wt (grams)	Wt (lbs)

Application Rate	350 #/mile
Truck RPM	1600

DIRECTION OF TRAVEL & Salt Drop Zone

Theoretical Salt Totals per pass:
350 #/mi * 1mi/ 5280' *100' = **6.63#**

	A	B	C	D	E	F	G	H	I	J	K	L
Avg. Salt Wt. (g)	***63.3***	***36.7***	***103.3***	***96.7***	***153.3***	***196.7***	***283.3***	***296.7***	***276.7***	***400.0***	***456.7***	***240.0***
Avg. Wt. Percent Distribution	***2.4%***	***1.4%***	***4.0%***	***3.7%***	***5.9%***	***7.6%***	***10.9%***	***11.4%***	***10.6%***	***15.4%***	***17.5%***	***9.2%***

Avg. Total	
Wt (g)	2603.3
Wt (lbs)	5.73

Operations Field Services Division — Maintenance

Bounce and Scatter Data Sheet

Date	Air Temp	Weather Conditions
6/28/2012	77°F - 78°F	

UNTREATED SALT

25 MPH CONVEYOR

12 Foot Shoulder | 12 Foot Lane | 12 Foot Lane | 12 Foot Shoulder

4 FT | 4 FT | 4 FT | 4 FT | 4 FT | **8 FT TARGET AREA** | 4 FT | 4 FT | 4 FT | 4 FT | 4 FT

1 lb = 454 g

PASS #1	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	NA *2930*	NA *2970*	3020	3050	3210	4810	4120	3410	3110	3070	NA *2940*	NA *2930*
Time: 6:48 a.m.												
Temp , Wind 77°F , 8mph SW												
NOTES: *Dropped 1' left of yellow * Negligible amounts present in outside lanes. Visual count taken in lieu of weight.	Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
	Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
	Salt wt (g)	**0** 12 grain neg	**0** 4 grain neg	**60**	**90**	**240**	**1780**	**1110**	**420**	**140**	**140**	**0** 5 grain neg	**0** 2 grain neg

PASS #2	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	NA *2930*	NA *2970*	2980	3070	3180	3640	4230	3580	3120	3030	NA *2940*	NA *2930*
Time: 7:13 a.m. ,												
Temp , Wind 77°F , 8mph SW												
NOTES: *Dropped right on yellow * Negligible amounts present in outside lanes. Visual count taken in lieu of weight. *1600-1700 truck RPM, 3rd gear.	Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
	Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
	Salt wt (g)	**0** 2 grain neg	**0** 13 grain neg	**20**	**110**	**210**	**610**	**1220**	**590**	**150**	**100**	**0** 10 grain neg	**0** 1 grain neg

PASS#3	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	NA *2930*	NA *2970*	2980	3040	3410	4270	3940	3420	3240	3100	NA *2940*	NA *2930*
Time: 7:33 a.m.												
Temp , Wind 78°F , 13mph WSW												
NOTES: *Dropped within 6" left of yellow * Negligible amounts present in outside lanes. Visual count taken in lieu of weight. *Done Vac 7:48 a.m.	Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
	Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
	Salt wt (g)	**0** 2 grain neg	**0** 8 grain neg	**20**	**80**	**440**	**1240**	**930**	**430**	**270**	**170**	**0** 29 grain neg	**0** 3 grain neg

100 Foot Test Area

Pass 1 Total Salt Collected	Wt (grams)	3980
	Wt (lbs)	8.77

Pass 2 Total Salt Collected	Wt (grams)	3010
	Wt (lbs)	6.63

Pass 3 Total Salt Collected	Wt (grams)	3580
	Wt (lbs)	7.89

Application Rate	350 #/mile
Truck RPM	1650

DIRECTION OF TRAVEL & Salt Drop Zone

Theoretical Salt Totals per pass:
350 #/mi * 1mi/ 5280' *100' = **6.63#**

	A	B	C	D	E	F	G	H	I	J	K	L
Avg. Salt Wt. (g)	***0.0***	***0.0***	***33.3***	***93.3***	***296.7***	***1210.0***	***1086.7***	***480.0***	***186.7***	***136.7***	***0.0***	***0.0***
Avg. Wt. Percent Distribution	***0.0%***	***0.0%***	***0.9%***	***2.6%***	***8.4%***	***34.3%***	***30.8%***	***13.6%***	***5.3%***	***3.9%***	***0.0%***	***0.0%***

Avg. Total	
Wt (g)	3523.3
Wt (lbs)	7.76

Operations Field Services Division

Maintenance

Bounce and Scatter Data Sheet

Date	Air Temp	Weather Conditions
6/28/2012	78°F	

UNTREATED SALT

35 MPH CONVEYOR

	12 Foot Shoulder			12 Foot Lane			12 Foot Lane			12 Foot Shoulder		
	4 FT	4 FT	4 FT	4 FT	4 FT	8 FT TARGET AREA	4 FT	4 FT	4 FT	4 FT	4 FT	
PASS #1	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Vac & Salt Combined Weight (grams)	NA *2930*	3010	3000	3020	3060	3160	3150	3110	3110	3120	3020	NA *2930*
Time: 7:57 a.m.												
Temp , Wind 78°F , 13mph WSW												
NOTES: Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
*Dropped within 6" left of yellow line. Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
*Truck 1600-1700 rpm in 4th gear.												
* Negligible amounts present in outside lanes. Visual count taken in lieu of weight. **Salt wt (g)**	0 15 grain neg	**40**	**40**	**60**	**90**	**130**	**140**	**120**	**140**	**190**	**80**	**0** 17 grain neg
PASS #2	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Vac & Salt Combined Weight (grams)	2990	3040	3080	3230	3490	3770	3880	3630	3660	3360	3200	NA *2930*
Time: 8:16 a.m.												
Temp , Wind 78°F , 13mph WSW												
NOTES: Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
*Dropped right on yellow line. Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
*More salt salt evident, and scatter betond grid. **Salt wt (g)**	**60**	**70**	**120**	**270**	**520**	**740**	**870**	**640**	**690**	**430**	**260**	**0** 36grain neg
*Jackson YDMP crew arrives.												
PASS#3	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Vac & Salt Combined Weight (grams)	2990	3040	3210	3270	3330	3480	3500	3520	3610	3340	3140	3040
Time: 8:40 a.m.												
Temp , Wind 78°F , 13mph WSW												
NOTES: Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
*Lansing YDMP crew arrives. Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
*Done collecting @ 9:00 a.m. **Salt wt (g)**	**60**	**70**	**250**	**310**	**360**	**450**	**490**	**530**	**640**	**410**	**200**	**110**

100 Foot Test Area

1 lb = 454 g

	Wt (grams)	Wt (lbs)
Pass 1 Total Salt Collected	1030	2.27
Pass 2 Total Salt Collected	4670	10.29
Pass 3 Total Salt Collected	3880	8.55

Application Rate	350 #/mile
Truck RPM	1500

DIRECTION OF TRAVEL & Salt Drop Zone

Theoretical Salt Totals per pass:
350 #/mi * 1mi/ 5280' *100' = **6.63#**

	A	B	C	D	E	F	G	H	I	J	K	L
Avg. Salt Wt. (g)	***40.0***	***60.0***	***136.7***	***213.3***	***323.3***	***440.0***	***500.0***	***430.0***	***490.0***	***343.3***	***180.0***	***36.7***
Avg. Wt. Percent Distribution	***1.3%***	***1.9%***	***4.3%***	***6.7%***	***10.1%***	***13.8%***	***15.7%***	***13.5%***	***15.3%***	***10.8%***	***5.6%***	***1.1%***

Avg. Total	
Wt (g)	3193.3
Wt (lbs)	7.03

Operations Field Services Division

Maintenance

Bounce and Scatter Data Sheet

Date	Air Temp	Weather Conditions
6/28/2012	79°F - 81°F	

UNTREATED SALT

45 MPH CONVEYOR

12 Foot Shoulder | 12 Foot Lane | 12 Foot Lane | 12 Foot Shoulder

4 FT | 4 FT | 4 FT | 4 FT | 4 FT | **8 FT TARGET AREA** | 4 FT | 4 FT | 4 FT | 4 FT | 4 FT

1 lb = 454 g

PASS #1	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	2980	3120	3200	3090	3170	3200	3220	3260	3280	3280	3120	3080
Time: 9:03 a.m.												
Temp , Wind 79°F , 13mph WSW												
NOTES: Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
Salt wt (g)	**50**	**150**	**240**	**130**	**200**	**170**	**210**	**270**	**310**	**350**	**180**	**150**

Pass 1 Total Salt Collected	Wt (grams)	Wt (lbs)
	2410	5.31

PASS #2	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	2970	3000	3030	3160	3190	3240	3340	3500	3490	3390	3150	3070
Time: 9:27 a.m.												
Temp , Wind 80°F , 14mph WSW												
NOTES: Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
*Dropped right on yellow line. Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
*Truck 1600 rpm, 5th gear.												
*Dropped within 6" left of yellow line. **Salt wt (g)**	**40**	**30**	**70**	**200**	**220**	**210**	**330**	**510**	**520**	**460**	**210**	**140**

Pass 2 Total Salt Collected	Wt (grams)	Wt (lbs)
	2940	6.48

PASS#3	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	3000	3080	3270	3390	3580	3620	3640	3510	3540	3460	3380	3040
Time: 9:48 a.m.												
Temp , Wind 81°F , 15mph WSW												
NOTES: Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
*Dropped within 6" left of yellow line. Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
*Truck 1600-1700 rpm in 4th gear.												
*Done collecting at 10:07 a.m. **Salt wt (g)**	**70**	**110**	**310**	**430**	**610**	**590**	**630**	**520**	**570**	**530**	**440**	**110**

Pass 3 Total Salt Collected	Wt (grams)	Wt (lbs)
	4920	10.84

100 Foot Test Area

Application Rate	350 #/mile
Truck RPM	1600

DIRECTION OF TRAVEL & Salt Drop Zone

Theoretical Salt Totals per pass:
350 #/mi * 1mi/ 5280' *100' = **6.63#**

	A	B	C	D	E	F	G	H	I	J	K	L
Avg. Salt Wt. (g)	***53.3***	***96.7***	***206.7***	***253.3***	***343.3***	***323.3***	***390.0***	***433.3***	***466.7***	***446.7***	***276.7***	***133.3***
Avg. Wt. Percent Distribution	***1.6%***	***2.8%***	***6.0%***	***7.4%***	***10.0%***	***9.4%***	***11.4%***	***12.7%***	***13.6%***	***13.0%***	***8.1%***	***3.9%***

Avg. Total	
Wt (g)	3423.3
Wt (lbs)	7.54

Operations Field Services Division — Maintenance

Bounce and Scatter Data Sheet

Date	Air Temp	Weather Conditions
6/28/2012	93°F - 95°F	

TREATED SALT

25 MPH CONVEYOR

12 Foot Shoulder | 12 Foot Lane | 12 Foot Lane | 12 Foot Shoulder

4 FT | 4 FT | 4 FT | 4 FT | 4 FT | **8 FT TARGET AREA** | 4 FT | 4 FT | 4 FT | 4 FT | 4 FT

1 lb = 454 g

PASS #1

	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	NA *2930*	NA *2970*	NA *2960*	3050	3480	7650	4310	3480	3130	NA *2930*	NA *2940*	NA *2930*
Time: 3:04 p.m.												
Temp , Wind 95°F , 14mph W												
NOTES: Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
*Dropped within 1' left of yellow line. Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
*Truck 1500-1600 rpm, 3rd gear.												
* Negligible amounts present in outside lanes. Visual count taken in lieu of weight. **Salt wt (g)**	0	0	0	**90**	**510**	**4620**	**1300**	**490**	**160**	0	0	0
	0 grain neg	0 grain neg	2 grain neg							22grain neg	0 grain neg	6 grain neg

Pass 1 Total Salt Collected: Wt (grams) 7170 | Wt (lbs) 15.79

PASS #2

	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	NA *2930*	NA *2970*	NA *2960*	3050	3410	5980	4610	3390	3110	NA *2930*	NA *2940*	NA *2930*
Time: 3:24 p.m.												
Temp , Wind 95°F , 14mph W												
NOTES: Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
*Dropped right on yellow line.												
* Negligible amounts present in outside lanes. Visual count taken in lieu of weight. **Salt wt (g)**	0	0	0	**90**	**440**	**2950**	**1600**	**400**	**140**	0	0	0
	2 grain neg	0 grain neg	4 grain neg							11 grain neg	7 grain neg	3 grain neg

Pass 2 Total Salt Collected: Wt (grams) 5620 | Wt (lbs) 12.38

PASS#3

	A	B	C	D	E	F	G	H	I	J	K	L
Vac & Salt Combined Weight (grams)	NA *2930*	NA *2970*	NA *2960*	3060	3480	4070	4000	3450	3150	NA *2930*	NA *2940*	NA *2930*
Time: 3:45 p.m.												
Temp , Wind 93°F , 14mph W												
NOTES: Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
*Dropped within 1' left of yellow line. Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
* Negligible amounts present in outside lanes. Visual count taken in lieu of weight. **Salt wt (g)**	0	0	0	**100**	**510**	**1040**	**990**	**460**	**180**	0	0	0
	0 grain neg	2 grain neg	5 grain neg							10 grain neg	2 grain neg	6 grain neg

Pass 3 Total Salt Collected: Wt (grams) 3280 | Wt (lbs) 7.22

100 Foot Test Area

Application Rate	350 #/mile
Truck RPM	1600

DIRECTION OF TRAVEL & Salt Drop Zone

Theoretical Salt Totals per pass:
350 #/mi * 1mi/ 5280' *100' = **6.63#**

	A	B	C	D	E	F	G	H	I	J	K	L
Avg. Salt Wt. (g)	***0.0***	***0.0***	***0.0***	***93.3***	***486.7***	***2870.0***	***1296.7***	***450.0***	***160.0***	***0.0***	***0.0***	***0.0***
Avg. Wt. Percent Distribution	***0.0%***	***0.0%***	***0.0%***	***1.7%***	***9.1%***	***53.6%***	***24.2%***	***8.4%***	***3.0%***	***0.0%***	***0.0%***	***0.0%***

Avg. Total	
Wt (g)	5356.7
Wt (lbs)	11.80

Operations Field Services Division

Maintenance

Bounce and Scatter Data Sheet

Date	Air Temp	Weather Conditions
6/28/2012	93°F - 94°F	

TREATED SALT

35 MPH Y-CONVEYOR

12 Foot Shoulder | 12 Foot Lane | 12 Foot Lane | 12 Foot Shoulder

4 FT | 4 FT | 4 FT | 4 FT | 4 FT | **8 FT TARGET AREA** | 4 FT | 4 FT | 4 FT | 4 FT | 4 FT

1 lb = 454 g

PASS #1	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Vac & Salt Combined Weight (grams)	2990	3030	3140	3400	4080	4040	4240	3700	3280	3170	3160	NA *2930*
Time: 1:48 p.m.												
Temp , Wind 93°F , 16mph W												
NOTES: Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
*Truck 1200 rpm, 3rd gear. Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
*Lansing YDMP leave **Salt wt (g)**	**60**	**60**	**180**	**440**	**1110**	**1010**	**1230**	**710**	**310**	**240**	**220**	**0** 8 grain neg

PASS #2	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Vac & Salt Combined Weight (grams)	2980	2980	3080	3220	3550	3760	4090	3720	3380	3210	3210	NA *2930*
Time: 2:08 p.m.												
Temp , Wind 93°F , 16mph W												
NOTES: Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
*Jackson YDMP leave Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
Salt wt (g)	**50**	**10**	**120**	**260**	**580**	**730**	**1080**	**730**	**410**	**280**	**270**	**0** 12grain neg

PASS#3	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Vac & Salt Combined Weight (grams)	NA *2930*	2990	2990	3100	3620	4460	3800	3480	3180	3090	3090	NA *2930*
Time: 2:28 p.m.												
Temp , Wind 94°F , 15mph W												
NOTES: Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
*Done collecting at 2:45. next is Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
25mph conveyor. **Salt wt (g)**	**0**	**20**	**30**	**140**	**650**	**1430**	**790**	**490**	**210**	**160**	**150**	**0**
	neg											neg

100 Foot Test Area

Pass 1 Total Salt Collected	Wt (grams)	Wt (lbs)
	5570	12.27

Pass 2 Total Salt Collected	Wt (grams)	Wt (lbs)
	4520	9.96

Pass 3 Total Salt Collected	Wt (grams)	Wt (lbs)
	4070	8.96

Application Rate	350 #/mile
Truck RPM	1200

DIRECTION OF TRAVEL & Salt Drop Zone

Theoretical Salt Totals per pass:
350 #/mi * 1mi/ 5280' *100' = **6.63#**

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Avg. Salt Wt. (g)	***36.7***	***30.0***	***110.0***	***280.0***	***780.0***	***1056.7***	***1033.3***	***643.3***	***310.0***	***226.7***	***213.3***	***0.0***
Avg. Wt. Percent Distribution	***0.8%***	***0.6%***	***2.3%***	***5.9%***	***16.5%***	***22.4%***	***21.9%***	***13.6%***	***6.6%***	***4.8%***	***4.5%***	***0.0%***

Avg. Total	
Wt (g)	4720.0
Wt (lbs)	10.40

Operations Field Services Division

Maintenance

Bounce and Scatter Data Sheet

Date	Air Temp	Weather Conditions
6/28/2012	93°F - 92°F	

TREATED SALT

45 MPH CONVEYOR

12 Foot Shoulder | 12 Foot Lane | 12 Foot Lane | 12 Foot Shoulder

4 FT | 4 FT | 4 FT | 4 FT | 4 FT | **8 FT TARGET AREA** | 4 FT | 4 FT | 4 FT | 4 FT | 4 FT

1 lb = 454 g

PASS #1		**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Vac & Salt Combined Weight (grams)		2960	3010	3160	3120	3170	3230	3240	3160	3080	3080	3120	3080
Time:	12:58 p.m.												
Temp , Wind	93°F , 13mph W												
NOTES:	Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
*Truck 4th gear.	Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
	Salt wt (g)	**30**	**40**	**200**	**160**	**200**	**200**	**230**	**170**	**110**	**150**	**180**	**150**

PASS #2		**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Vac & Salt Combined Weight (grams)		2990	3020	3110	3340	3530	3740	3820	3630	3550	3630	3400	3100
Time:	1:13 p.m.												
Temp , Wind	93°F , 13mph WSW												
NOTES:	Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
	Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
	Salt wt (g)	**60**	**50**	**150**	**380**	**560**	**710**	**810**	**640**	**580**	**700**	**460**	**170**

PASS#3		**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Vac & Salt Combined Weight (grams)		2960	3010	3140	3420	3640	4090	4260	3370	3250	3180	3140	3050
Time:	1:31 p.m.												
Temp , Wind	92°F , 17mph WSW												
NOTES:	Vac ID	A	B	C	D	E	F	G	H	I	J	K	L
*Done collecting at 1:47.	Vac Wt (g)	2930	2970	2960	2960	2970	3030	3010	2990	2970	2930	2940	2930
	Salt wt (g)	**30**	**40**	**180**	**460**	**670**	**1060**	**1250**	**380**	**280**	**250**	**200**	**120**

100 Foot Test Area

Pass 1 Total Salt Collected	Wt (grams)	1820
	Wt (lbs)	4.01

Pass 2 Total Salt Collected	Wt (grams)	5270
	Wt (lbs)	11.61

Pass 3 Total Salt Collected	Wt (grams)	4920
	Wt (lbs)	10.84

Application Rate	350 #/mile
Truck RPM	1600

DIRECTION OF TRAVEL & Salt Drop Zone

Theoretical Salt Totals per pass:
350 #/mi * 1mi/ 5280' *100' = **6.63#**

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Avg. Salt Wt. (g)	***40.0***	***43.3***	***176.7***	***333.3***	***476.7***	***656.7***	***763.3***	***396.7***	***323.7***	***366.7***	***280.0***	***146.7***
Avg. Wt. Percent Distribution	***1.0%***	***1.1%***	***4.4%***	***8.3%***	***11.9%***	***16.4%***	***19.1%***	***9.9%***	***8.1%***	***9.2%***	***7.0%***	***3.7%***

Avg. Total	
Wt (g)	4003.3
Wt (lbs)	8.82

Bounce and Scatter Data Summary Sheet

	A	B	C	D	E	F	G	H	I	J	K	L	
Avg. Wt. Percent Dist	0.0%	0.0%	2.3%	5.3%	10.7%	21.7%	30.7%	15.2%	7.9%	6.2%	0.0%	0.0%	Untreated, 25 mph, Y-Chute
Avg. Wt. Percent Dist	3.1%	3.4%	3.5%	6.3%	9.9%	12.3%	16.5%	15.6%	9.8%	8.4%	5.8%	5.5%	Untreated, 35 mph, Y-Chute
Avg. Wt. Percent Dist	3.6%	3.8%	5.5%	7.3%	9.5%	11.0%	12.4%	11.5%	***12.5%***	9.5%	7.8%	5.6%	Untreated, 45 mph, Y-Chute
Avg. Wt. Percent Dist	0.0%	0.0%	0.0%	0.0%	2.4%	19.1%	48.5%	23.1%	6.9%	0.0%	0.0%	0.0%	Treated, 25 mph, Y-Chute
Avg. Wt. Percent Dist	0.7%	0.7%	2.6%	5.1%	10.8%	10.9%	18.9%	17.5%	12.3%	9.2%	7.2%	4.1%	Treated, 35 mph, Y-Chute
Avg. Wt. Percent Dist	2.4%	1.4%	4.0%	3.7%	5.9%	7.6%	10.9%	11.4%	10.6%	15.4%	17.5%	9.2%	Treated, 45 mph, Y-Chute
Avg. Wt. Percent Dist	0.0%	0.0%	0.9%	2.6%	8.4%	34.3%	30.8%	13.6%	5.3%	3.9%	0.0%	0.0%	Untreated, 25 mph, Conveyor
Avg. Wt. Percent Dist	1.3%	1.9%	4.3%	6.7%	10.1%	13.8%	15.7%	***13.5%***	15.3%	10.8%	5.6%	1.1%	Untreated, 35 mph, Conveyor
Avg. Wt. Percent Dist	1.6%	2.8%	6.0%	7.4%	***10.0%***	9.4%	11.4%	12.7%	13.6%	13.0%	8.1%	3.9%	Untreated, 45 mph, Conveyor
Avg. Wt. Percent Dist	0.0%	0.0%	0.0%	1.7%	9.1%	53.6%	24.2%	8.4%	3.0%	0.0%	0.0%	0.0%	Treated, 25 mph, Conveyor
Avg. Wt. Percent Dist	0.8%	0.6%	2.3%	5.9%	16.5%	22.4%	21.9%	13.6%	6.6%	4.8%	4.5%	0.0%	Treated, 35 mph, Conveyor
Avg. Wt. Percent Dist	1.0%	1.1%	4.4%	8.3%	11.9%	16.4%	19.1%	9.9%	***8.1%***	9.2%	7.0%	3.7%	Treated, 45 mph, Conveyor

Pass 1 (all lanes) not included in avgs (heavier).

Pass 2B and 2I not included in averages.

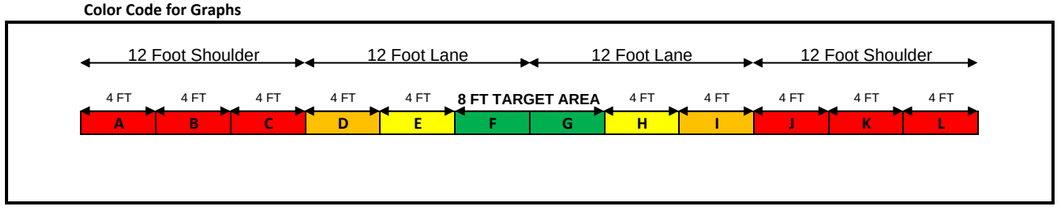
pass 2C not included in averages.

All values in pass 1 much lighter, but kept in avgs.
All values kept in avgs.

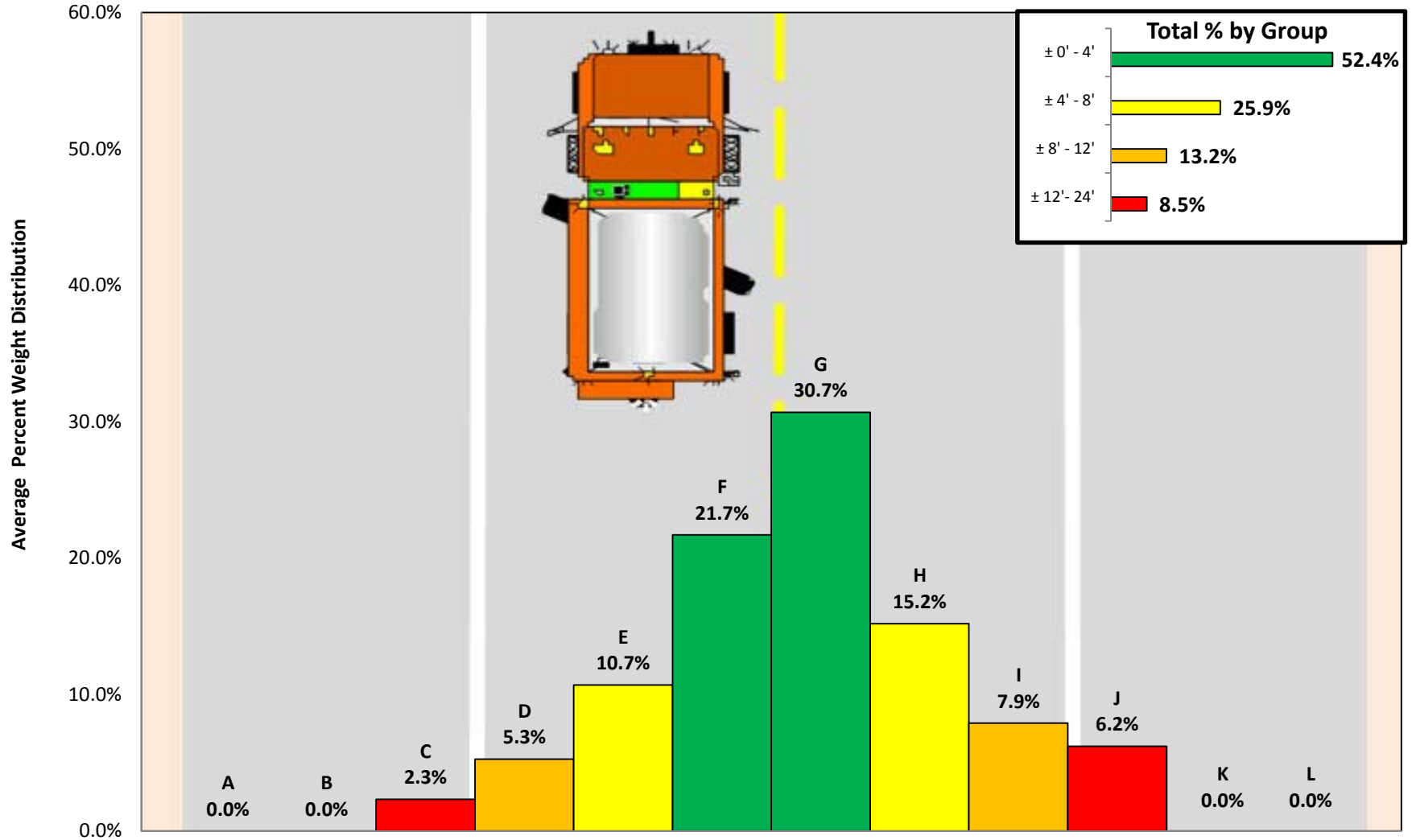
Red ± 12'- 24'	Orange ± 8' - 12'	Yellow ± 4' - 8'	Green ± 0' - 4'	Total % By Group
8.5%	13.2%	25.9%	52.4%	Untreated, 25 mph, Y-Chute
29.7%	16.0%	25.5%	28.8%	Untreated, 35 mph, Y-Chute
35.8%	19.8%	21.0%	23.4%	Untreated, 45 mph, Y-Chute
0.0%	6.9%	25.5%	67.6%	Treated, 25 mph, Y-Chute
24.4%	17.4%	28.3%	29.8%	Treated, 35 mph, Y-Chute
49.9%	14.3%	17.3%	18.4%	Treated, 45 mph, Y-Chute
4.8%	7.9%	22.0%	65.2%	Untreated, 25 mph, Conveyor
24.9%	22.0%	23.6%	29.4%	Untreated, 35 mph, Conveyor
35.4%	21.0%	22.7%	20.8%	Untreated, 45 mph, Conveyor
0.0%	4.7%	17.5%	77.8%	Treated, 25 mph, Conveyor
13.1%	12.5%	30.2%	44.3%	Treated, 35 mph, Conveyor
26.3%	16.4%	21.8%	35.5%	Treated, 45 mph, Conveyor

Bold Italic values do not follow same trend as others in salt/truck type

Color Code for Graphs



Bounce and Scatter Collection Graphs



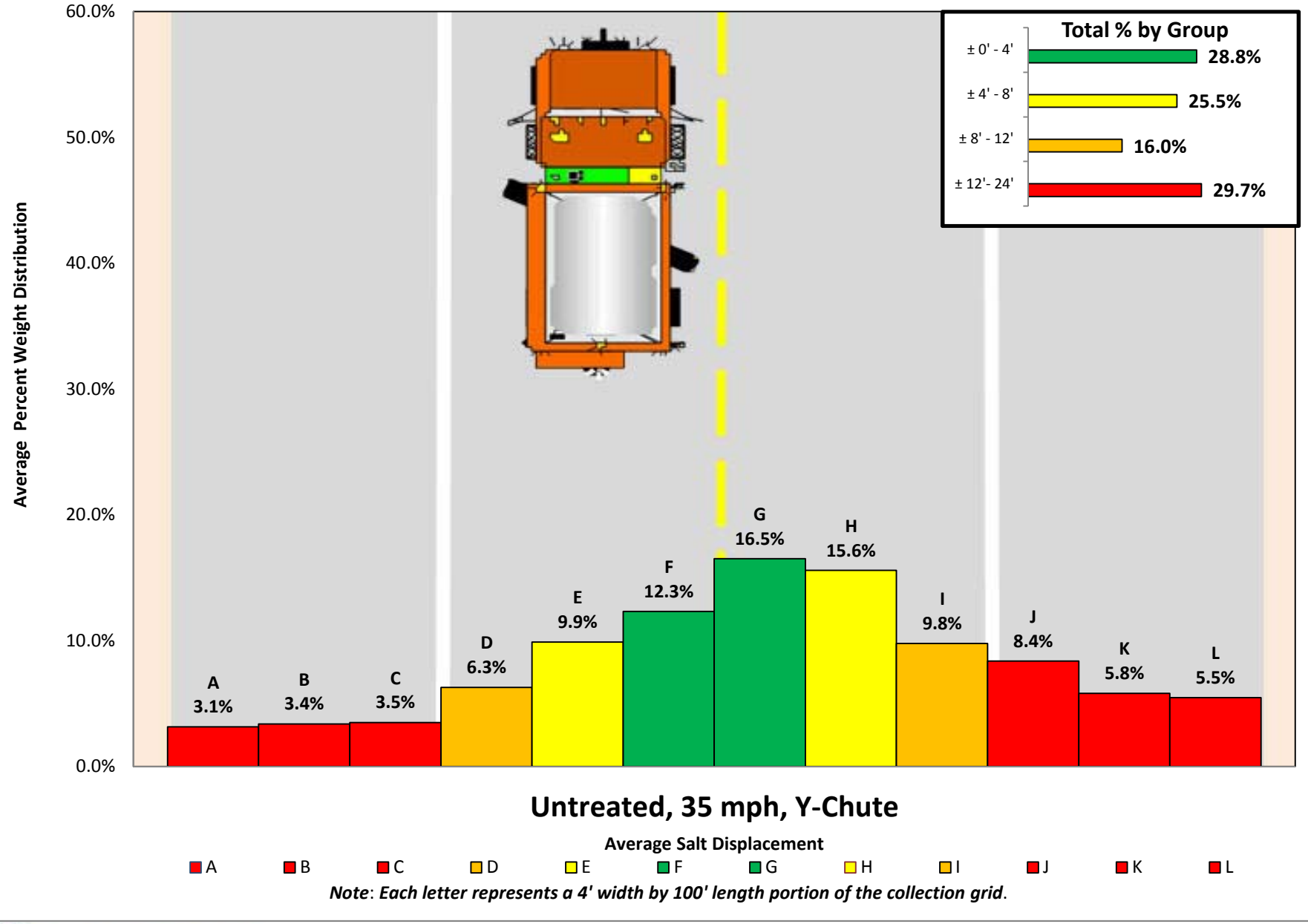
Untreated, 25 mph, Y-Chute

Average Salt Displacement

A B C D E F G H I J K L

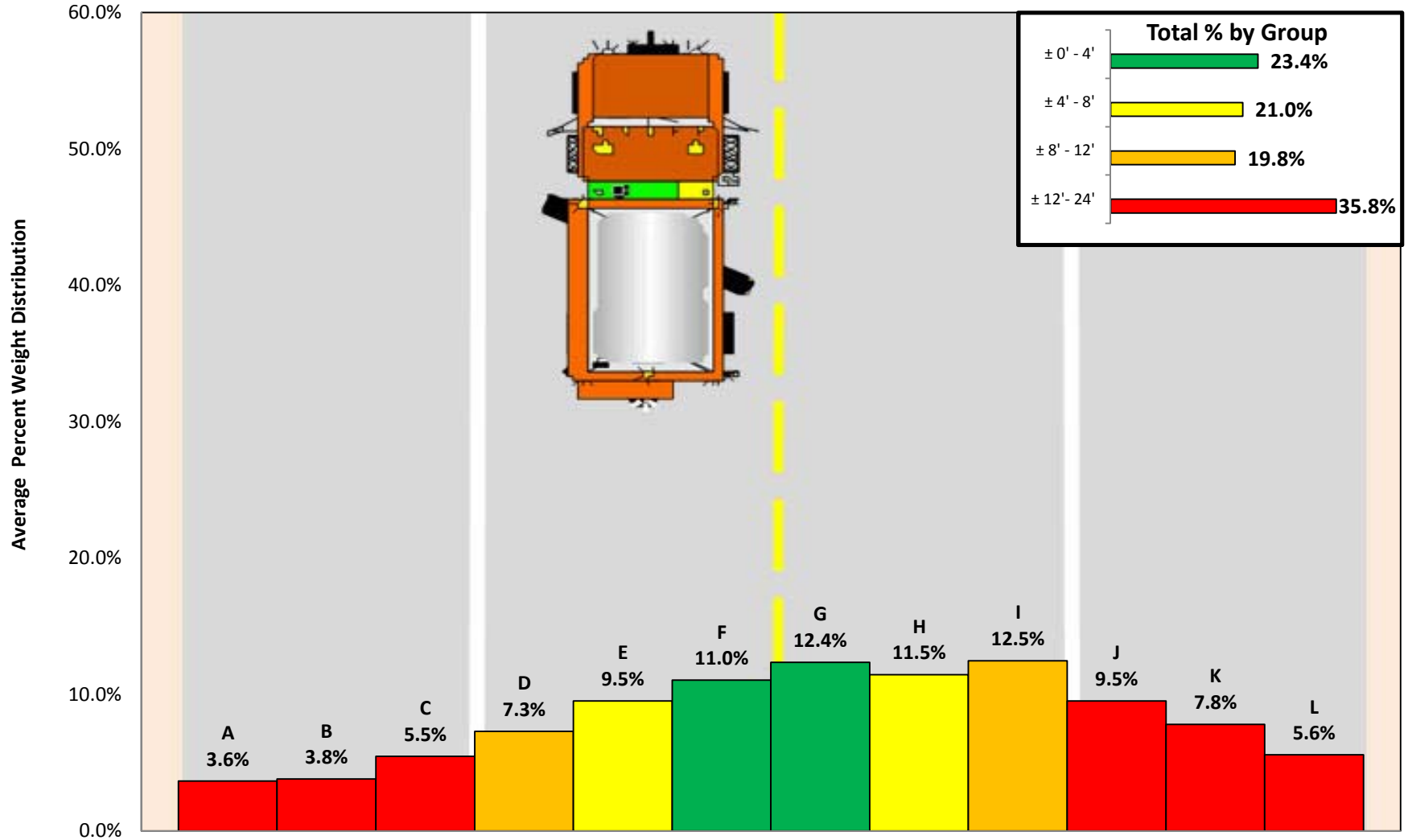
***Note**: Each letter represents a 4' width by 100' length portion of the collection grid.*

Bounce and Scatter Collection Graphs



***Note**: Each letter represents a 4' width by 100' length portion of the collection grid.*

Bounce and Scatter Collection Graphs



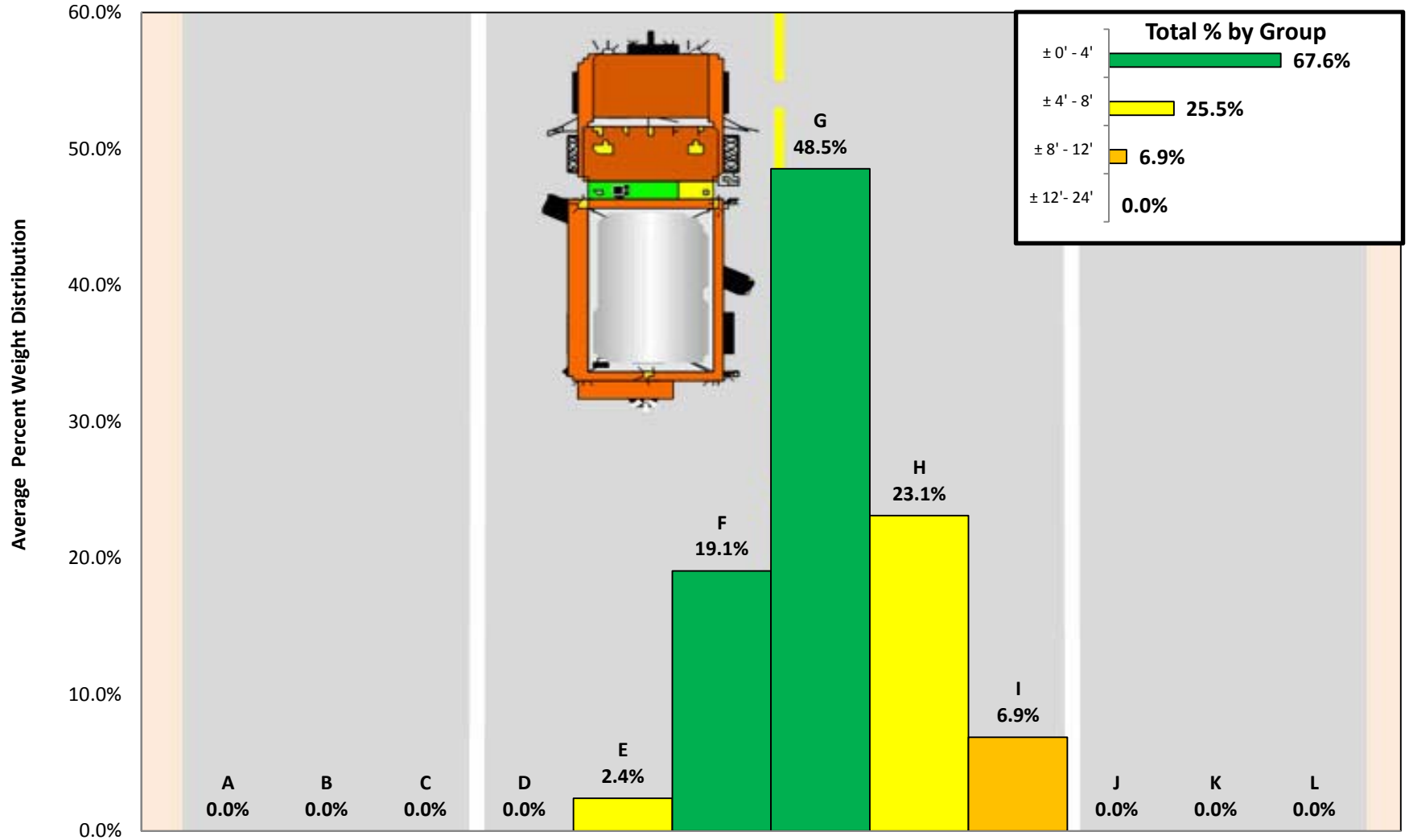
Untreated, 45 mph, Y-Chute

Average Salt Displacement

A B C D E F G H I J K L

***Note**: Each letter represents a 4' width by 100' length portion of the collection grid.*

Bounce and Scatter Collection Graphs



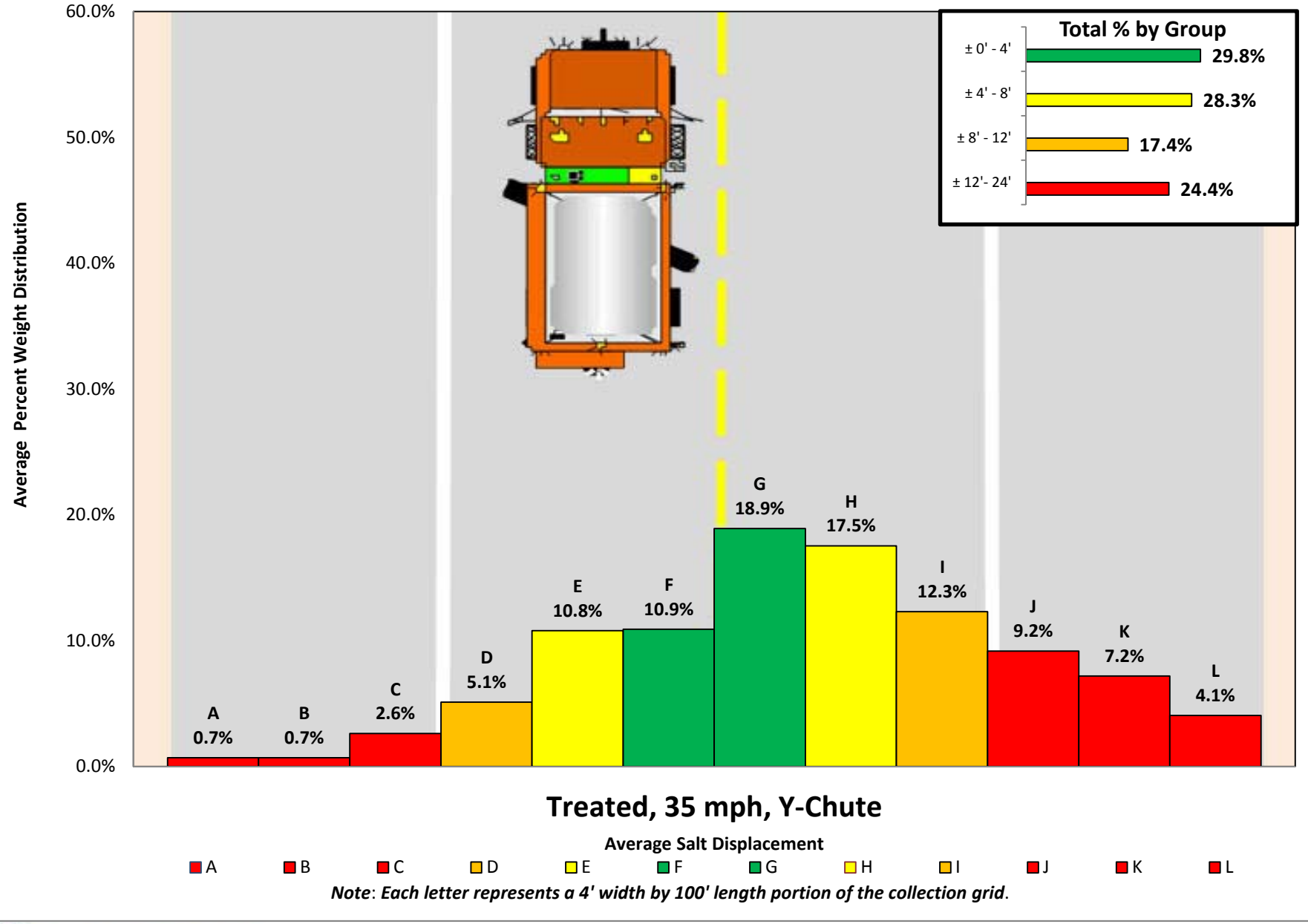
Treated, 25 mph, Y-Chute

Average Salt Displacement

A B C D E F G H I J K L

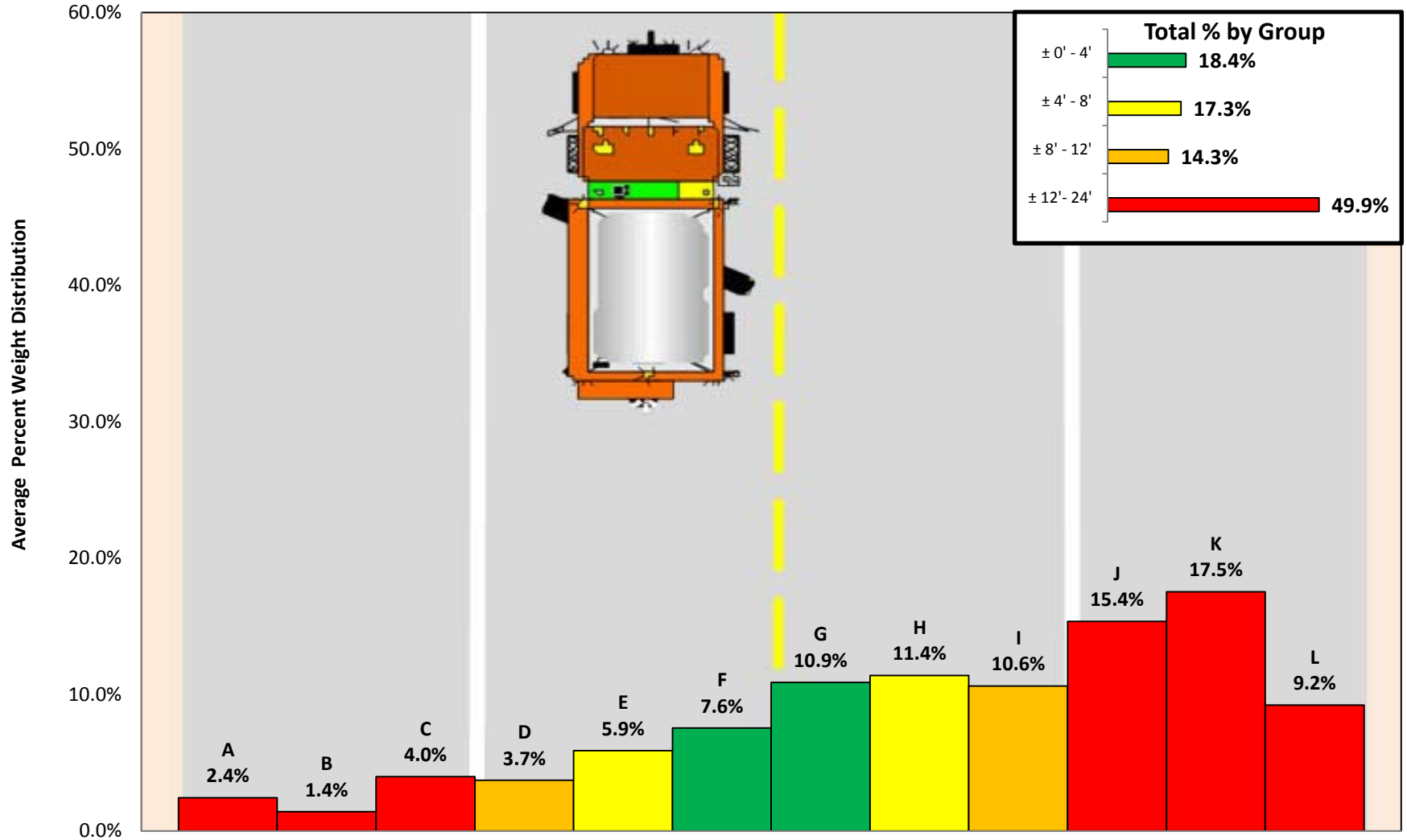
***Note**: Each letter represents a 4' width by 100' length portion of the collection grid.*

Bounce and Scatter Collection Graphs



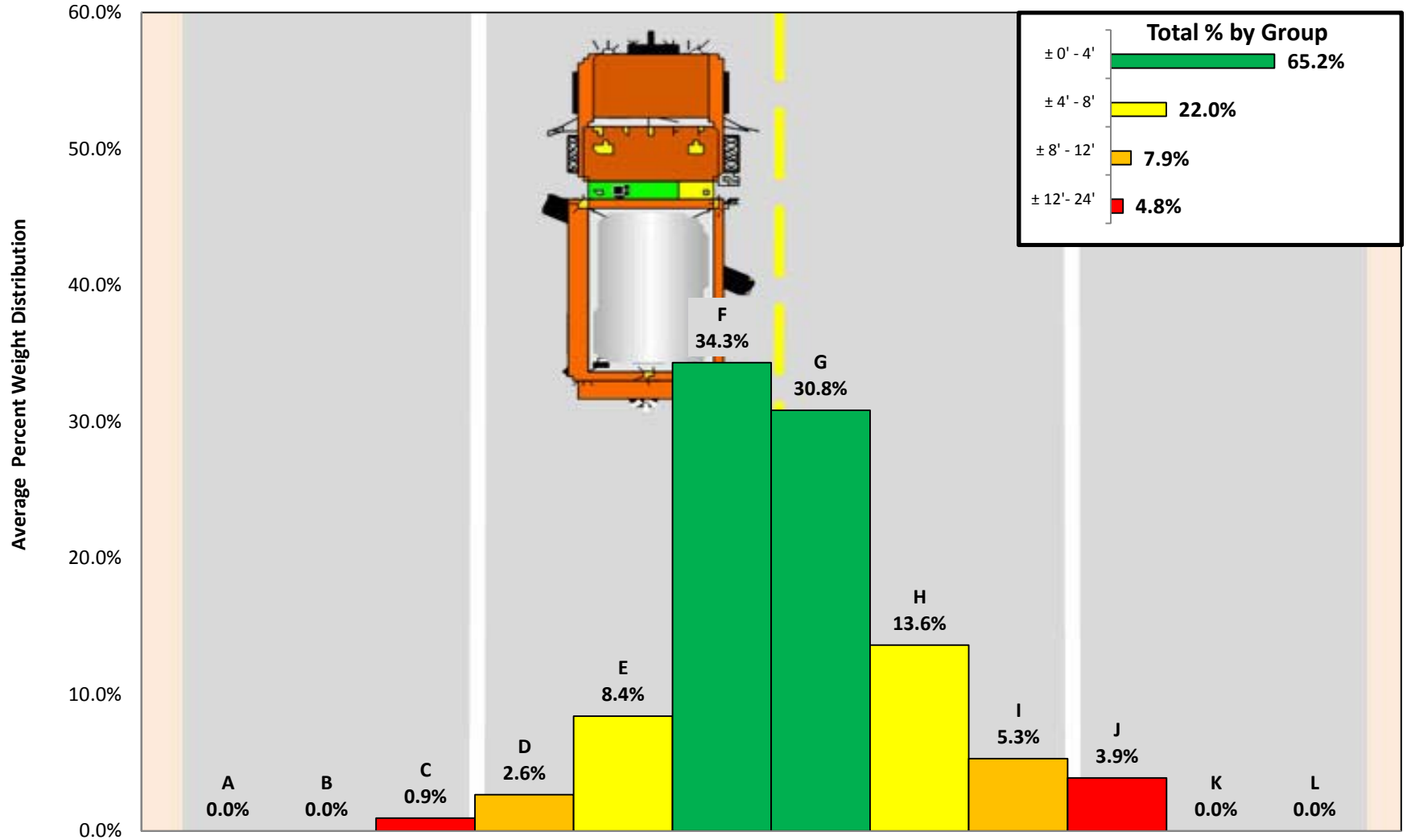
***Note**: Each letter represents a 4' width by 100' length portion of the collection grid.*

Bounce and Scatter Collection Graphs



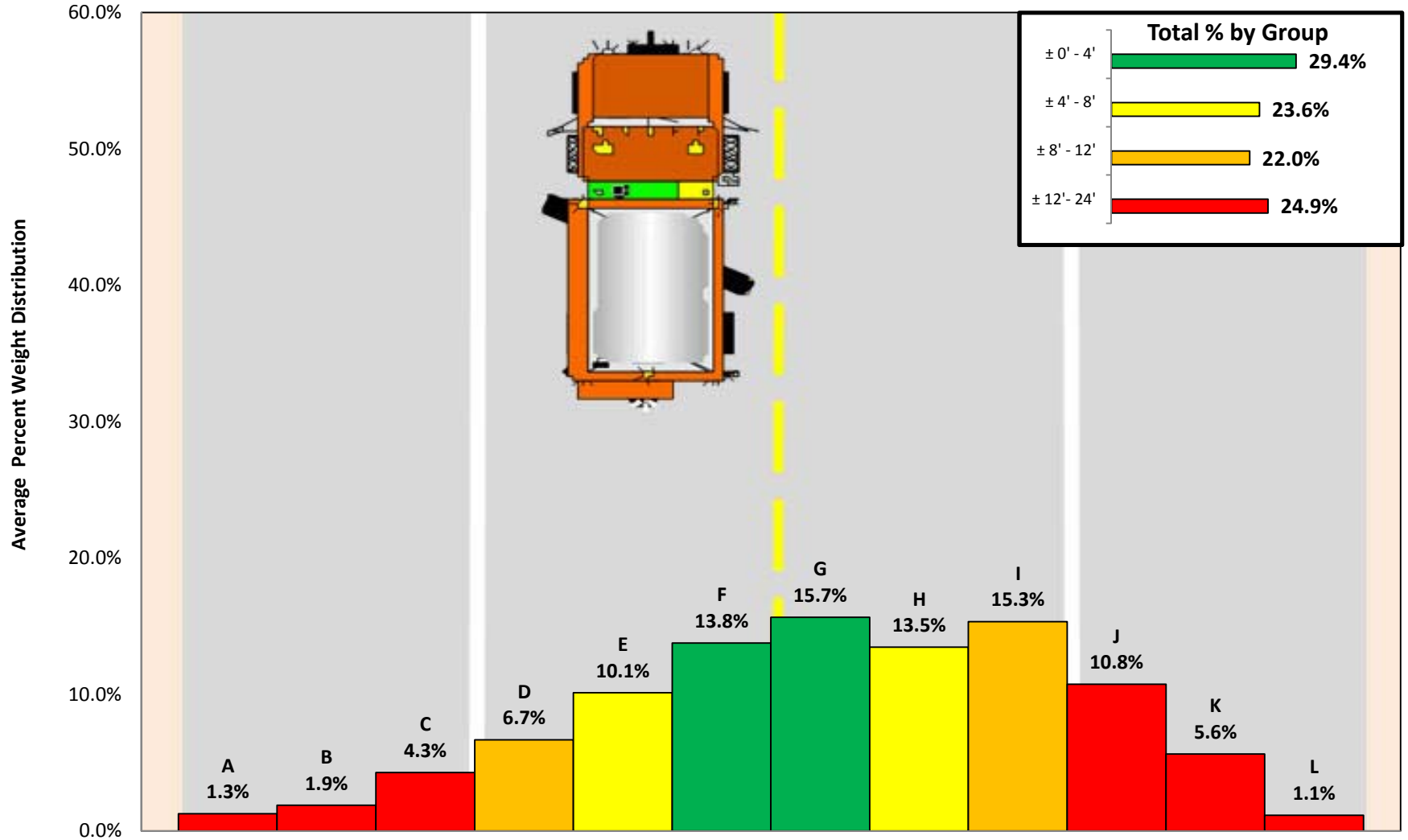
***Note**: Each letter represents a 4' width by 100' length portion of the collection grid.*

Bounce and Scatter Collection Graphs



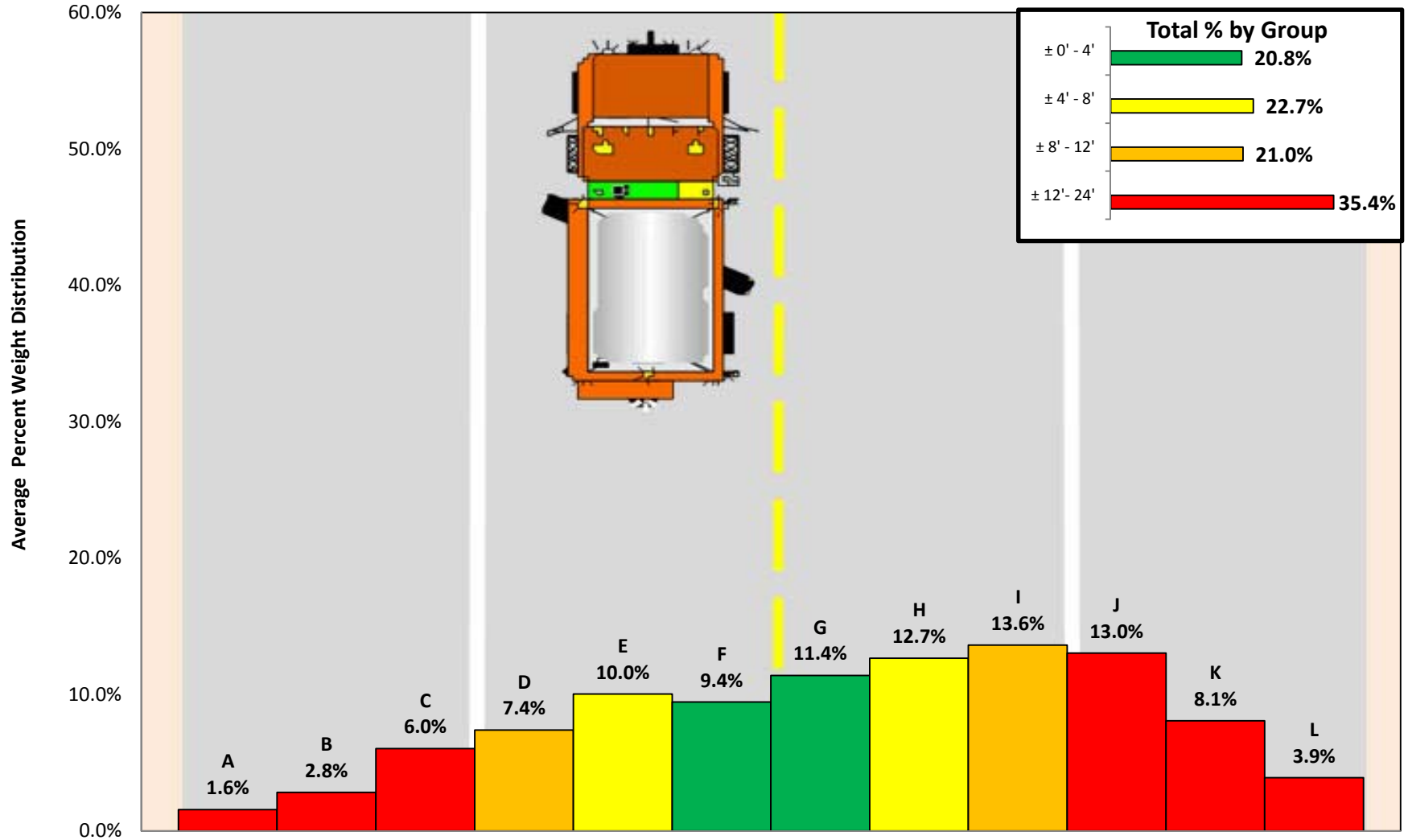
***Note**: Each letter represents a 4' width by 100' length portion of the collection grid.*

Bounce and Scatter Collection Graphs



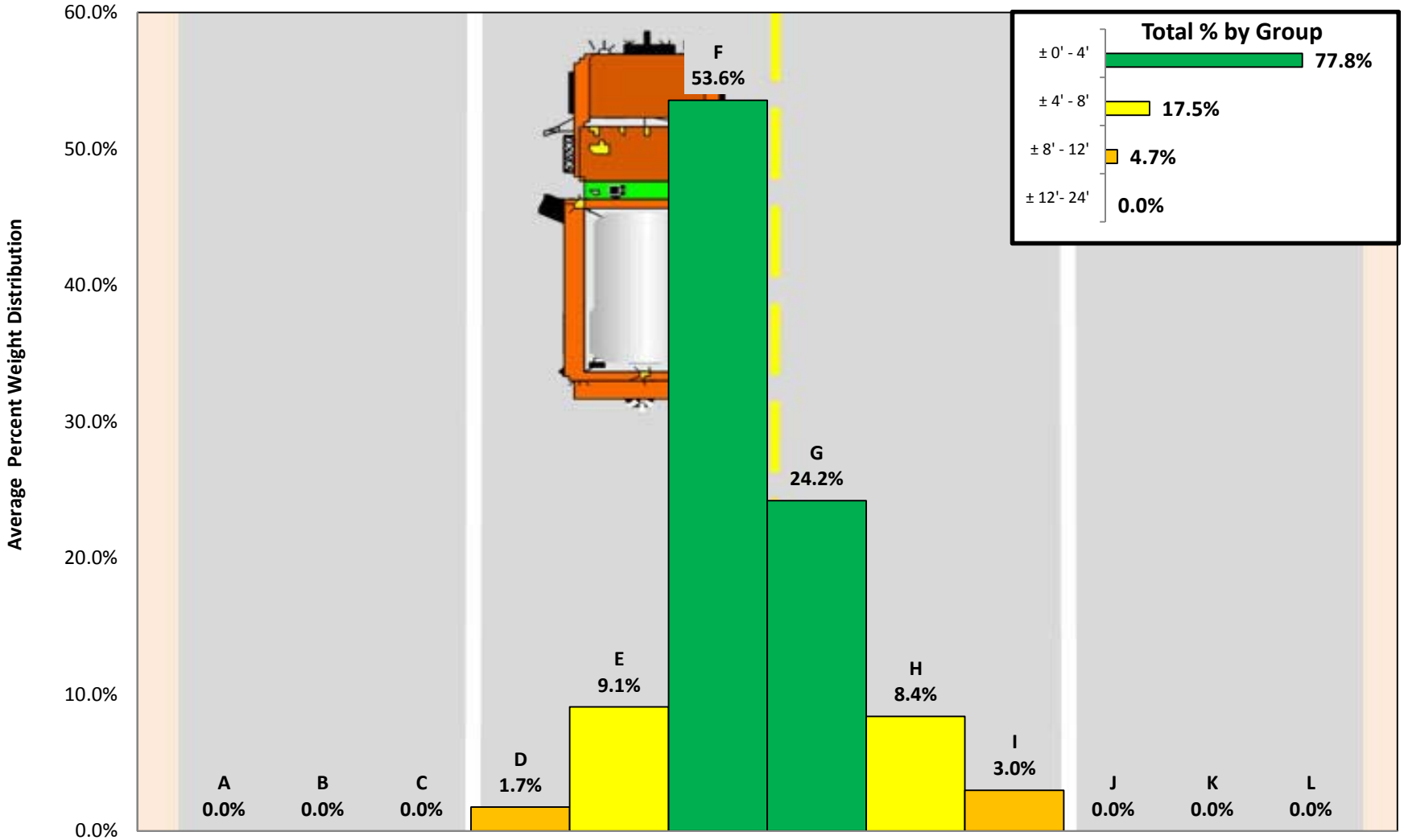
***Note**: Each letter represents a 4' width by 100' length portion of the collection grid.*

Bounce and Scatter Collection Graphs



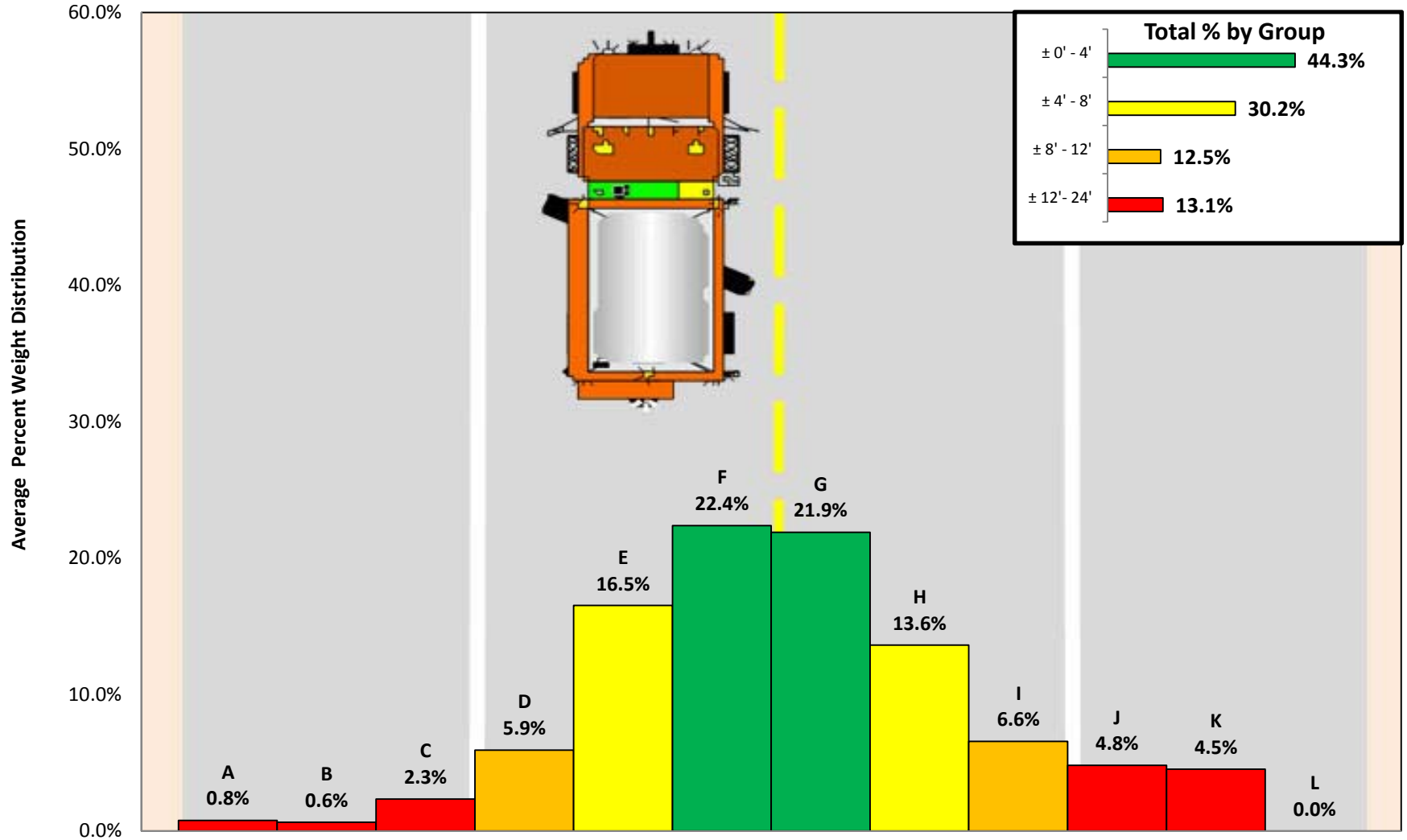
***Note**: Each letter represents a 4' width by 100' length portion of the collection grid.*

Bounce and Scatter Collection Graphs



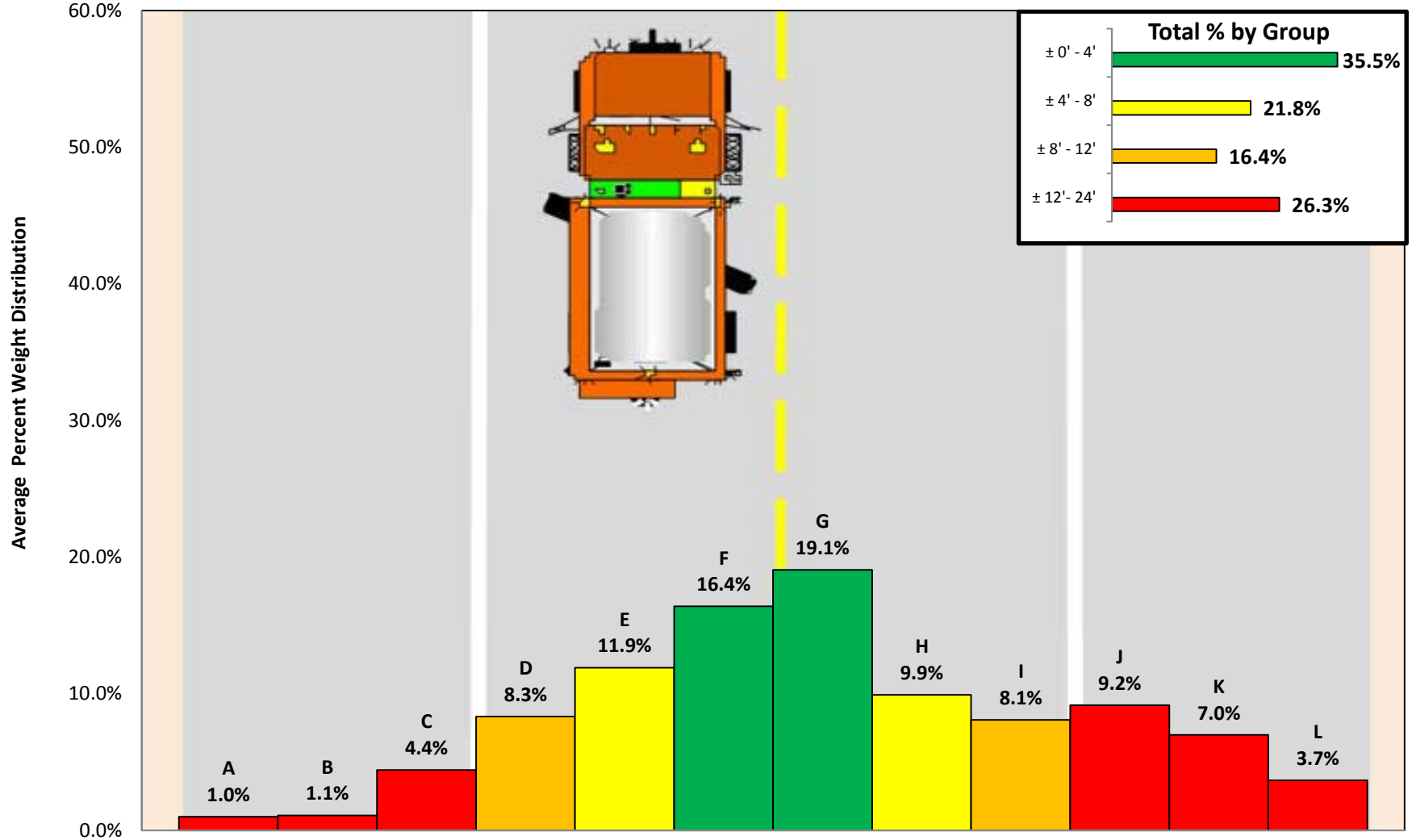
***Note**: **Each letter represents a 4' width by 100' length portion of the collection grid**.*

Bounce and Scatter Collection Graphs



***Note**: Each letter represents a 4' width by 100' length portion of the collection grid.*

Bounce and Scatter Collection Graphs



***Note**: Each letter represents a 4' width by 100' length portion of the collection grid.*