WIM System Field Calibration and Validation Summary Report

New Mexico SPS-1
SHRP ID – 350100

Validation Date: January 12, 2011
Submitted: 2/3/2011

Table of Contents

List of Figures

List of Tables

1 Executive Summary

A WIM validation was performed on January 11 and 12, 2011 at the New Mexico SPS-1 site located on route I-25 at milepost 36.1, 0.5 miles west of Rincon Road interchange.

This site was installed on April 30, 2008. The in-road sensors are installed in the northbound lane. The site is equipped with quartz WIM sensors and IRD iSINC WIM controller. The LTPP lane is identified as lane 1 in the WIM controller. From a comparison between the report of the most recent validation of this equipment on August 21, 2008 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

The equipment is in working order. Electronic and electrical checks of all WIM components determined that the equipment is operating within tolerances. Further equipment discussion is provided in Section 3.

During the on-site pavement evaluation, no pavement distresses that would affect the performance of the WIM scales were noted. Observations of trucks passing over the site did not detect any motions by the trucks that would affect WIM system accuracies. Further pavement condition discussion is provided in Section 4.

Based on the criteria contained in the LTPP Field Operations Guide for SPS WIM Sites, Version 1.0 (05/09), this site is providing research quality loading data. The summary results of the validation are provided in Table 1-1 below.

Table 1-1 – Post-Validation Results – 12-Jan-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-1.3 ± 6.5%	Pass
Tandem Axles	±15 percent	-0.2 ± 9.1%	Pass
GVW	±10 percent	-0.5 ± 7.0%	Pass
Vehicle Length	±3 percent (1.9 ft)	-0.6 ± 1.1 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.3 ft	Pass

Truck speeds were manually collected for each test run by a radar gun and compared with the speed reported by the WIM equipment. For this site, the error in speed measurement was 0.1 ± 1.4 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Operations Guide for SPS WIM Sites. However, since the site is measuring axle spacing length with a mean error of 0.0 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly.

This site is providing research quality vehicle classification data for heavy trucks (Class 6 – 13). The heavy truck misclassification rate of 0.0% is within the 2.0% acceptability criterion for

LTPP SPS WIM sites. The overall misclassification rate of 1.0% from the 100 truck sample (Class 4 – 13) was due to one Class 5 vehicle being identified as a Class8 vehicle.

There were two test trucks used for the post-validation. They were configured and loaded as follows:

- The *Primary* truck was a Class 9 vehicle with air suspension on the tractor and trailer tandems, and standard (4 feet) tandem spacings. It was loaded with a crane counterweight.

- The *Secondary* truck was a Class 9 vehicle with steel spring suspension on the tractor tandem, steel spring on the trailer tandem, standard tandem spacing on the tractor and standard tandem on the trailer. The Secondary truck was loaded with railcar trucks.

Prior to the validation, the test trucks were weighed and measured, cold tire pressures were taken, and photographs of the trucks, loads and suspensions were obtained (see Section 7). Axle length (AL) was measured from the center hub of the first axle to the center hub of the last axle. Overall length (OL) was measured from the edge of the front bumper to the edge of the rear bumper. The test trucks were re-weighed at the conclusion of the validation. The average post-validation test truck weights and measurements are provided in Table 1-2.

Table 1-2 – Post-Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	75.8	9.8	16.5	16.5	16.4	16.4	15.9	4.3	36.0	5.0	61.2	71.0
2	66.1	11.5	14.6	14.6	12.7	12.7	17.9	4.3	27.3	4.1	53.6	58.3

The posted speed limit at the site is 75 mph. During the testing, the speed of the test trucks ranged from to 54 to 75 mph, a variance of 21 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 34.4 to 74.5 degrees Fahrenheit, a range of 40.1 degrees Fahrenheit. The sunny weather conditions provided for attaining the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 24 shows that there are 19 consecutive months of level "E" WIM data for this site. This site requires at least 4 additional years of data to meet the minimum of five years of research quality data.

2 WIM System Data Availability and Pre-Visit Data Analysis

To assess the quality of the current traffic data, a pre-visit analysis was conducted by comparing a two-week data sample from December 13, 2010 (Data) to the most recent Comparison Data Set (CDS) from August 11, 2008. The assessments performed prior to the site visits are used to develop reasonable expectations for the validation. The results of further investigations performed as a result of the analyses are provided in Section 5 of this report.

2.1 LTPP WIM Data Availability

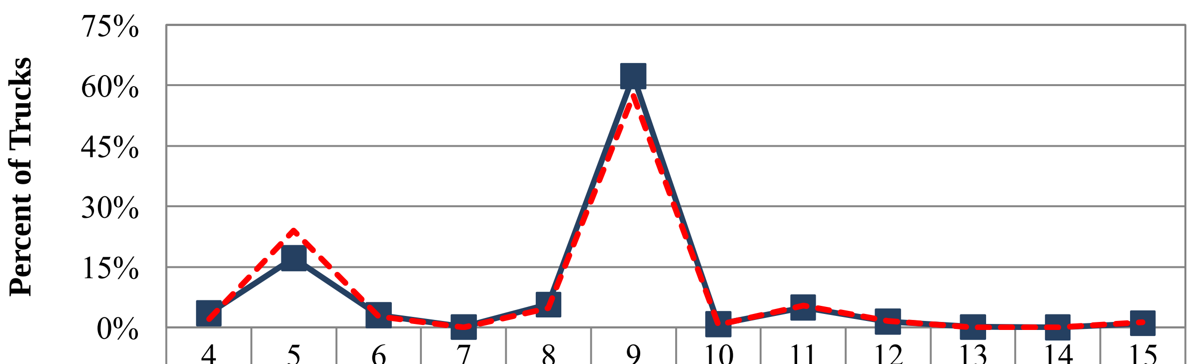
A review of the LTPP Standard Release Database 24 shows that there are 19 consecutive months of level "E" WIM data for this site. This site requires 4 additional years of data to meet the minimum of five years of research quality data. The 2008 data does not meet the 210-day minimum requirement for a calendar year. Table 2-1 provides a breakdown of the available data for years 2008 and 2009.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2008	201	7
2009	361	12

2.2 Classification Data Analysis

The traffic data was analyzed to determine the expected truck distributions. This analysis provides a basis for the classification distribution study that was conducted on site. Figure 2-1 provides a comparison of the truck type distributions for the two datasets.



	4	5	6	7	8	9	10	11	12	13	14	15
Data	3.5%	17.2%	3.1%	0.1%	5.6%	62.3%	0.8%	4.9%	1.4%	0.1%	0.0%	1.0%
CDS	2.0%	24.0%	2.7%	0.0%	4.8%	57.5%	0.6%	5.4%	1.6%	0.1%	0.0%	1.3%

Figure 2-1 – Comparison of Truck Distribution

Table 2-2 provides statistics for the truck distributions at the site for the two periods represented by the two datasets. The table shows that according to the most recent data, the most frequent truck types crossing the WIM scale are Class 9 (62.3%) and Class 5 (17.2%). Table 2-2 also provides data for vehicle Classes 14 and 15. Class 14 vehicles are vehicles that are reported by the WIM equipment as having irregular measurements and cannot be classified properly, such as negative speeds from vehicles passing in the opposite direction of a two-lane road. Class 15 vehicles are unclassified vehicles. The table indicates that 1.0 percent of the vehicles at this site are unclassified.

Table 2-2 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	8/11/2008		12/13/2010		
4	273	2.0%	357	3.5%	1.5%
5	3290	24.0%	1757	17.2%	-6.8%
6	372	2.7%	312	3.1%	0.3%
7	3	0.0%	11	0.1%	0.1%
8	653	4.8%	577	5.6%	0.9%
9	7868	57.5%	6370	62.3%	4.8%
10	79	0.6%	81	0.8%	0.2%
11	742	5.4%	506	4.9%	-0.5%
12	220	1.6%	143	1.4%	-0.2%
13	8	0.1%	9	0.1%	0.0%
14	0	0.0%	0	0.0%	0.0%
15	184	1.3%	102	1.0%	-0.3%

From the table it can be seen that the number of Class 9 vehicles has increased by 4.8 percent from August 2008 and December 2010. Changes in the number of heavier trucks may be attributed to seasonal variations in truck distributions. During the same time period, the number of Class 5 trucks decreased by 6.8 percent. These differences may be attributed to small sample size used to develop vehicle class distributions, changes in the use of the roadway for local deliveries, cross-classifications of type 3 and 5 vehicles, as well as natural variations in truck volumes.

2.3 Speed Data Analysis

The traffic data received from the Phase II Contractor was analyzed to determine the expected truck speed distributions. This will provide a basis for the speed of the test trucks during validation testing. The CDS distribution of speeds is shown in Figure 2-2.

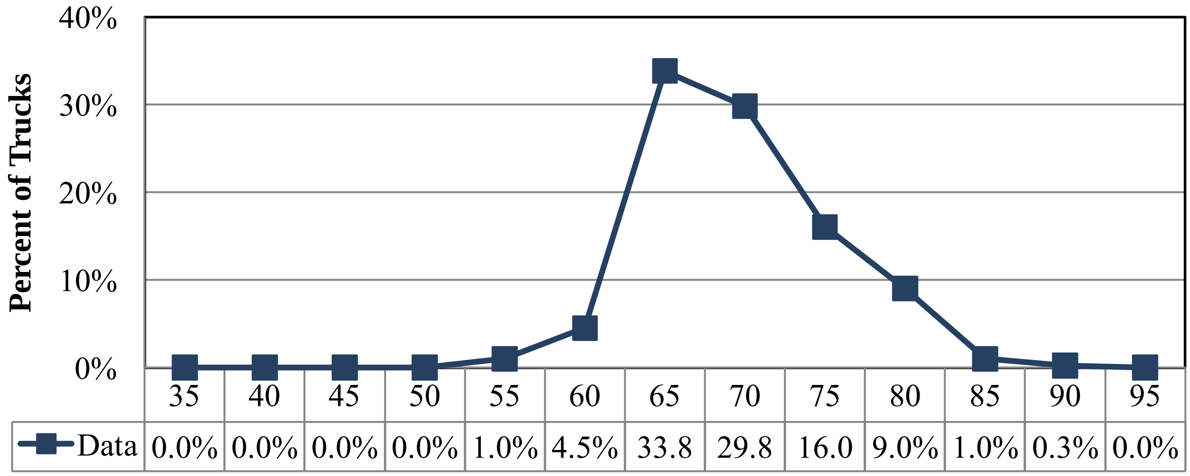


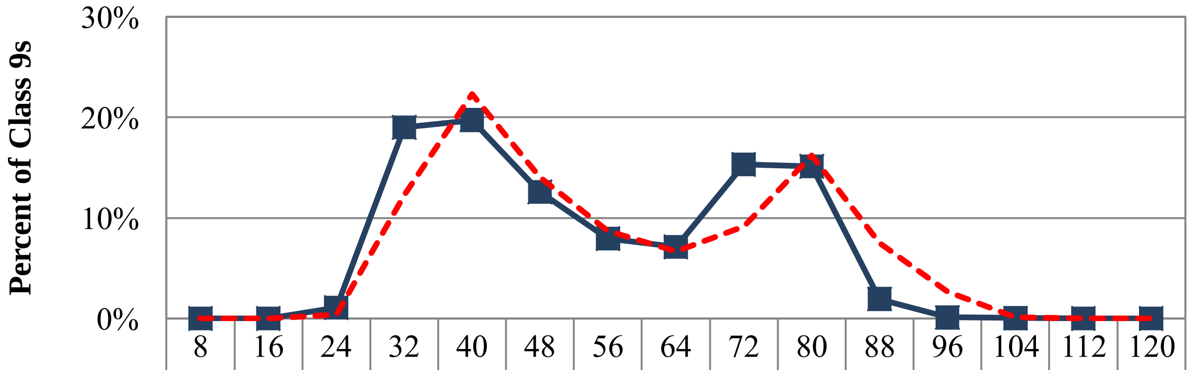
Figure 2-2 – Truck Speed Distribution – 31-Dec-10

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 65 and 70 mph. The posted speed limit at this site is 75 and the 85th percentile speed for trucks at this site is 75 mph. The coverage of truck speeds for the validation will be 55 and 75 mph.

2.4 GVW Data Analysis

The traffic CDS data received from the Regional Support Contractor was analyzed to determine the expected Class 9 GVW distributions. Figure 2-3 shows a comparison between GVW plots generated using a two-week W-card sample from December 2010 and the Comparison Data Set from August 2008.

As shown in Figure 2-3, there is a shift to the left for the unloaded and loaded peaks between the August 2008 Comparison Data Set (CDS) and the December 2010 two-week sample W-card data set (Data). The results indicate that the recent GVW estimates are now lower at this site.



	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
Data	0.0%	0.0%	1.1%	19.0	19.7	12.6	7.9%	7.1%	15.3	15.1	1.9%	0.1%	0.0%	0.0%	0.0%
CDS	0.0%	0.0%	0.4%	12.2	22.3	14.1	8.7%	6.7%	9.1%	16.2	7.5%	2.7%	0.1%	0.0%	0.0%

Figure 2-3 – Comparison of Class 9 GVW Distribution

Table 2-3 is provided to show the statistical comparison between the Comparison Data Set and the current dataset for Class 9 GVW.

Table 2-3 – Class 9 GVW Distribution from W-Card

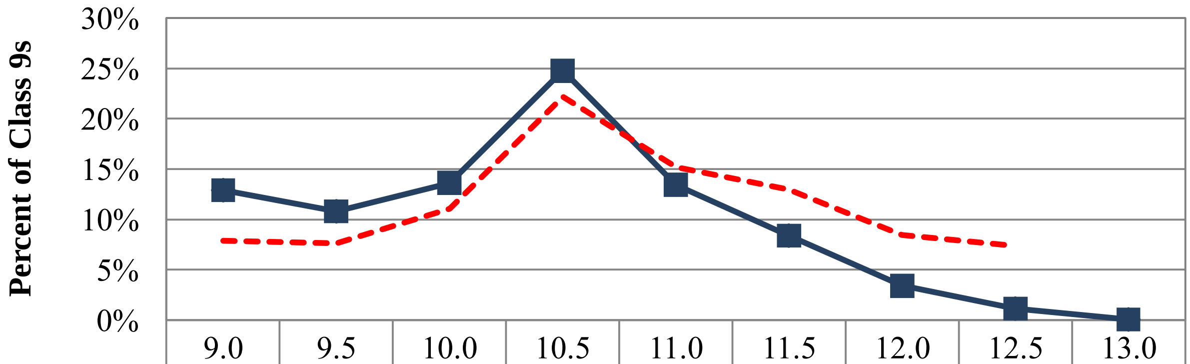
GVW weight bins (kips)	CDS		Data		Change
	Date				
	8/11/2008		12/13/2010		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	30	0.4%	69	1.1%	0.7%
32	959	12.2%	1209	19.0%	6.8%
40	1747	22.3%	1255	19.7%	-2.6%
48	1101	14.1%	800	12.6%	-1.5%
56	683	8.7%	505	7.9%	-0.8%
64	522	6.7%	453	7.1%	0.5%
72	716	9.1%	975	15.3%	6.2%
80	1268	16.2%	962	15.1%	-1.1%
88	587	7.5%	123	1.9%	-5.6%
96	208	2.7%	6	0.1%	-2.6%
104	9	0.1%	2	0.0%	-0.1%
112	1	0.0%	0	0.0%	0.0%
120	0	0.0%	0	0.0%	0.0%
Average =	53.6		50.2		-3.4

As shown in the table, the number of unloaded class 9 trucks in the 32 to 40 kips range decreased by 2.6 percent and the number of loaded class 9 trucks in the 72 to 80 kips range decreased by 1.1 percent. The number of overweight trucks decreased during this time period by 8.3 percent and the overall GVW average for this site decreased from 53.6 kips to 50.2 kips, or 3.4%.

2.5 Class 9 Front Axle Weight Data Analysis

The CDS data received from the Regional Support Contractor was analyzed to determine the expected average front axle weight. This will provide a basis for the evaluation of the quality of the data by comparing the average front axle weight from the sample data with the expected average front axle weight average from the comparison data set.

Figure 2-4 shows a comparison between Class 9 front axle weight plots generated by using the two week W-card sample from December 2010 and the Comparison Data Set from August 2008.



	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0
Data	12.9%	10.8%	13.6%	24.8%	13.4%	8.4%	3.4%	1.1%	0.1%
CDS	7.9%	7.6%	11.1%	22.2%	15.2%	13.0%	8.5%	7.3%	

Figure 2-4 – Distribution of Class 9 Front Axle Weights

It can be seen in the figure that the greatest percentage of trucks have front axle weights ranging from 10.5 to 11.0 kips, and the percentage of trucks within this range have increased between the August 2008 Comparison Data Set (CDS) and the December 2010 dataset (Data). The number of trucks with heavier front axle weights has decreased.

Table 2-4 provides the Class 9 front axle weight distribution data for the August 2008 Comparison Data Set (CDS) and the December 2010 dataset (Data).

Table 2-4 – Class 9 Front Axle Weight Distribution from W-Card

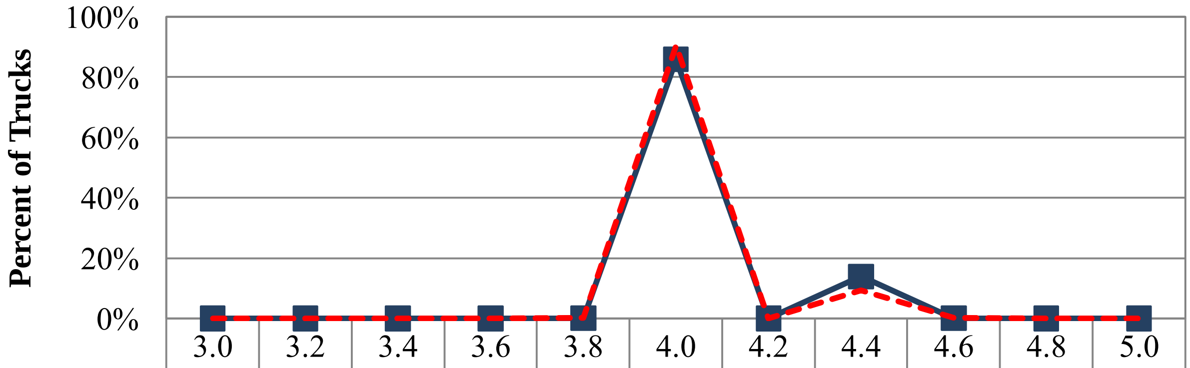
F/A weight bins (kips)	CDS		Data		Change
	Date				
	8/11/2008		12/13/2010		
9.0	398	5.2%	726	11.4%	6.3%
9.5	607	7.9%	820	12.9%	5.0%
10.0	585	7.6%	686	10.8%	3.2%
10.5	850	11.1%	865	13.6%	2.6%
11.0	1703	22.2%	1572	24.8%	2.6%
11.5	1165	15.2%	853	13.4%	-1.7%
12.0	995	13.0%	533	8.4%	-4.6%
12.5	651	8.5%	216	3.4%	-5.1%
13.0	564	7.3%	72	1.1%	-6.2%
13.5	163	2.1%	4	0.1%	-2.1%
Average =	11.0		10.3		-6.3

The table shows that the average front axle weight for Class 9 trucks has decreased by 0.7 kips, or -6.3 percent. According to the current data, the majority of the Class 9 front axle weights are between 10.5 and 11.0 kips and the average front axle weight for Class 9 trucks is 10.3 kips. This decrease is consistent with the decrease in Class 9 GVW.

2.6 Class 9 Tractor Tandem Spacing Data Analysis

The CDS data received from the Regional Support Contractor was analyzed to determine the expected average tractor tandem spacing. This will provide a basis for the evaluation of the accuracy of the equipment distance and speed measurements by comparing the average tractor tandem spacing from the current data sample with the expected average tractor tandem from the data comparison set.

The class 9 tractor tandem spacing plots in Figure 2-5 are provided to indicate possible shifts in WIM system distance and speed measurement accuracies.



	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0
Data	0.0%	0.0%	0.0%	0.0%	0.1%	85.9%	0.0%	13.9%	0.1%	0.0%	0.0%
CDS	0.0%	0.0%	0.0%	0.0%	0.2%	90.4%	0.0%	9.3%	0.1%	0.0%	0.0%

Figure 2-5 – Comparison of Class 9 Tractor Tandem Spacing

As seen in the figure, the Class 9 tractor tandem spacing for the August 2008 Comparison Data Set and the December 2010 Data are nearly identical.

Table 2-5 shows the Class 9 axle spacings between the second and third axles.

Table 2-5 – Class 9 Axle 3 to 4 Spacing from W-Card

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	8/11/2008		12/13/2010		
3.0	0	0.0%	0	0.0%	0.0%
3.2	0	0.0%	1	0.0%	0.0%
3.4	0	0.0%	0	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	14	0.2%	4	0.1%	-0.1%
4.0	7081	90.4%	5463	85.9%	-4.5%
4.2	0	0.0%	0	0.0%	0.0%
4.4	725	9.3%	885	13.9%	4.7%
4.6	9	0.1%	6	0.1%	0.0%
4.8	0	0.0%	0	0.0%	0.0%
5.0	2	0.0%	0	0.0%	0.0%
Average =	4.0		4.0		0.0

From the table it can be seen that the range in drive tandem spacing for Class 9 trucks at this site is between 3.8 and 4.6 feet. The average tractor tandem spacing is 4.0 feet, which is identical to the expected average of 4.0 feet from the comparison data set. Further analyses are performed during the validation and post-validation analysis.

2.7 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (August 2008) based on the last calibration with the most recent two-week WIM data sample from the site (December 2010). Comparison of vehicle class distribution data indicates a 4.8 percent increased in the number of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have decreased by 6.3 percent and average Class 9 GVW has decreased by 3.4 percent for the December 2010 data. The data indicates an average truck tandem spacing of 4.0 feet, which is identical to the expected average of 4.0 feet.

3 WIM Equipment Discussion

From a comparison between the report of the most recent validation of this equipment on August 21, 2008 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

3.1 Description

This site was installed on April 30, 2008 by International Road Dynamics. It is instrumented with quartz weighing sensors and IRD iSINC WIM Controller. As the installation contractor, IRD also performs routine equipment maintenance and data quality checks of the WIM data.

3.2 Physical Inspection

Prior to the pre-validation test truck runs, a physical inspection of all WIM equipment and support services equipment was conducted. No deficiencies were noted. Photographs of all system components were taken and are presented in Section 7.

3.3 Electronic and Electrical Testing

Electronic and electrical checks of all system components were conducted prior to the pre-validation test truck runs. Dynamic and static electronic checks of the in-road sensors were performed with no deficiencies noted. All values for the WIM sensors and inductive loops were within tolerances. Electronic tests of the power and communication devices indicated that they were operating normally.

3.4 Equipment Troubleshooting and Diagnostics

The WIM system appeared to collect, analyze and report vehicle measurements normally. No troubleshooting actions were taken.

3.5 Recommended Equipment Maintenance

No equipment maintenance actions are recommended.

4 Pavement Discussion

4.1 Pavement Condition Survey

During a visual distress survey of the pavement conducted from the shoulder, no areas of pavement distress that may affect the accuracy of the WIM sensors were noted.

4.2 Profile and Vehicle Interaction

Profile data was collected on April 23, 2010 by the Southern Regional Support Contractor using a high-speed profiler, where the operator measures the pavement profile over the entire one-thousand foot long WIM Section, beginning 900 feet prior to WIM scales and ending 100 feet after the WIM scales. Each pass collects International Roughness Index (IRI) values in both the left and right wheel paths. For this site, 11 profile passes were made, 5 in the center of the travel lane and 6 that were shifted to the left and to the right of the center of the travel lane.

From a pre-visit review of the IRI values for the center, right, and left profile runs, the highest IRI value within the 1000 foot WIM section is 112 in/mi and is located approximately 456 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 187 in/mi and is located approximately 38 feet prior to the WIM scale. These areas of the pavement section were closely investigated during the validation visit, and truck dynamics in this area were closely observed. There were no distresses observed that would influence truck dynamics in the WIM scale area.

Additionally, a visual observation of the trucks as they approach, traverse and leave the sensor area did not indicate any visible motion of the trucks that would affect the performance of the WIM scales. Trucks appear to track down the center of the lane.

4.3 LTPP Pavement Profile Data Analysis

The IRI data files are processed using the WIM Smoothness Index software. The indices produced by the software provide an indication of whether or not the pavement roughness may affect the operation of the WIM equipment. The recommended thresholds for WIM Site pavement smoothness are provided in Table 4-1.

Table 4-1 – Recommended WIM Smoothness Index Thresholds

Index	Lower Threshold (m/km)	Upper Threshold (m/km)
Long Range Index (LRI)	0.50	2.1
Short Range Index (SRI)	0.50	2.1
Peak LRI	0.50	2.1
Peak SRI	0.75	2.9

When all values are less than the lower threshold shown in Table 4-1, it is unlikely that pavement conditions will significantly influence sensor output. Values between the threshold values may or may not influence the accuracy of the sensor output and values above the upper threshold would lead to sensor output that would preclude achieving the research quality loading data.

The profile analysis was based on four different indices: Long Range Index (LRI), which represents the pavement roughness starting 25.8 m prior to the scale and ending 3.2 m after the scale in the direction of travel; Short Range Index (SRI), which represents the pavement roughness beginning 2.74 m prior to the WIM scale and ending 0.46 m after the scale; Peak LRI – the highest value of LRI within 30 m prior to the scale; and Peak SRI – the highest value of SRI between 2.45 m prior to the scale and 1.5 m after the scale. The results from the analysis for each of the indices for the right wheel path (RWP) and left wheel path (LWP) values for the 3 left, 3 right and 5 center profiler runs are presented in Table 4-2.

Table 4-2 – WIM Index Values

Profiler Passes			**Pass 1**	**Pass 2**	**Pass 3**	**Pass 4**	**Pass 5**	**Avg**
Left	LWP	LRI (m/km)	0.901	0.915	1.047			0.954
		SRI (m/km)	0.584	*0.484*	0.822			0.630
		Peak LRI (m/km)	**0.901**	**0.924**	**1.047**			**0.957**
		Peak SRI (m/km)	0.669	0.564	0.991			0.741
	RWP	LRI (m/km)	0.706	0.710	0.600			0.672
		SRI (m/km)	0.810	0.718	0.680			0.736
		Peak LRI (m/km)	0.714	0.710	0.600			0.675
		Peak SRI (m/km)	0.844	0.797	*0.701*			0.781
Center	LWP	LRI (m/km)	0.668	0.698	0.650	0.689	0.734	0.676
		SRI (m/km)	1.005	0.686	0.715	0.898	0.856	0.826
		Peak LRI (m/km)	0.679	0.704	0.650	0.693	0.737	0.682
		Peak SRI (m/km)	1.053	*0.733*	0.768	0.914	0.876	0.867
	RWP	LRI (m/km)	0.542	0.553	0.596	0.576	0.600	0.567
		SRI (m/km)	0.585	0.712	0.640	0.518	0.545	0.614
		Peak LRI (m/km)	0.609	0.553	0.596	0.616	0.601	0.594
		Peak SRI (m/km)	*0.611*	*0.713*	*0.676*	*0.611*	*0.696*	*0.653*
Right	LWP	LRI (m/km)	0.533	0.564	0.614			0.570
		SRI (m/km)	0.577	0.576	*0.473*			0.542
		Peak LRI (m/km)	0.533	0.564	0.616			0.571
		Peak SRI (m/km)	*0.579*	*0.597*	*0.542*			*0.573*
	RWP	LRI (m/km)	0.693	0.615	0.528			0.612
		SRI (m/km)	*0.472*	0.593	*0.421*			*0.495*
		Peak LRI (m/km)	0.693	0.615	0.556			0.621
		Peak SRI (m/km)	0.849	0.784	*0.479*			*0.704*

From Table 4-2 it can be seen that most of the indices computed from the profiles are between the upper and lower threshold values, with the remaining values under the lower threshold (shown in italics). The highest values, on average, are the Peak LRI values in the left wheel path of the left shift passes (shown in bold).

4.4 Recommended Pavement Remediation

No pavement remediation is recommended.

5 Statistical Reliability of the WIM Equipment

The following section provides summaries of data collected during the pre-validation, the calibration, and the post-validation test truck runs, as well as information resulting from the classification and speed studies. All analyses of test truck data and information on necessary equipment adjustments are provided.

5.1 Pre-Validation

The first set of test runs provides a general overview of system performance prior to any calibration adjustments for the given environmental, vehicle speed and other conditions.

The 40 pre-validation test truck runs were conducted on January 11, 2011, beginning at approximately 8:46 AM and continuing until 4:36 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with a crane counterweight, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.

- A Class 9 truck, loaded with railcar trucks, and equipped with steel spring suspension on the tractor, steel spring suspension on the trailer, with standard tandem spacing on the tractor and standard tandem spacing on the trailer.

The test trucks were weighed prior to the pre-validation and were re-weighed at the conclusion of the pre-validation. The average test truck weights and measurements are provided in Table 5-1.

Table 5-1 – Pre-Validation Test Truck Weights and Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	76.1	10.2	16.5	16.5	16.5	16.5	15.9	4.3	36.0	5.0	61.2	71.0
2	65.9	11.4	14.6	14.6	12.7	12.7	17.9	4.3	27.3	4.1	53.6	58.3

Test truck speeds varied by 25 mph, from 50 to 75 mph. The measured pre-validation pavement temperatures varied 30.0 degrees Fahrenheit, from 37.4 to 67.4. The sunny weather conditions provided for reaching the desired 30 degree temperature range. Table 5-2 provides a summary of the pre-validation results.

Table 5-2 – Pre-Validation Overall Results – 11-Jan-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-4.9 ± 8.5%	Pass
Tandem Axles	±15 percent	-0.8 ± 8.6%	Pass
GVW	±10 percent	-1.4 ± 6.8%	Pass
Vehicle Length	±3 percent (1.9 ft)	3.0 ± 0.9 ft	FAIL
Axle Length	± 0.5 ft [150mm]	0.3 ± 0.4 ft	FAIL

Truck speed was manually collected for each test run using a radar gun and compared with the speed reported by the WIM equipment. For this site, the average error in speed measurement over all speeds was 0.2 ± 1.8 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Guide. Since the site is measuring axle spacing length with a mean error of 0.3 ± 0.4 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is not set correctly and that the speeds being reported by the WIM equipment are not within acceptable ranges.

5.1.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relationship exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 75 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-3 below.

Table 5-3 – Pre-Validation Results by Speed – 11-Jan-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		50.0 to 58.3 mph	58.4 to 66.8 mph	66.9 to 75.0 mph
Steering Axles	±20 percent	-2.7 ± 6.3%	-4.6 ± 6.3%	-6.9 ± 10.8%
Tandem Axles	±15 percent	0.9 ± 6.5%	-1.9 ± 8.4%	-1.3 ± 10.7%
GVW	±10 percent	0.4 ± 3.7%	-2.3 ± 4.8%	-2.2 ± 9.5%
Vehicle Length	±3 percent (1.9 ft)	2.9 ± 0.6 ft	2.9 ± 1.1 ft	3.1 ± 1.0 ft
Vehicle Speed	± 1.0 mph	0.0 ± 2.3 mph	0.0 ± 2.5 mph	0.4 ± 1.1 mph
Axle Length	± 0.5 ft [150mm]	0.2 ± 0.4 ft	0.3 ± 0.4 ft	0.4 ± 0.2 ft

From the table, it can be seen that the WIM equipment underestimates all weights at the medium and high speeds. There appears to be a relationship between weight estimate errors and speed at this site where the mean errors and the variation of errors appear to increase as speed increases.

To aid in the speed analysis, several graphs were developed to illustrate the possible effects of speed on GVW, single axle, and axle group weights, and axle and overall length distance measurements, as discussed in the following sections.

5.1.1.1 GVW Errors by Speed

As shown in Figure 5-1, the WIM equipment generally underestimates GVW at medium and high speeds and the range in error increases with increase in speed.

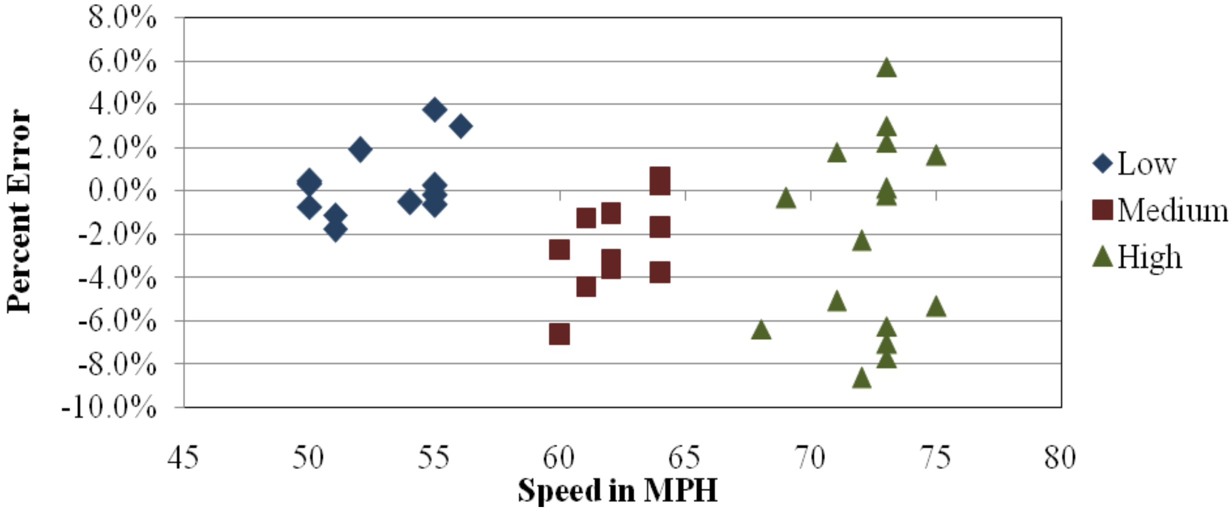


Figure 5-1 – Pre-Validation GVW Error by Speed – 11-Jan-11

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment increasingly underestimates steering axle weights as speed increases. The range in error is lesser at medium speeds when compared with low and high speeds.

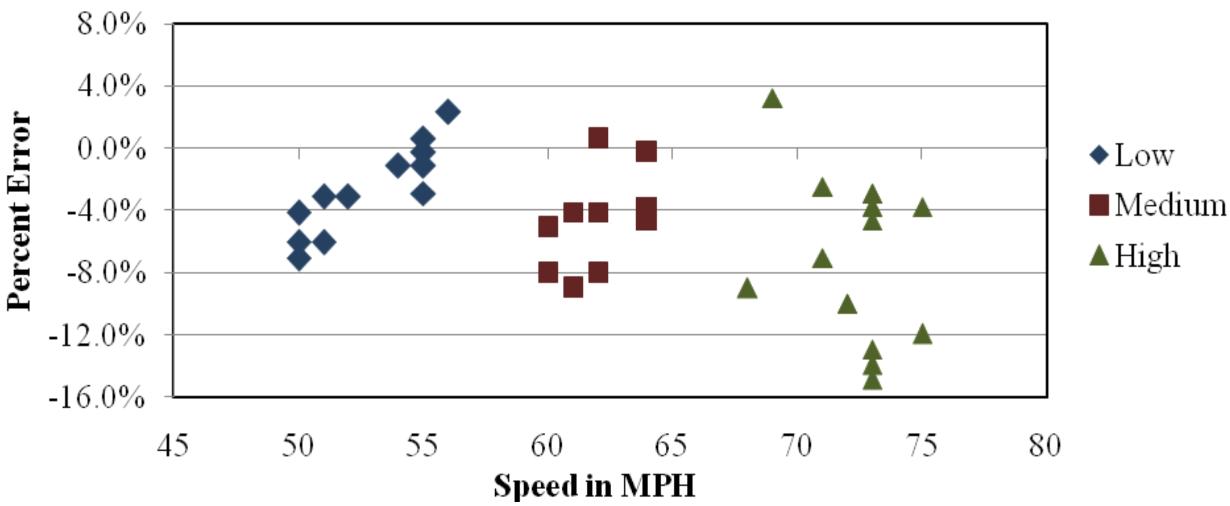


Figure 5-2 – Pre-Validation Steering Axle Weight Errors by Speed – 11-Jan-11

5.1.1.3 Tandem Axle Weight Errors by Speed

As shown in

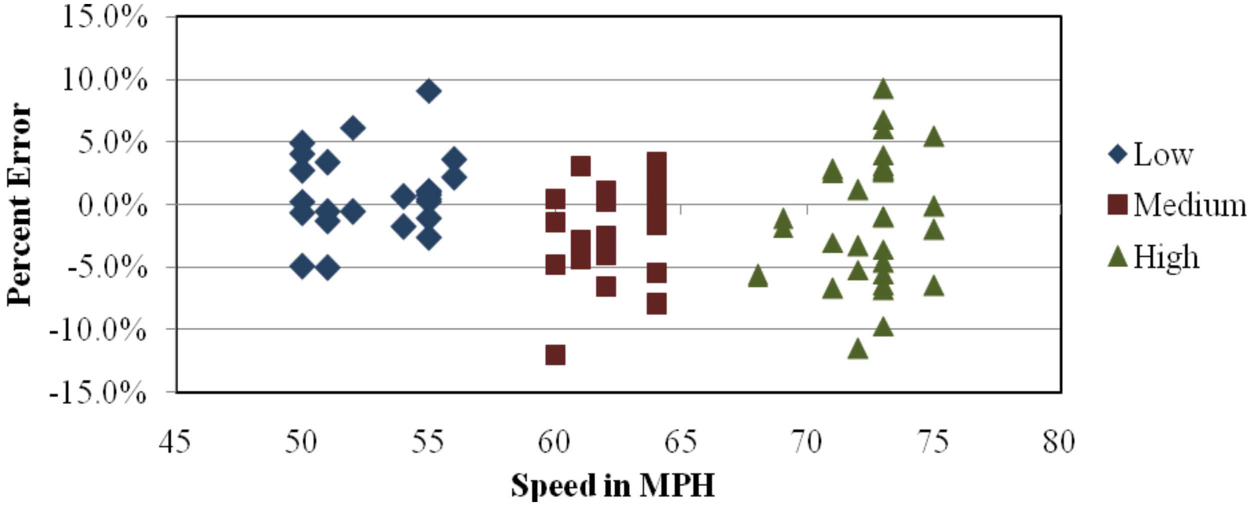


Figure 5-3, the equipment underestimates tandem axle weights at medium and high speeds. The range in error is greater at the high speeds when compared with low and medium speeds.

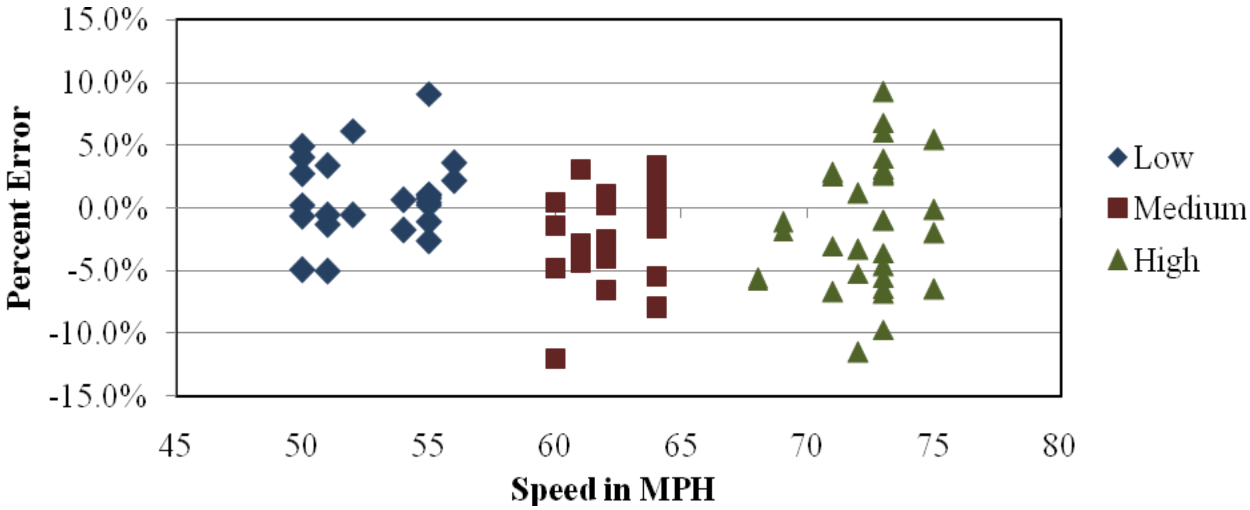


Figure 5-3 – Pre-Validation Tandem Axle Weight Errors by Speed – 11-Jan-11

5.1.1.4 GVW Errors by Speed and Truck Type

When the GVW error for each truck is analyzed as a function of speed, it can be seen that the WIM equipment underestimates GVW for the heavily loaded (Primary) truck to a greater degree than the partially loaded (Secondary) truck at the higher speeds. Distribution of errors is shown graphically in Figure 5-4.

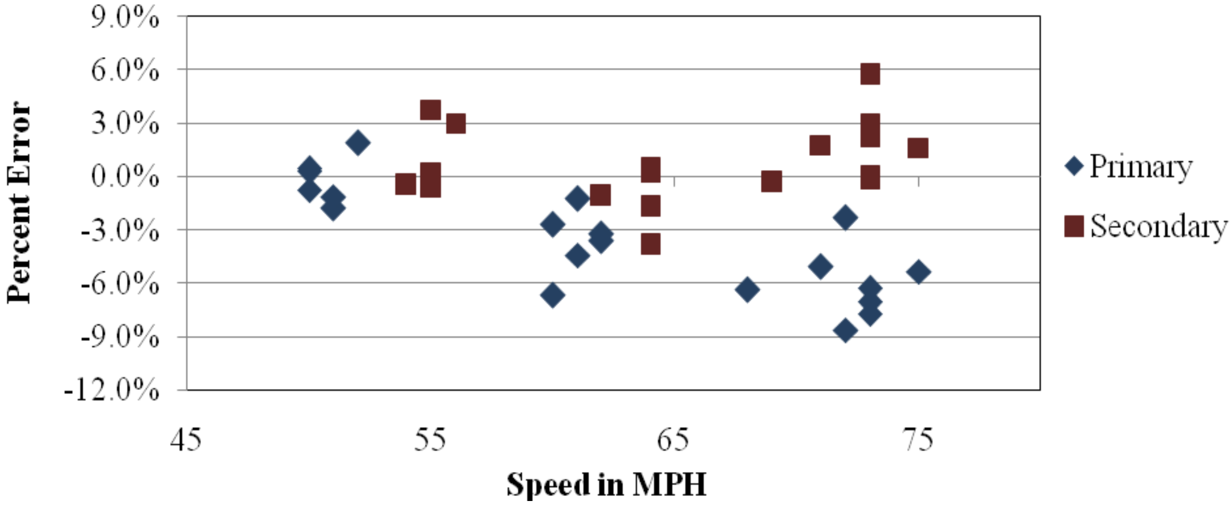


Figure 5-4 – Pre-Validation GVW Errors by Truck and Speed – 11-Jan-11

5.1.1.5 Axle Length Errors by Speed

For this site, the equipment increasingly overestimates axle lengths with an increase in speed. The range in axle length measurement error ranged from -0.1 feet to 0.7 feet. Distribution of errors is shown graphically in

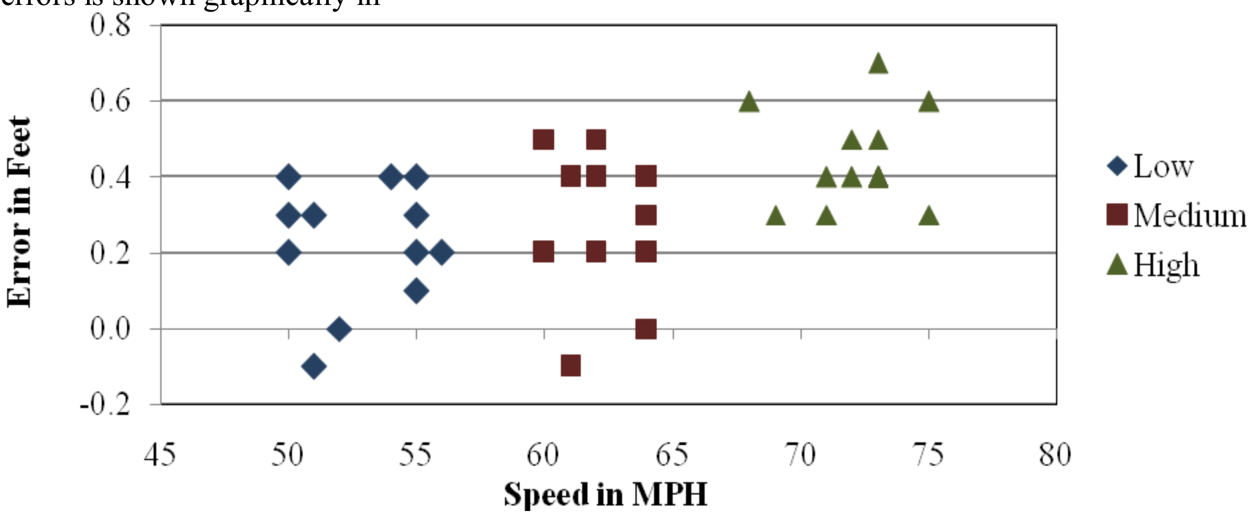


Figure **5-5**.

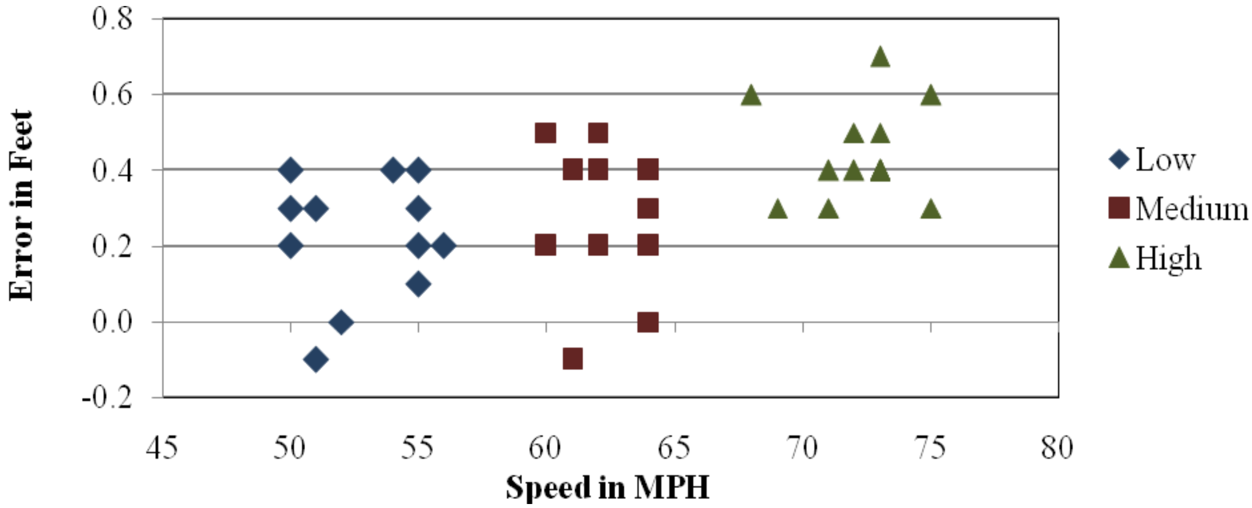


Figure 5-5 – Pre-Validation Axle Length Errors by Speed – 11-Jan-11

5.1.1.6 Overall Length Errors by Speed

For this system, the WIM equipment overestimated overall vehicle length consistently over the entire range of speeds, with an error range of 2.0 to 4.0 feet. Distribution of errors is shown graphically in Figure 5-6.

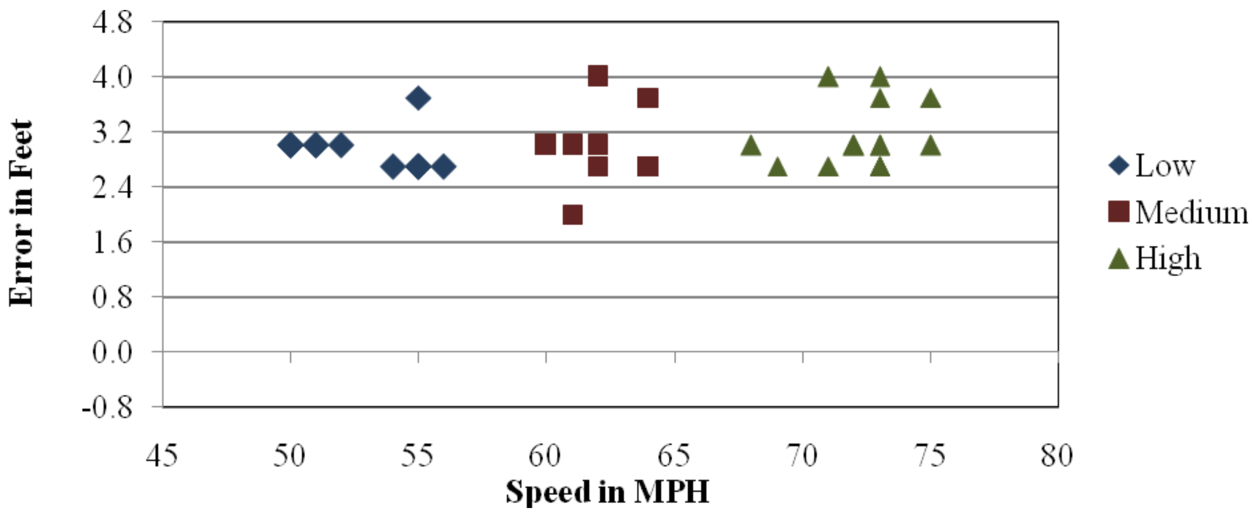


Figure 5-6 – Pre-Validation Overall Length Error by Speed – 11-Jan-11

5.1.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether there is a relation between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures varied by 30.0 degrees, from 37.4 to 67.4 degrees

Fahrenheit. The pre-validation test runs are being reported under three temperature groups as shown in Table 5-4.

Table 5-4 – Pre-Validation Results by Temperature – 11-Jan-11

Parameter	95% Confidence Limit of Error	Low 37.4 to 50 degF	Medium 50.1 to 60.0 degF	High 60.1 to 67.4 degF
Steering Axles	±20 percent	-4.2 ± 10%	-5.1 ± 8.9%	-5.4 ± 9.3%
Tandem Axles	±15 percent	-0.8 ± 7.8%	-1.0 ± 10%	-0.7 ± 9.7%
GVW	±10 percent	-1.3 ± 7.1%	-1.5 ± 7.7%	-1.5 ± 7.6%
Vehicle Length	±3 percent (1.9 ft)	3.2 ± 1.5 ft	2.9 ± 0.3 ft	3.0 ± 0.7 ft
Vehicle Speed	± 1.0 mph	0.2 ± 2.6 mph	0.2 ± 1.9 mph	0.1 ± 1.4 mph
Axle Length	± 0.5 ft [150mm]	0.3 ± 0.5 ft	0.3 ± 0.3 ft	0.4 ± 0.3 ft

To aid in the analysis, several graphs were developed to illustrate the possible effects of temperature on GVW, single axle, and axle group weights.

5.1.2.1 GVW Errors by Temperature

From Figure 5-7, it can be seen that the equipment appears to estimate GVW with similar bias across the all temperature ranges.

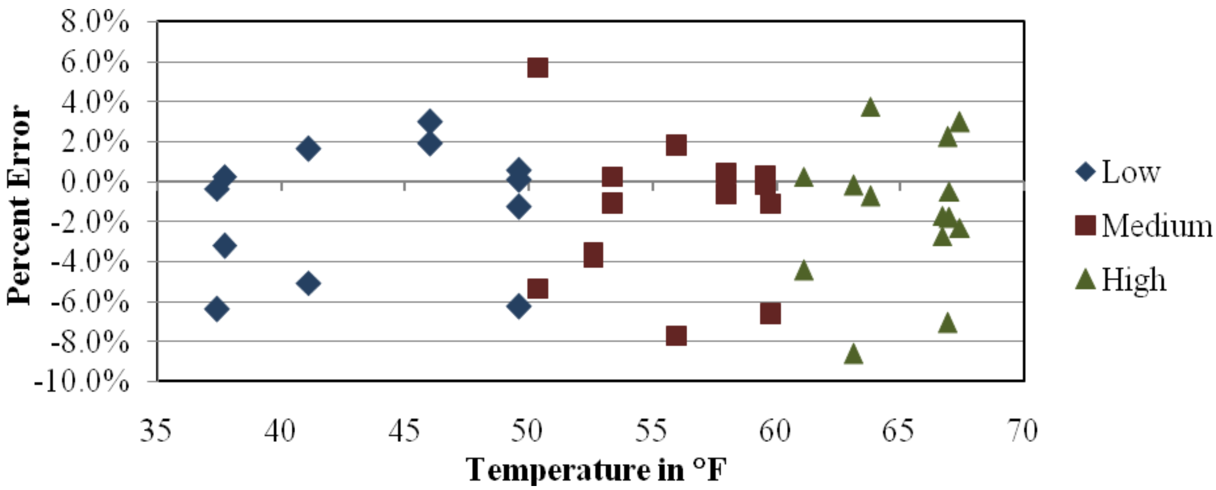


Figure 5-7 – Pre-Validation GVW Errors by Temperature – 11-Jan-11

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 demonstrates that for steering axles, the WIM equipment generally underestimates weights at all temperature. The range in error is reasonably consistent over the range of temperatures.

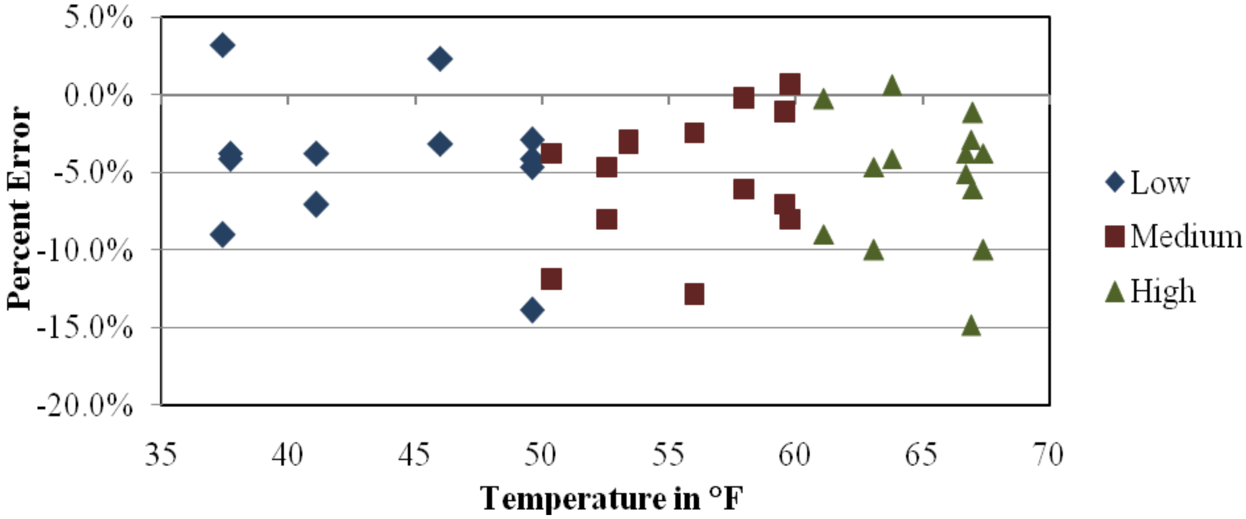


Figure 5-8 – Pre-Validation Steering Axle Weight Errors by Temperature – 11-Jan-11

5.1.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-9, the equipment estimates tandem axle weights with similar accuracy at all temperatures. The range in tandem axle errors is also consistent at all temperatures.

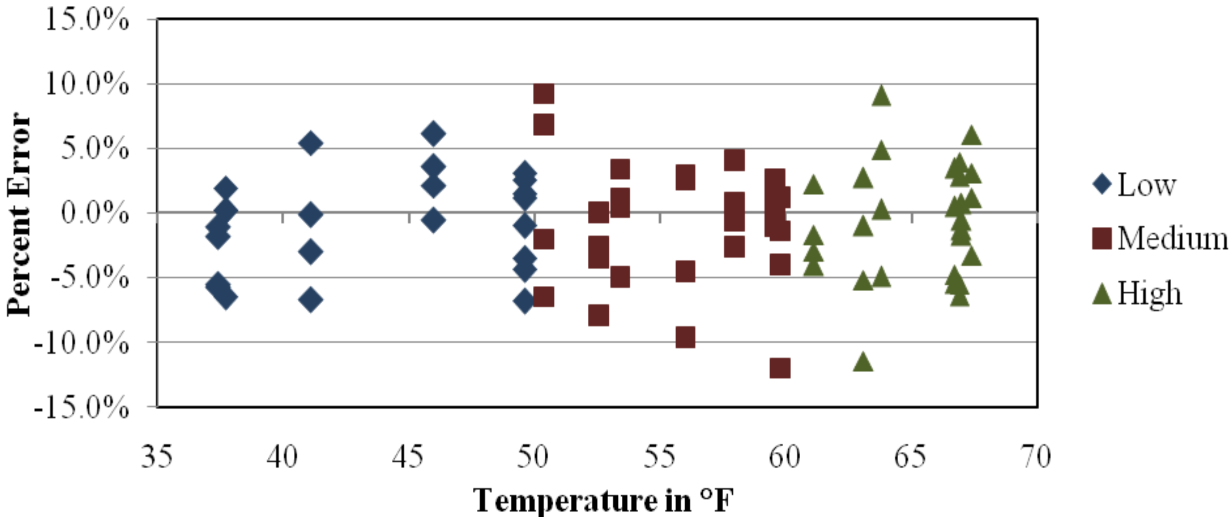


Figure 5-9 – Pre-Validation Tandem Axle Weight Errors by Temperature – 11-Jan-11

5.1.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-10, when analyzed for each test truck, the WIM equipment underestimates GVW for the heavily loaded (Primary) truck to a greater degree than the partially loaded

(Secondary) truck at all temperature ranges.

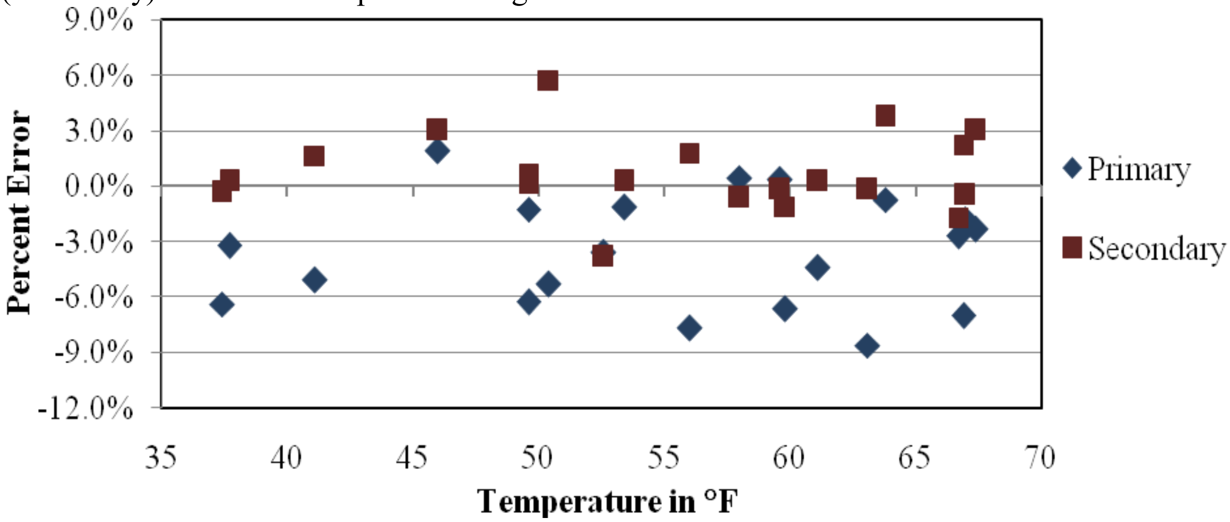


Figure 5-10 – Pre-Validation GVW Error by Truck and Temperature – 11-Jan-11

5.1.3 Classification and Speed Evaluation

The pre-validation classification and speed study involved the comparison of vehicle classification and speed data collected manually with the information for the same vehicles reported by the WIM equipment.

For the pre-validation classification study at this site, a manual sample of 100 vehicles including 100 trucks (Class 4 through 13) was collected. Video was collected during the study to provide a means for further analysis of misclassifications and vehicles whose classifications could not be determined with a high degree of certainty in the field. Table 5-5 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study.

Table 5-5 – Pre-Validation Classification Study Results – 11-Jan-11

Class	4	5	6	7	8	9	10	11	12	13
Observed Count	2	24	8	0	2	61	1	2	0	0
WIM Count	1	23	8	0	3	60	1	2	0	0
Observed Percent	2	24	8	0	2	61	1	2	0	0
WIM Percent	1	23	8	0	3	60	1	2	0	0
Misclassified Count	1	1	0	0	0	0	0	0	0	0
Misclassified Percent	50	4	0	N/A	0	0	0	0	N/A	N/A
Unclassified Count	0	1	0	0	0	1	0	0	0	0
Unclassified Percent	0	4	0	N/A	0	2	0	0	N/A	N/A

Misclassified vehicles are defined as those vehicles that are manually classified by observation as one class of vehicle but identified by the WIM equipment as another class of vehicle. The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample.

For this site, the classification study resulted in the misclassification of one Class 5 vehicle as a Class 8 and one Class 4 vehicle as a Class 5, as well as unclassifying one Class 5 and on Class 9 vehicles. Collectively, this resulted in an undercount of one Class 4, one Class 5, and one Class 9, and an overcount of one Class 8 by the WIM equipment, as shown in the table above. The misclassifications by pair are provided in Table 5-6. Unclassified vehicles are provided in Table 5-7.

Table 5-6 – Pre-Validation Misclassifications by Pair – 11-Jan-11

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/5	0	5/9	0	9/5	0
3/8	0	6/4	0	9/8	0
4/5	1	6/7	0	9/10	0
4/6	0	6/8	0	10/9	0
5/3	0	6/10	0	10/13	0
5/4	0	7/6	0	11/12	0
5/6	0	8/3	0	12/11	0
5/7	0	8/5	0	13/10	0
5/8	1	8/9	0	13/11	0

Based on the vehicles observed during the pre-validation study, the misclassification percentage is 0.0% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 2.0%.

Unclassified vehicles are defined as those vehicles that cannot be identified by the WIM equipment algorithm. These are typically trucks with unusual trailer tandem configurations and are identified as Class 15 by the WIM equipment. The unclassified vehicles by pair are provided in Table 5-7.

Table 5-7 – Pre-Validation Unclassified Trucks by Pair – 11-Jan-11

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/15	0	7/15	0	11/15	0
4/15	0	8/15	0	12/15	0
5/15	1	9/15	1	13/15	0
6/15	0	10/15			

Based on the manually collected sample of the 100 trucks, 2.0% of the vehicles at this site were reported as unclassified during the study. This is within the established criteria of 2.0% for LTTP SPS WIM sites. The unclassified vehicles were a Class 5 and a Class 9 truck which could not be identified by the WIM equipment. For speed, the mean error for WIM equipment speed measurement was 0.6 mph; the range of errors was 1.5 mph.

5.2 Calibration

The WIM equipment required two calibration iterations between the pre- and post-validations. Information regarding the basis for changing equipment compensation factors, supporting data for the changes, and the resulting WIM accuracies from the calibrations are provided in this section.

The operating system weight compensation parameters that were in place prior to the pre-validation are shown in Table 5-8.

Table 5-8 – Initial System Parameters – 12-Jan-11

Speed Point	MPH	Left		Right	
		1	3	2	4
88	55	3288	3288	2988	2988
96	60	3288	3288	2988	2988
104	65	3132	3132	2844	2844
112	70	3121	3121	2834	2834
120	75	3137	3137	2849	2849
Axle Distance (cm)		306			
Dynamic Comp (%)		103			

5.2.1 Calibration Iteration 1

5.2.1.1 Equipment Adjustments

For GVW, the pre-validation test truck runs produced an overall error of -1.4% and errors of 0.3%, -1.27%, and -1.56% at the 55, 65 and 75 mph speed points respectively. The errors for 55, 65 and 75 mph speeds were interpolated to derive new compensation factors for the 60 and 70 mph speed points. To compensate for these errors, the changes in Table 5-9 were made to the compensation factors.

Table 5-9 – Calibration 1 Equipment Factor Changes – 12-Jan-11

Speed Points	Old Factors		Error	New Factors	
	Left	Right		Left	Right

	1	3	2	4		1	2	3	4
88	3288	3288	2988	2988	0.27%	3255	3255	2958	2958
96	3288	3288	2988	2988	-3.20%	3355	3355	3049	3049
104	3132	3132	2844	2844	-1.27%	3196	3196	2902	2902
112	3121	3121	2834	2834	-3.52%	3185	3185	2892	2892
120	3137	3137	2849	2849	-1.56%	3201	3201	2907	2907
Axle Distance (cm)	306				-0.66%	304			
Dynamic Comp (%)	103				-2.93%	105			

5.2.1.2 Calibration 1 Results

The results of the 12 first calibration verification runs are provided in Table 5-10 and Figure 5-11. As can be seen in the table, the mean error of GVW estimates was not reduced as a result of the first calibration iteration.

Table 5-10 – Calibration 1 Results – 12-Jan-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	0.0 ± 7.5%	Pass
Tandem Axles	±15 percent	2.2 ± 11.6%	Pass
GVW	±10 percent	1.7 ± 9.2%	FAIL
Vehicle Length	±3 percent (1.9 ft)	0.6 ± 5.5 ft	FAIL
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.3 ft	Pass

Figure 5-11 shows that the WIM equipment is overestimating GVW at the low and high speeds. The range in error appears to increase as speed increases.

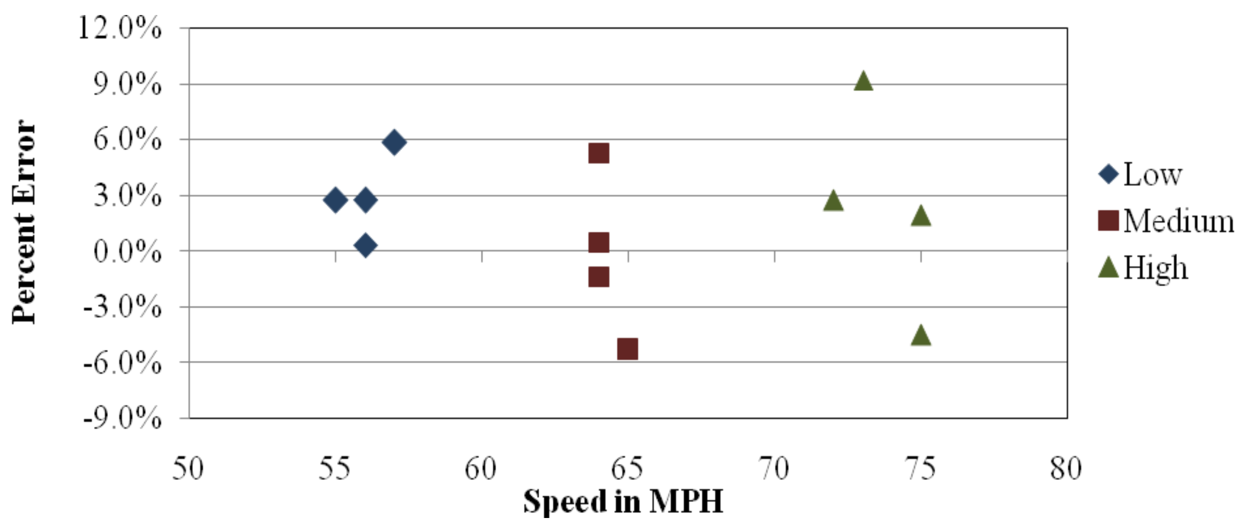


Figure 5-11 – Calibration 1 GVW Error by Speed – 12-Jan-11

Based on the results of the first calibration, where GVW weight estimate bias was +1.7 percent, a second calibration was deemed necessary.

5.2.2 Calibration Iteration 2

5.2.2.1 Equipment Adjustments

The first calibration test truck runs produced an overall error of 1.7% and errors of 3.2%, 0.2%, and 2.5% at the 55, 65 and 75 mph speed points, respectively. The errors for 55, 65 and 75 mph were interpolated to derive new compensation factors for the 60 and 70 mph speed points. To compensate for these errors, the following changes to the compensation factors were made:

Table 5-11 – Calibration 2 Equipment Factor Changes – 12-Jan-11

Speed Points	Old Factors				Error	New Factors			
	1	2	3	4		1	2	3	4
88	3255	3255	2958	2958	3.17%	3156	3156	2868	2868
96	3355	3355	3049	3049	1.59%	3303	3303	3002	3002
104	3196	3196	2902	2902	0.02%	3196	3196	2902	2902
112	3185	3185	2892	2892	1.24%	3185	3185	2892	2892
120	3201	3201	2907	2907	2.45%	3201	3201	2907	2907
Axle Distance (cm)	304				0.03%	304			
Dynamic Comp (%)	105				0.15%	105			

5.2.2.2 Calibration 2 Results

The results of the 20 second calibration verification runs are provided in Table 5-12 and Figure 5-12. As can be seen in the table, the mean error for GVW estimates was reduced as a result of the second calibration iteration. The WIM equipment appears to be measuring GVW accurately at all speeds.

Table 5-12 – Calibration 2 Results – 12-Jan-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-2.5 ± 6.3%	Pass
Tandem Axles	±15 percent	-0.6 ± 10.4%	Pass
GVW	±10 percent	-1.0 ± 8.3%	Pass
Vehicle Length	±3 percent (1.9 ft)	-0.9 ± 1.1 ft	FAIL
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.3 ft	Pass

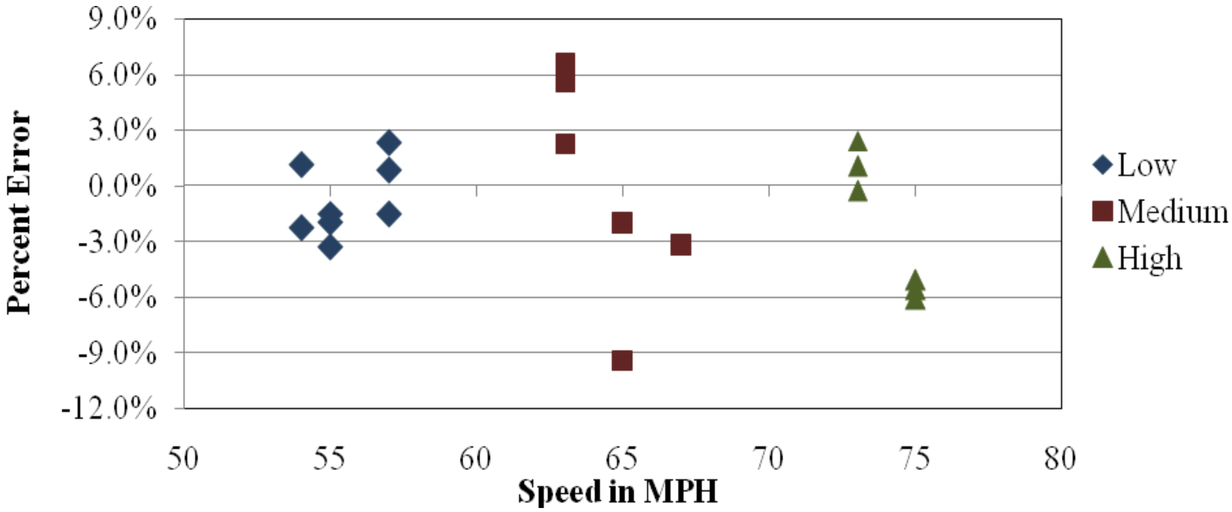


Figure 5-12 – Calibration 2 GVW Error by Speed – 12-Jan-11

Based on the results of the second calibration, where the GVW estimate bias decreased to -1.0 percent, a third calibration was not considered to be necessary. The 20 calibration runs were combined with 20 additional post-validation runs to complete the WIM system validation.

5.3 Post-Validation

The 40 post-validation test truck runs were conducted on January 12, 2011, beginning at approximately 9:01 AM and continuing until 2:00 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with crane counterweights, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.
- A Class 9 truck, loaded with railcar trucks, and equipped with steel spring suspension on the tractor, steel spring suspension on the trailer, with standard tandem spacing on the tractor and a standard tandem spacing on the trailer.

The test trucks were weighed prior to the post-validation and re-weighed at the conclusion of the post-validation. The average test truck weights and measurements are provided in Table 5-13.

Table 5-13 - Post-Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	75.8	9.8	16.5	16.5	16.4	16.4	15.9	4.3	36.0	5.0	61.2	71.0
2	66.1	11.5	14.6	14.6	12.7	12.7	17.9	4.3	27.3	4.1	53.6	58.3

Test truck speeds varied by 21 mph, from 54 to 75 mph. The measured post-validation pavement temperatures varied 40.1 degrees Fahrenheit, from 34.4 to 74.5. The sunny weather conditions provided for reaching the desired 30 degree temperature range. Table 5-14 is a summary of post validation results.

Table 5-14 – Post-Validation Overall Results – 12-Jan-11

Parameter	**95% Confidence Limit of Error**	**Site Values**	**Pass/Fail**
Steering Axles	±20 percent	-1.3 ± 6.5%	Pass
Tandem Axles	±15 percent	-0.2 ± 9.1%	Pass
GVW	±10 percent	-0.5 ± 7.0%	Pass
Vehicle Length	±3 percent (1.9 ft)	-0.6 ± 1.1 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.3 ft	Pass

Truck speed was manually collected for each test run using a radar gun and compared with the speed reported by the WIM equipment. For this site, the average error in speed measurement for all speeds was 0.1 ± 1.4 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Guide. However, since the site is measuring axle spacing length with a mean error of 0.0 feet, and the speed and axle spacing length measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within acceptable ranges.

5.3.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relation exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 75 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-15 below.

Table 5-15 – Post-Validation Results by Speed – 12-Jan-11

Parameter	**95% Confidence Limit of Error**	**Low**	**Medium**	**High**
		54.0 to 61.0 mph	**61.1 to 68.1 mph**	**68.2 to 75.0 mph**
Steering Axles	±20 percent	-2.3 ± 3.4%	2.3 ± 4.6%	-2.7 ± 7.5%
Tandem Axles	±15 percent	-1.8 ± 7.7%	1.4 ± 10.9%	0.3 ± 10.0%
GVW	±10 percent	-1.8 ± 5.4%	1.4 ± 8.7%	-0.2 ± 8.0%
Vehicle Length	±3 percent (1.9 ft)	-0.8 ± 1.1 ft	-0.8 ± 1.1 ft	-0.4 ± 1.2 ft

Vehicle Speed	± 1.0 mph	0.4 ± 1.3 mph	-0.3 ± 1.1 mph	-0.1 ± 1.7 mph
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.3 ft	-0.1 ± 0.4 ft	0.0 ± 0.3 ft

From the table, it can be seen that the WIM equipment estimates all weights with reasonable accuracy and the range of errors is consistent at all speeds. There does not appear to be a relationship between weight estimates and speed at this site.

To aid in the speed analysis, several graphs were developed to illustrate the possible effects of speed on GVW, single axle, and axle group weights, and axle and overall length distance measurements, as discussed in the following paragraphs.

5.3.1.1 GVW Errors by Speed

As shown in Figure 5-13, the equipment estimated GVW with reasonable accuracy at all speeds. The range in error and bias is similar throughout the entire speed range.

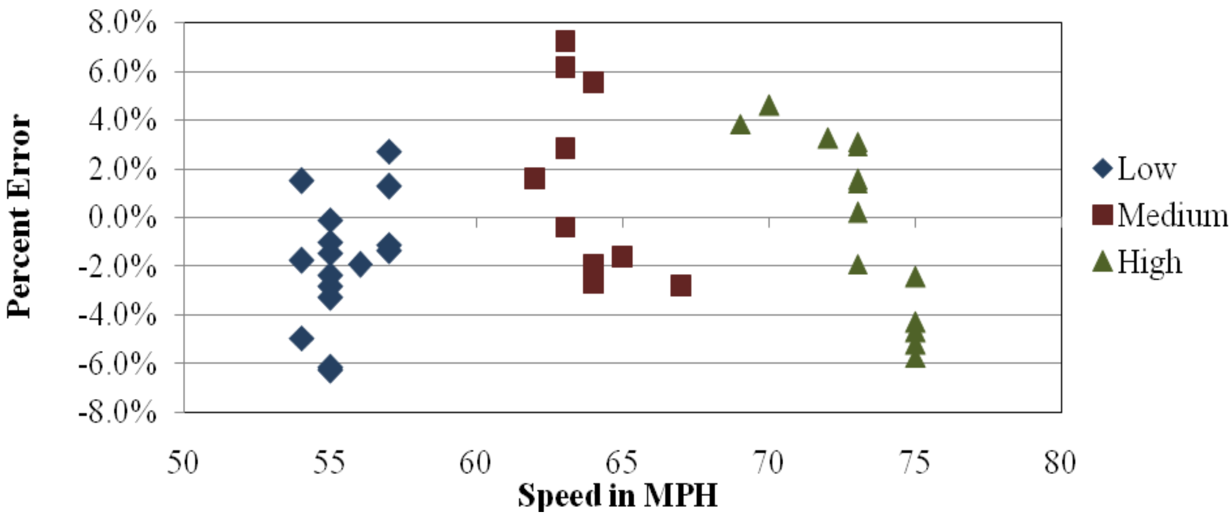


Figure 5-13 – Post-Validation GVW Errors by Speed – 12-Jan-11

5.3.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-14, the equipment estimated steering axle weights with reasonable accuracy at all speeds. The range in error and bias is similar throughout the entire speed range. Distribution of errors is shown graphically in the figure.

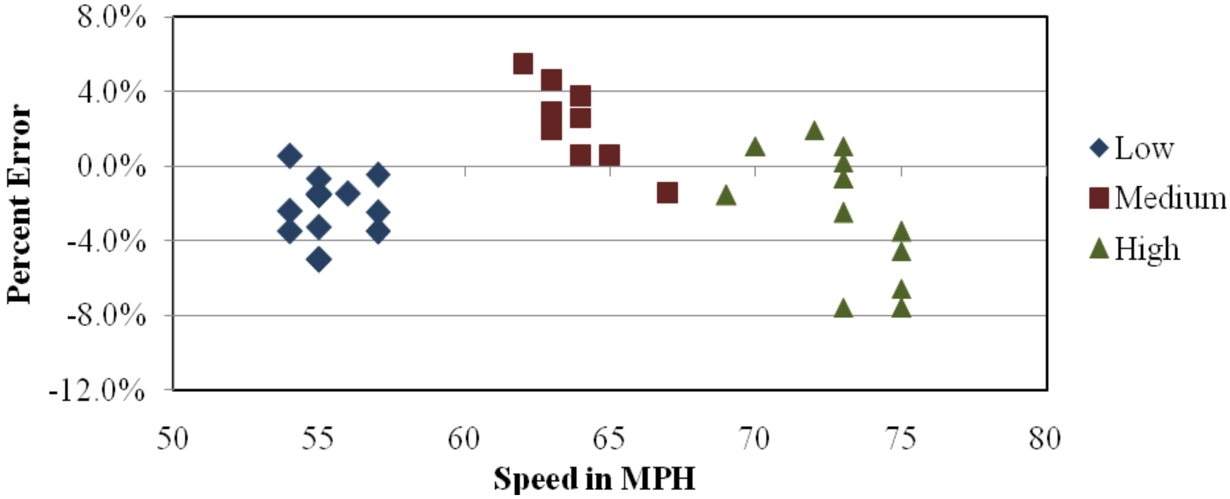


Figure 5-14 – Post-Validation Steering Axle Weight Errors by Speed – 12-Jan-11

5.3.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-15, the equipment estimated tandem axle weights with reasonable accuracy at all speeds. The range in error and bias is similar throughout the entire speed range.

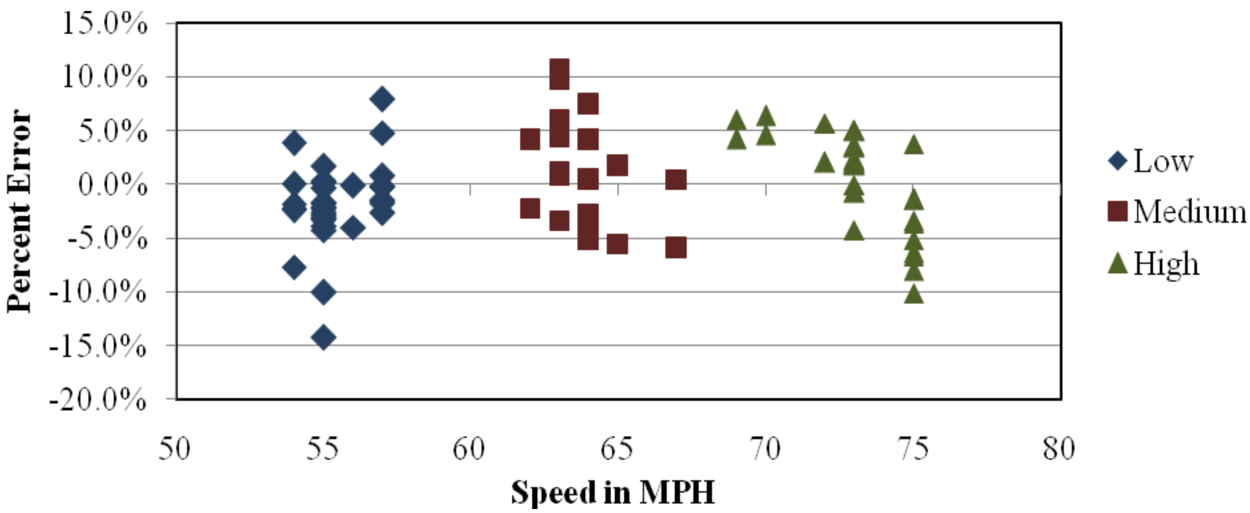


Figure 5-15 – Post-Validation Tandem Axle Weight Errors by Speed – 12-Jan-11

5.3.1.4 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-16 that when the GVW errors are analyzed by truck type, the WIM equipment underestimates GVW for the heavily loaded (Primary) truck at the medium and high speeds. On the other hand, the GVW for the partially loaded (Secondary) truck were overestimated at medium and high speeds.

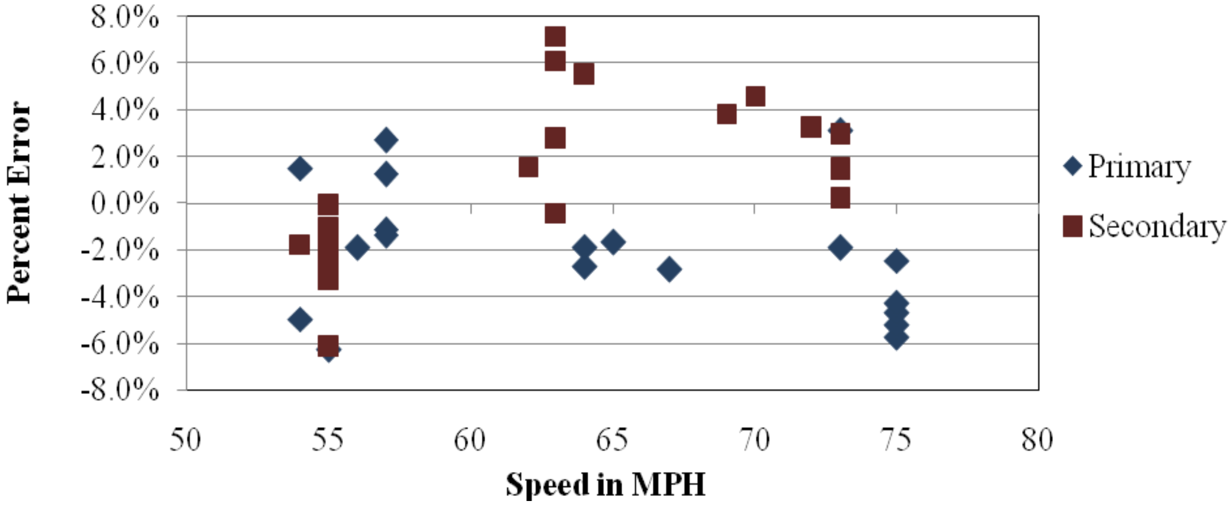


Figure 5-16 – Post-Validation GVW Error by Truck and Speed – 12-Jan-11

5.3.1.5 Axle Length Errors by Speed

For this site, the error in axle length measurement was consistent at all speeds. The range in axle length measurement error ranged from -0.4 feet to 0.3 feet. Distribution of errors is shown graphically in Figure 5-17.

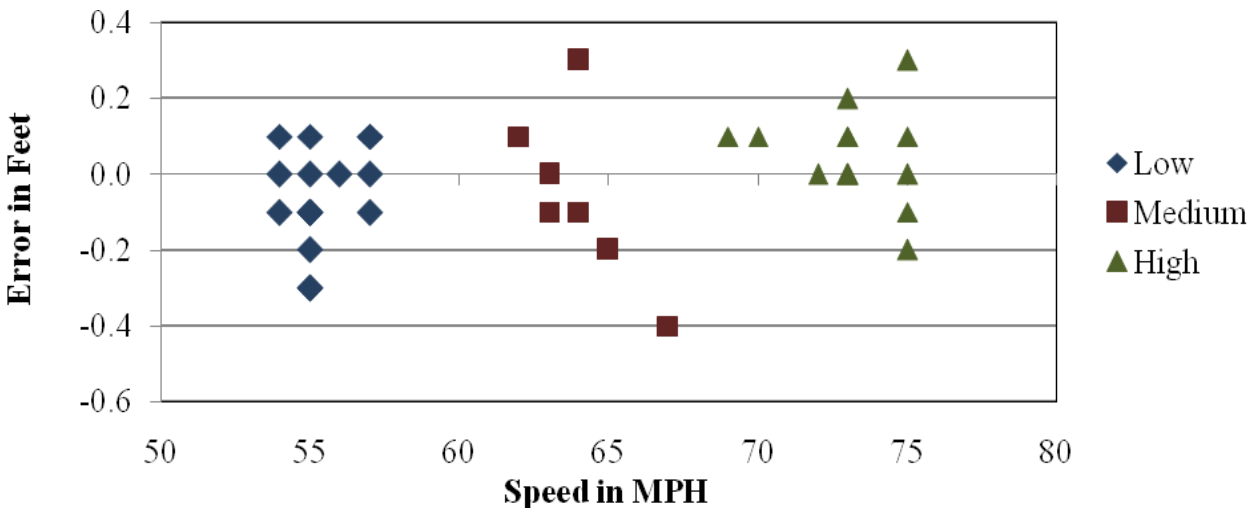


Figure 5-17 – Post-Validation Axle Length Error by Speed – 12-Jan-11

5.3.1.6 Overall Length Errors by Speed

For this system, the WIM equipment generally underestimated overall length over the entire range of speeds, with errors ranging from -1.3 to 0.7 feet. Distribution of errors is shown graphically in Figure 5-18.

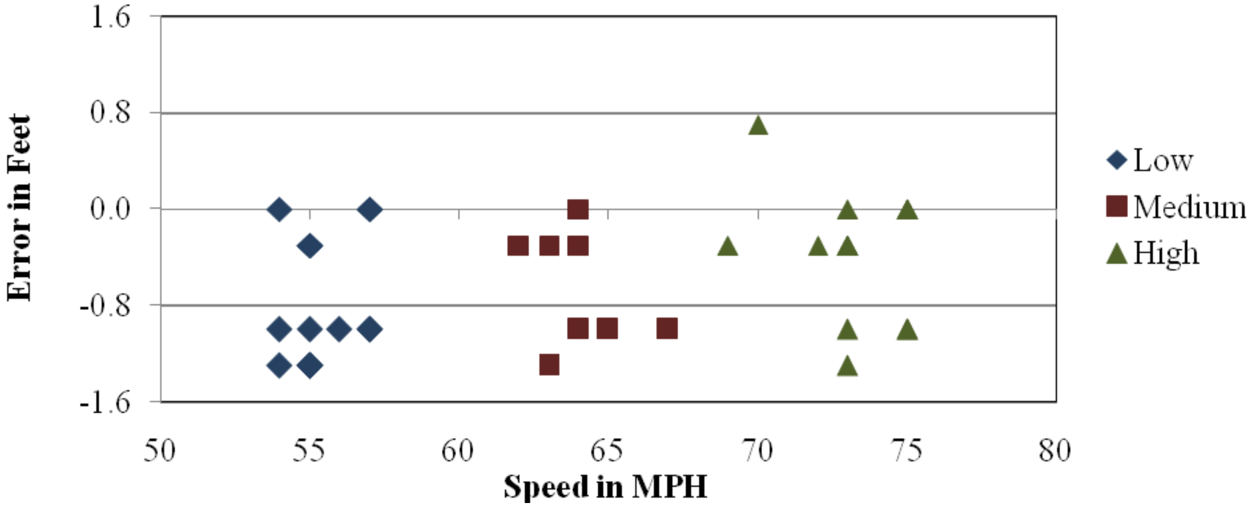


Figure 5-18 – Post-Validation Overall Length Error by Speed – 12-Jan-11

5.3.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether there is a relation between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures varied 40.1 degrees, from 34.4 to 74.5 degrees Fahrenheit. The post-validation test runs are being reported under three temperature groups as shown in Table 5-16 below.

Table 5-16 – Post-Validation Results by Temperature – 12-Jan-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		34.4 to 47.8 degF	47.9 to 61.2 degF	61.3 to 74.5 degF
Steering Axles	±20 percent	-1.0 ± 7.1%	-1.9 ± 3.6%	-1.3 ± 9.0%
Tandem Axles	±15 percent	0.7 ± 10.0%	-0.8 ± 10.8%	-1.2 ± 7.7%
GVW	±10 percent	0.3 ± 8.1%	-0.9 ± 8.9%	-1.3 ± 5.1%
Vehicle Length	±3 percent (1.9 ft)	-0.9 ± 0.9 ft	-0.4 ± 1.4 ft	-0.3 ± 0.9 ft
Vehicle Speed	± 1.0 mph	0.2 ± 1.4 mph	-0.1 ± 2.0 mph	-0.1 ± 1.5 mph
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.3 ft	0 ± 0.4 ft	0.0 ± 0.3 ft

To aid in the analysis, several graphs were developed to illustrate the possible effects of temperature on GVW, single axle weights, and axle group weights.

5.3.2.1 GVW Errors by Temperature

From Figure 5-19, it can be seen that the equipment appears to estimate GVW with reasonable accuracy across the range of temperatures observed in the field. There appears to be a correlation between temperature and weight estimates where the error range decreases with increase in temperature.

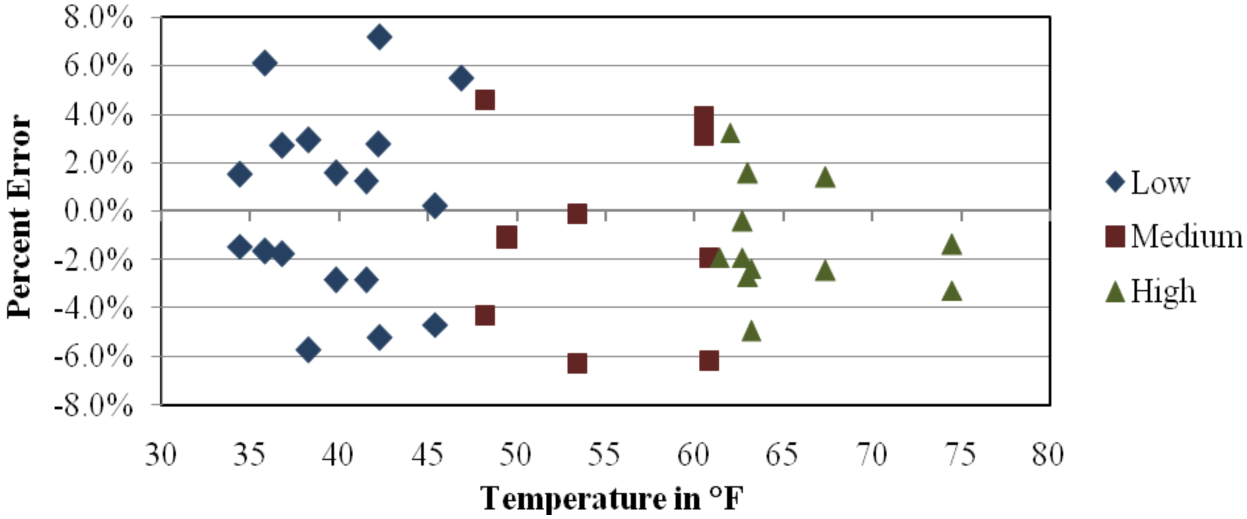


Figure 5-19 – Post-Validation GVW Errors by Temperature – 12-Jan-11

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-20 demonstrates that for steering axles, the WIM equipment appears to estimate with reasonable accuracy across the range of temperatures. The range in error is the smaller at medium temperatures when compared with low and high temperatures.

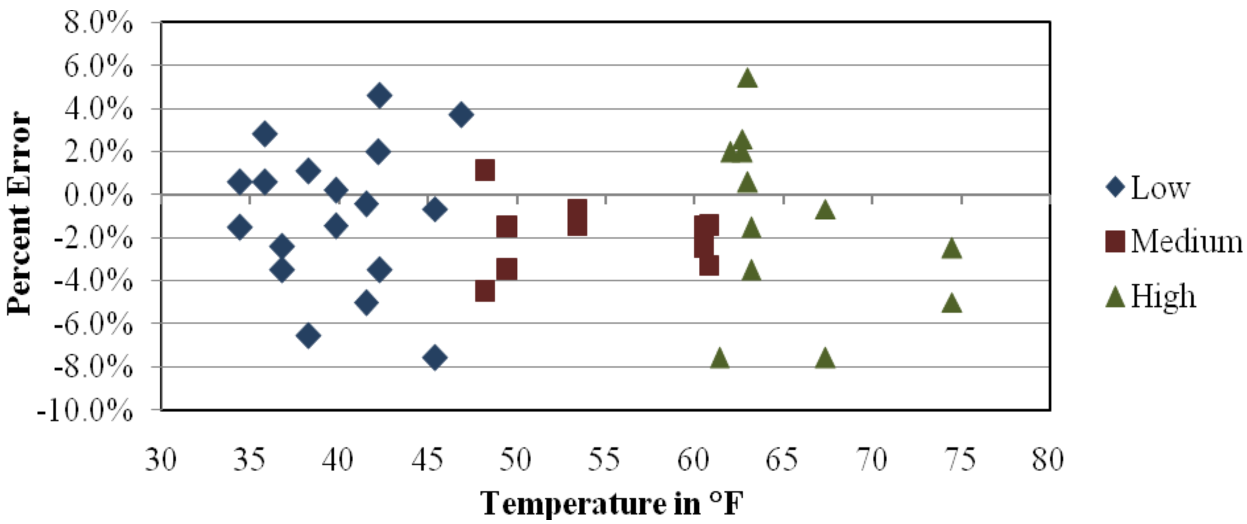


Figure 5-20 – Post-Validation Steering Axle Weight Errors by Temperature – 12-Jan-11

5.3.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-21, the WIM equipment appears to estimate tandem axle weights with similar accuracy at all temperatures. The range in tandem axle errors is smaller at high temperatures when compared with low and medium temperatures.

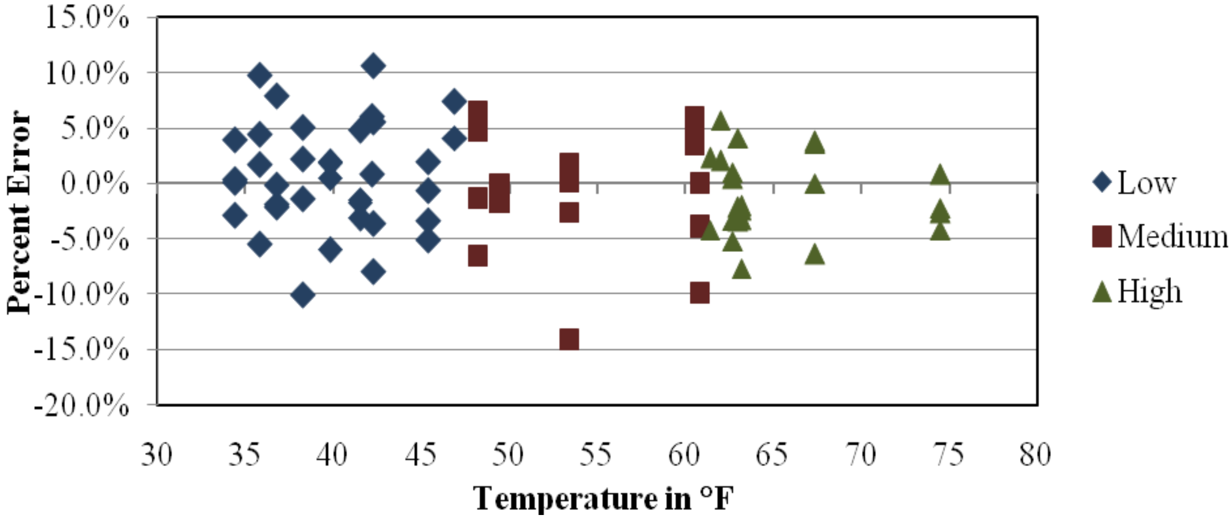


Figure 5-21 – Post-Validation Tandem Axle Weight Errors by Temperature – 12-Jan-11

5.3.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-22, when analyzed by truck type, the WIM equipment underestimates GVW for the heavily loaded (Primary) truck and overestimates GVW for the partially loaded (Secondary) truck at the lower temperatures.

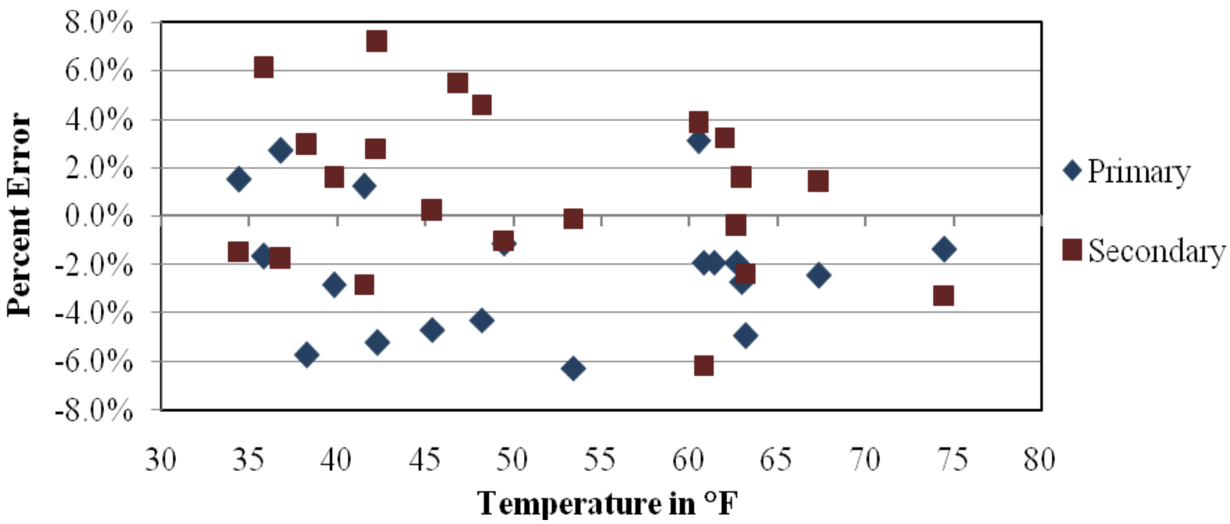


Figure 5-22 – Post-Validation GVW Error by Truck and Temperature – 12-Jan-11

5.3.3 Multivariable Analysis

This section provides additional analysis of post-validation results using a multivariable statistical technique of multiple linear regression. The same calibration data analyzed and discussed previously are analyzed again, but this time using a more sophisticated statistical methodology. The objective of the additional analysis is to investigate if the trends identified using previous analyses are statistically significant, and to quantify these trends.

Multivariable analyses provide additional insight on how speed, temperature, and truck type affect weight measurement errors for a specific site. It is expected that multivariable analyses done systematically for many sites will reveal overall trends.

5.3.3.1 Data

All errors from the weight measurement data collected by the equipment during the validation were analyzed. The percent error is defined as percentage difference between the weight measured by the WIM system and the static weight. Compared to analysis described previously, the weight of "axle group" was evaluated separately for tandem axles on tractors and on trailers. The separate evaluation was carried out because the axles on trailers may have different dynamic response to loads than tandem axles on tractors

The measurement errors were statistically attributed to the following variables or factors:

- Truck type. Primary truck and secondary truck.
- Truck test speed. Truck test speed ranged from 54 to 75 mph.
- Pavement temperature. Pavement temperature ranged from 34.4 to 74.5 degrees Fahrenheit.
- Interaction between the factors such as the interaction between speed and pavement temperature.

5.3.3.2 Results

For analysis of GVW weights, the value of regression coefficients and their statistical properties are summarized in Table 5-17. The value of regression coefficients defines the slope of the relationship between the % error in GVW and the predictor variables (speed, temperature, and truck type). The values of the t-distribution (for the regression coefficients) given in Table 5-17 table are for the null hypothesis that assumes that the coefficients are equal to zero. Only truck type was found to have statistically significant effect on the GVW measurement errors. The probability that the effect of truck type on the GVW errors occurred by chance alone was less than 1 percent.

Table 5-17 – Table of Regression Coefficients for Measurement Error of GVW

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value
Intercept	-0.9222	4.5877	-0.2010	0.8418

Speed	0.0730	0.0630	1.1595	0.2539
Temp	-0.0519	0.0413	-1.2585	0.2163
Truck	-3.2522	0.9847	-3.3027	0.0022

The relationship between temperature and measurement errors is shown in Figure 5-23. The figure includes trend line for the predicted percent error. Besides the visual assessment of the relationship, Figure 5-23 provides quantification and statistical assessment of the relationship.

The quantification is provided by the value of the regression coefficient, in this case 0.0519 (in Table 5-17). This means, for example, that for a 30 degree increase in temperature, the % error is increased by about 1.6 % (0.0519 x 30). The statistical assessment of the relationship is provided by the probability value of the regression coefficient.

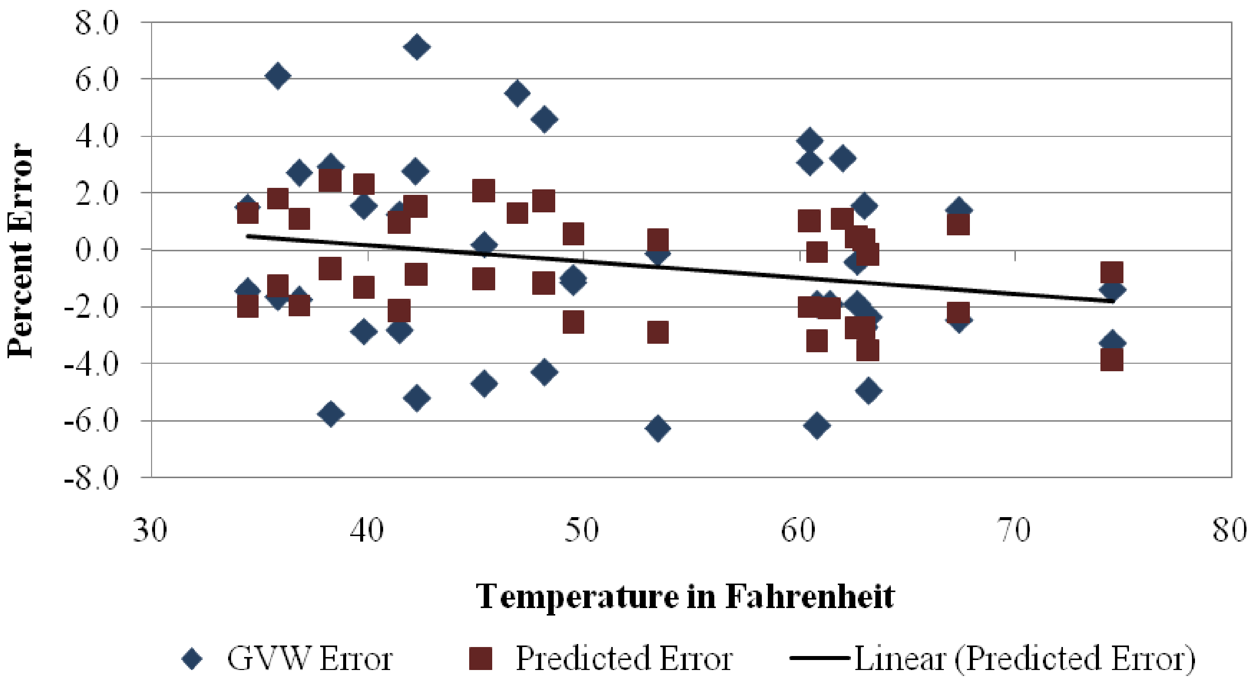


Figure 5-23 – Influence of Temperature on the Measurement Error of GVW

The effect speed on GWV was not statistically significant. The probability that the regression coefficient for speed (-0.00519) in Table 5-17) is not different from zero was 0.2163. In other words, there is about 22 percent chance that the value of the regression coefficient is due to the chance alone.

The interaction between speed, temperature, and truck type was investigated by adding an interactive variable (or variables) such as the product of speed and temperature. No interactive variables were statistically significant. The intercept was not statistically significant and does not have practical meaning.

5.3.3.3 Summary Results

Table 5-18 lists regression coefficients and their probability values for all combinations of factors and % errors evaluated. Not listed in the table are factor interactions because the interactions were not statistically significant. Entries in the table are provided only if the probability value was smaller than 0.20. The dash in Table 5-18 indicates that the relationship was not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 5-18 – Summary of Regression Analysis

	Factor					
	Speed		Temperature		Truck type	
Weight, % error	Regression coefficient	Probability value	Regression coefficient	Probability value	Regression coefficient	Probability value
GVW	-	-	-	-	-3.2522	0.0022
Steering axle	-	-	-	-	-2.7818	0.0057
Tandem axle tractor	-	-	-0.0868	0.0552	-	-
Tandem axle trailer	0.2163	0.0314	-	-	-5.9807	0.0003

5.3.3.4 Conclusions

1. Speed had statistically significant effect on measurement errors of only tandem axles on trailers.

2. Temperature had statistically significant effect on measurement errors of only tandem axles on tractors.

3. Truck type had statistically significant effect on measurement errors of the GVW, steering axle weight, and the tandem axle trailer. The regression coefficient for truck type in Table 5-18, represent the difference between the mean errors for the Primary and Secondary trucks. (Truck type is an indicator variable with values of 0 or 1.). For example, the mean error in GVW for the Primary truck was about 3.3 % larger than the error for the Secondary truck.

4. Even though some of the factors had statistically significant effect on measurement errors, the practical significance of these factors is small and does not affect the validity of the calibration.

5.3.4 Classification and Speed Evaluation

The post-validation classification and speed study involved the comparison of vehicle classification and speed data collected manually with the information for the same vehicles reported by the WIM equipment.

For the post-validation classification study at this site, a manual sample of 100 vehicles including 100 trucks (Class 4 through 13) was collected. Video was collected during the study to provide a means for further analysis of misclassifications and vehicles whose classifications could not be determined with a high degree of certainty in the field. Table 5-19 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study.

Table 5-19 – Post-Validation Classification Study Results – 12-Jan-11

Class	4	5	6	7	8	9	10	11	12	13
Observed Count	1	27	8	0	0	64	0	0	0	0
WIM Count	1	26	8	0	1	64	0	0	0	0
Observed Percent	1	27	8	0	0	64	0	0	0	0
WIM Percent	1	26	8	0	1	64	0	0	0	0
Misclassified Count	0	1	0	0	0	0	0	0	0	0
Misclassified Percent	0	4	0	N/A	N/A	0	N/A	N/A	N/A	N/A
Unclassified Count	0	0	0	0	0	0	0	0	0	0
Unclassified Percent	0	0	0	N/A	0	0	N/A	N/A	N/A	N/A

Misclassified vehicles are defined as those vehicles that are manually classified by observation as one class of vehicle but identified by the WIM equipment as another class of vehicle. The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample.

For this site, the classification study resulted in the misclassification of one Class 5 vehicle as a Class 8. This resulted in an undercount of one Class 5 and an overcount of one Class 8 by the WIM equipment, as shown in the table above. The misclassifications by pair are provided in Table 5-20.

Table 5-20 – Post-Validation Misclassifications by Pair – 12-Jan-11

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/5	0	5/9	0	9/5	0
3/8	0	6/4	0	9/8	0
4/5	0	6/7	0	9/10	0

4/6	0	6/8	0	10/9	0
5/3	0	6/10	0	10/13	0
5/4	0	7/6	0	11/12	0
5/6	0	8/3	0	12/11	0
5/7	0	8/5	0	13/10	0
5/8	1	8/9	0	13/11	0

Based on the vehicles observed during the post-validation study, the misclassification percentage is 0.0% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 1.0%.

As shown in the table, the only misclassification was a Class 5 identified by the WIM equipment as Class 8.

Unclassified vehicles are defined as those vehicles that cannot be identified by the WIM equipment algorithm. These are typically trucks with unusual trailer tandem configurations and are identified as Class 15 by the WIM equipment. The unclassified vehicles by pair are provided in Table 5-21.

Table 5-21 – Post-Validation Unclassified Trucks by Pair – 12-Jan-11

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/15	0	7/15	0	11/15	0
4/15	0	8/15	0	12/15	0
5/15	0	9/15	0	13/15	0
6/15	0	10/15			

Based on the manually collected sample of the 100 trucks, there were no vehicles at this site reported as unclassified during the study. This is within the established criteria of 2.0% for LTTP SPS WIM sites.

For speed, the mean error for WIM equipment speed measurement was 0.2 mph; the range of errors was 0.8 mph.

5.3.5 Predicted Error Trend

Figure 5-24 is provided to illustrate the predicted GVW error with respect to the post-validation errors by speed.

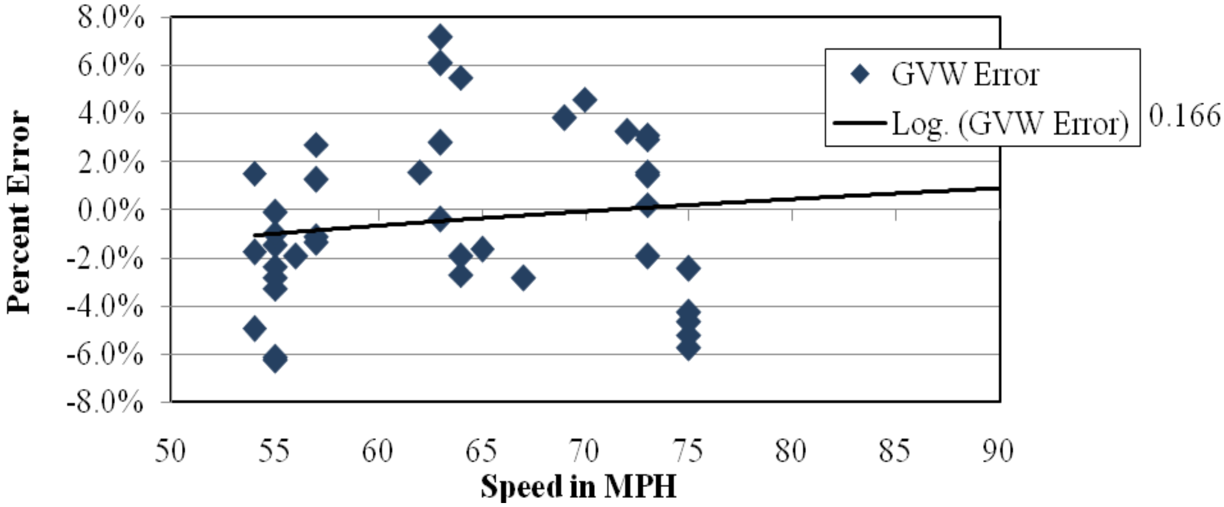


Figure 5-24 – GVW Error Trend

Figure 5-25 is provided to illustrate the predicted Steering Axle error with respect to the post-validation errors by speed.

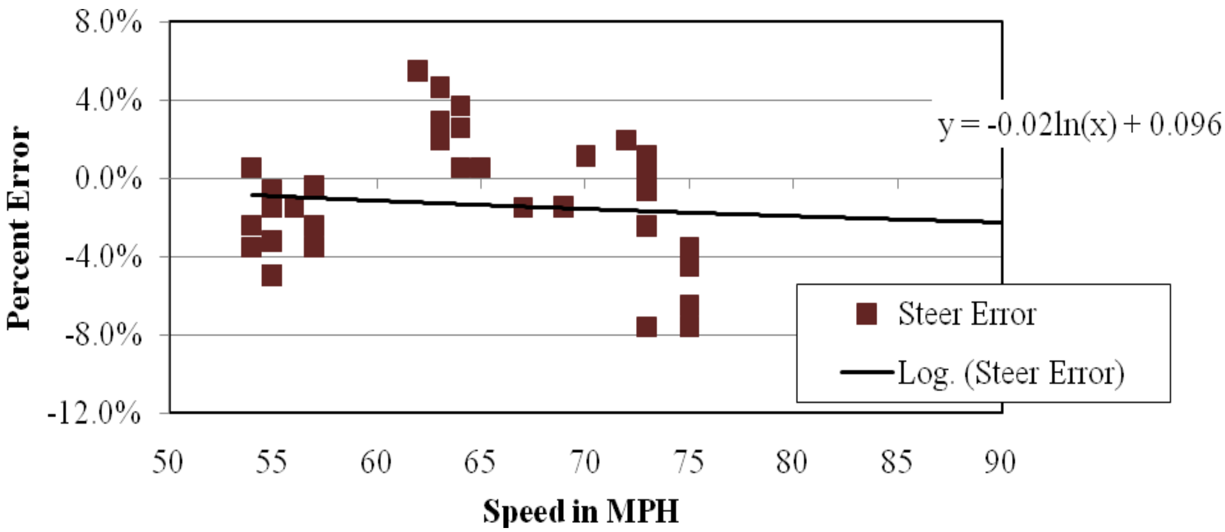


Figure 5-25 – Steering Axle Error Trend

The final compensation factors left in place at the conclusion of the validation are provided in Table 5-22.

Table 5-22 – Final Compensation Factors

Speed Point	MPH	Left		Right	
		1	3	2	4
88	55	3156	3156	2868	2868

96	60	3303	3303	3002	3002
104	65	3196	3196	2902	2902
112	70	3185	3185	2892	2892
120	75	3201	3201	2907	2907
Axle Distance (cm)	304				
Dynamic Comp (%)	105				

6 Previous WIM Site Validation Information

The information reported in this section provides a summary of the performance of the WIM equipment since it was installed or since the first validation was performed on the equipment. The information includes historical data on weight and classification accuracies as well as a comparison of post-validation results.

6.1 Sheet 16s

This site has validation information from one previous visits as well as the current one as summarized in the tables below and provided on the Traffic Sheet 16. Table 6-1 data was extracted from the previous validation and was updated to include the results of this validation.

Table 6-1 – Classification Validation History

Date	Misclassification Percentage by Class										Pct Unclass
	4	5	6	7	8	9	10	11	12	13	
20-Aug-08	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0
21-Aug-08	0	11	0	N/A	10	0	N/A	0	0	N/A	0
11-Jan-11	50	4	0	N/A	0	0	0	0	N/A	N/A	2
12-Jan-11	0	4	0	N/A	N/A	0	N/A	N/A	N/A	N/A	0

Table 6-2 data was extracted from the previous validation and was updated to include the results of this validation. The table provides the mean error and standard deviation for GVW, single axles and tandems for prior pre- and post-validations as reported on the LTPP Traffic Sheet 16s.

Table 6-2 – Weight Validation History

Date	Mean Error ± SD		
	GVW	Single Axles	Tandem
20-Aug-08	5.0 ± 1.6	2.1 ± 2.3	5.7 ± 3.1
21-Aug-08	1.0 ± 2.4	0.8 ± 2.7	1.1 ± 3.6
11-Jan-11	-1.4 ± 3.4	-4.9 ± 4.2	-0.8 ± 4.3
12-Jan-11	-0.5 ± 3.5	-1.3 ± 3.2	-0.2 ± 4.5

The variability of the weight errors appears to have increased since the site was first validated. From this information, it appears that the system demonstrates a tendency for the equipment to move toward an underestimation of GVW over time. The table also demonstrates the effectiveness of the validations in bringing the weight estimations within LTPP SPS WIM equipment tolerances.

6.2 Comparison of Past Validation Results

A comparison of the post-validation results from previous visits is provided in Table 6-3. The table provides the historical performance of the WIM system with regard to the 95% Confidence Interval tolerances.

Table 6-3 – Comparison of Post-Validation Results

Parameter	95 % Confidence Limit of Error	Site Values (Mean Error ± 95% Confidence Interval)	
		21-Aug-08	12-Jan-11
Steering Axles	±20 percent	0.8 ± 5.5	-1.3 ± 6.5
Tandem Axles	±15 percent	1.1 ± 7.1	-0.2 ± 9.1
GVW	±10 percent	1.0 ± 4.9	-0.5 ± 7.0

From the table, it appears that the variance for all weights has increased since the equipment was installed. This could be to deterioration in the pavement condition or degradation of the WIM sensor response to the applied dynamic forces.

A review of the LTPP Standard Release Database 24 shows that there are 19 consecutive months of level "E" WIM data for this site. This site requires 4 additional years of data to meet the minimum of five years of research quality data.

7 Additional Information

The following information is provided in the attached appendix:

- Site Photographs
    - Equipment
    - Test Trucks
    - Pavement Condition
- Pre-validation Sheet 16 – Site Calibration Summary
- Post-validation Sheet 16 – Site Calibration Summary
- Pre-validation Sheet 20 – Classification and Speed Study
- Post-validation Sheet 20 – Classification and Speed Study

Additional information is available upon request through LTPP INFO at ltppinfo@dot.gov, or telephone (202) 493-3035. This information includes:

- Sheet 17 – WIM Site Inventory
- Sheet 18 – WIM Site Coordination
- Sheet 19 – Calibration Test Truck Data
- Sheet 21 – WIM System Truck Records
- Sheet 22 – Site Equipment Assessment plus Addendum
- Sheet 24A/B – Site Photograph Logs
- Updated Handout Guide

WIM System Field Calibration and Validation - Photos

New Mexico, SPS-1
SHRP ID: 350100

Validation Date: January 12, 2011

Photo 1 – Cabinet Exterior

Photo 2 – Cabinet Interior (Front)

Photo 3 – Cabinet Interior (Back)

Photo 4 – Leading Loop

Photo 5 – Leading WIM Sensor

Photo 6 – Trailing WIM Sensor

Photo 7 – Trailing Loop Sensor

Photo 8 – Solar Panel

Photo 9 – Cellular Modem

Photo 10 – Downstream

Photo 11 – Upstream

Photo 12 – Truck 1

Photo 13 – Truck 1 Tractor

Photo 14 – Truck 1 Suspension 1

Photo 15 – Truck 1 Suspension 2

Photo 16 – Truck 1 Suspension 3

Photo 17 – Truck 1 Suspension 4/5

Photo 18 – Truck 2

Photo 19 – Truck 2 Tractor

Photo 20 – Truck 2 Suspension 1

Photo 21 – Truck 2 Suspension 2

Photo 22 – Truck 2 Suspension 3

Photo 23 – Truck 2 Suspension 4/5

Photo 24 – Truck 2 Suspension 5

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 35 SPS WIM ID: 350100 DATE (mm/dd/yyyy) 1/11/2011

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 1/11/11

2. **TYPE OF EQUIPMENT CALIBRATED:** Both

3. **REASON FOR CALIBRATION:** LTPP Validation

4. **SENSORS INSTALLED IN LTPP LANE AT THIS SITE** (Select all that apply):
   a. Inductance Loops
   b. Quartz Piezo
   c.
   d.

5. **EQUIPMENT MANUFACTURER:** IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. **CALIBRATION TECHNIQUE USED:** Test Trucks

Number of Trucks Compared:
Number of Test Trucks Used: 2
Passes Per Truck: 20

	Type	Drive Suspension	Trailer Suspension
Truck 1:	9	air	air
Truck 2:	9	steel spring	steel spring
Truck 3:			

7. **SUMMARY CALIBRATION RESULTS** (expressed as a %):

Mean Difference Between -

Dynamic and Static GVW:	-1.4%	Standard Deviation:	3.4%
Dynamic and Static Single Axle:	-4.9%	Standard Deviation:	4.2%
Dynamic and Static Double Axles:	-0.8%	Standard Deviation:	4.3%

8. **NUMBER OF SPEEDS AT WHICH CALIBRATION WAS PERFORMED:** 3

9. **DEFINE SPEED RANGES IN MPH:**

			Low		High	Runs
a.	Low	-	50.0	to	58.3	12
b.	Medium	-	58.4	to	66.8	12
c.	High	-	66.9	to	75.0	16
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)	35 350100 1/11/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3201 | 2907

11. IS AUTO- CALIBRATION USED AT THIS SITE? No

If yes , define auto-calibration value(s):

CLASSIFIER TEST SPECIFICS

12. METHOD FOR COLLECTING INDEPENDENT VOLUME MEASUREMENT BY VEHICLE CLASS:

Manual

13. METHOD TO DETERMINE LENGTH OF COUNT: Number of Trucks

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	-2.0	FHWA Class		-	
FHWA Class 8:	50.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 2.0%

Validation Test Truck Run Set - Pre

Person Leading Calibration Effort: **Dean J. Wolf**

Contact Information: Phone: 717-512-6638

E-mail: dwolf@ara.com

Traffic Sheet 16	STATE CODE:	35
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	350100
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	1/12/2011

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 1/12/11

2. TYPE OF EQUIPMENT CALIBRATED: Both

3. REASON FOR CALIBRATION: LTPP Validation

4. SENSORS INSTALLED IN LTPP LANE AT THIS SITE (Select all that apply):

a. Inductance Loops c.

b. Quartz Piezo d.

5. EQUIPMENT MANUFACTURER: IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. CALIBRATION TECHNIQUE USED: Test Trucks

Number of Trucks Compared:

Number of Test Trucks Used: 2

Passes Per Truck: 6

	Type	Drive Suspension	Trailer Suspension
Truck 1:	9	air	air
Truck 2:	9	steel spring	steel spring
Truck 3:	0	0	0

7. SUMMARY CALIBRATION RESULTS (expressed as a %):

Mean Difference Between -

Dynamic and Static GVW:	1.7%	Standard Deviation:	4.2%
Dynamic and Static Single Axle:	0.0%	Standard Deviation:	3.4%
Dynamic and Static Double Axles:	2.2%	Standard Deviation:	5.3%

8. NUMBER OF SPEEDS AT WHICH CALIBRATION WAS PERFORMED: 3

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	55.0	to	61.7	4
b.	Medium	-	61.8	to	68.4	4
c.	High	-	68.5	to	75.0	4
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 35 SPS WIM ID: 350100 DATE (mm/dd/yyyy) 1/12/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 0

11. IS AUTO- CALIBRATION USED AT THIS SITE? No

If yes , define auto-calibration value(s):

The Auto-cal feature is using a linear progression of numerical values, starting at 1000 for 0 degrees, with a value incremented by 4 for every degree up to 100 degrees.

CLASSIFIER TEST SPECIFICS

12. METHOD FOR COLLECTING INDEPENDENT VOLUME MEASUREMENT BY VEHICLE CLASS:

Manual

13. METHOD TO DETERMINE LENGTH OF COUNT: Number of Trucks

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	-2.0	FHWA Class		-	
FHWA Class 8:	50.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 2.0%

Validation Test Truck Run Set - Cal 1

Person Leading Calibration Effort: **Dean J. Wolf**

Contact Information: Phone: 717-512-6638

E-mail: dwolf@ara.com

Traffic Sheet 16	STATE CODE:	35
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	350100
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	1/12/2011

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 1/12/11

2. **TYPE OF EQUIPMENT CALIBRATED:** Both

3. **REASON FOR CALIBRATION:** LTPP Validation

4. **SENSORS INSTALLED IN LTPP LANE AT THIS SITE** (Select all that apply):
   a. Inductance Loops
   b. Quartz Piezo
   c.
   d.

5. **EQUIPMENT MANUFACTURER:** IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. **CALIBRATION TECHNIQUE USED:** Test Trucks

Number of Trucks Compared:
Number of Test Trucks Used: 2
Passes Per Truck: 10

	Type	Drive Suspension	Trailer Suspension
Truck 1:	9	air	air
Truck 2:	9	steel spring	steel spring
Truck 3:	0	0	0

7. **SUMMARY CALIBRATION RESULTS** (expressed as a %):

Mean Difference Between -

	Mean		Standard Deviation
Dynamic and Static GVW:	-1.0%	Standard Deviation:	3.9%
Dynamic and Static Single Axle:	-2.5%	Standard Deviation:	3.0%
Dynamic and Static Double Axles:	-0.6%	Standard Deviation:	5.0%

8. **NUMBER OF SPEEDS AT WHICH CALIBRATION WAS PERFORMED:** 3

9. **DEFINE SPEED RANGES IN MPH:**

			Low		High	Runs
a.	Low	-	54.0	to	61.0	8
b.	Medium	-	61.1	to	68.1	6
c.	High	-	68.2	to	75.0	6
d.		-		to		
e.		-		to		

Traffic Sheet 16	STATE CODE:	35
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	350100
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	1/12/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 0

11. IS AUTO- CALIBRATION USED AT THIS SITE? No

If yes , define auto-calibration value(s):

The Auto-cal feature is using a linear progression of numerical values, starting at 1000 for 0 degrees, with a value incremented by 4 for every degree up to 100 degrees.

CLASSIFIER TEST SPECIFICS

12. METHOD FOR COLLECTING INDEPENDENT VOLUME MEASUREMENT BY VEHICLE CLASS:

Manual

13. METHOD TO DETERMINE LENGTH OF COUNT: Number of Trucks

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	______	FHWA Class ______	-	______
FHWA Class 8:	______	FHWA Class ______	-	______
		FHWA Class ______	-	______
		FHWA Class ______	-	______

Percent of "Unclassified" Vehicles: 2.0%

Validation Test Truck Run Set - Cal 2

Person Leading Calibration Effort: **Dean J. Wolf**

Contact Information: Phone: 717-512-6638

E-mail: dwolf@ara.com

Traffic Sheet 16	STATE CODE:	35
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	350100
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	1/12/2011

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 1/12/11

2. TYPE OF EQUIPMENT CALIBRATED: Both

3. REASON FOR CALIBRATION: LTPP Validation

4. SENSORS INSTALLED IN LTPP LANE AT THIS SITE (Select all that apply):

a. Inductance Loops
c.
b. Quartz Piezo
d.

5. EQUIPMENT MANUFACTURER: IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. CALIBRATION TECHNIQUE USED: Test Trucks

Number of Trucks Compared:
Number of Test Trucks Used: 2
Passes Per Truck: 20

	Type	Drive Suspension	Trailer Suspension
Truck 1:	9	air	air
Truck 2:	9	steel spring	steel spring
Truck 3:			

7. SUMMARY CALIBRATION RESULTS (expressed as a %):

Mean Difference Between -

Dynamic and Static GVW:	-0.5%	Standard Deviation:	3.5%
Dynamic and Static Single Axle:	-1.3%	Standard Deviation:	3.2%
Dynamic and Static Double Axles:	-0.2%	Standard Deviation:	4.5%

8. NUMBER OF SPEEDS AT WHICH CALIBRATION WAS PERFORMED: 3

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	54.0	to	61.0	16
b.	Medium	-	61.1	to	68.1	10
c.	High	-	68.2	to	75.0	14
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 35 SPS WIM ID: 350100 DATE (mm/dd/yyyy) 1/12/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3241 | 2943

11. IS AUTO- CALIBRATION USED AT THIS SITE? No

If yes , define auto-calibration value(s):

CLASSIFIER TEST SPECIFICS

12. METHOD FOR COLLECTING INDEPENDENT VOLUME MEASUREMENT BY VEHICLE CLASS:

Manual

13. METHOD TO DETERMINE LENGTH OF COUNT: Number of Trucks

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	0.0	FHWA Class		-	
FHWA Class 8:	Unk	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Post

Person Leading Calibration Effort: **Dean J. Wolf**

Contact Information: Phone: 717-512-6638

E-mail: dwolf@ara.com

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE:	35
	SPS WIM ID:	350100
	DATE (mm/dd/yyyy)	1/11/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
68	9	19319	68	9	74	9	19439	71	9
68	9	19332	68	9	70	5	19443	70	5
65	9	19343	66	9	70	9	19451	69	9
62	9	19344	62	9	72	6	19455	70	6
60	5	19345	60	5	73	5	19456	72	5
68	5	19347	67	5	60	9	19465	60	9
72	9	19356	72	9	70	9	19477	69	9
65	5	19360	59	5	**69**	**15**	**19478**	**68**	**9**
67	9	19361	68	9	64	6	19480	68	6
75	9	19363	75	9	70	9	19486	70	9
68	6	19365	67	6	69	9	19487	69	9
75	5	19367	71	5	55	5	19492	54	5
59	11	19379	59	11	52	6	19494	50	6
59	9	19382	58	9	63	5	19496	62	5
50	6	19386	49	6	78	9	19497	76	9
55	5	19388	54	5	76	9	19498	76	9
75	9	19401	73	9	62	9	19499	61	9
68	9	19403	69	9	65	9	19508	64	9
65	9	19405	66	9	60	9	19511	59	9
75	9	19406	74	9	76	5	19518	74	5
70	9	19407	70	9	68	9	19525	68	9
70	9	19409	73	9	55	5	19526	54	5
73	9	19430	78	9	77	5	19527	76	5
68	5	19432	68	5	60	6	19528	60	6
60	11	19436	59	11	73	9	19533	73	9

Sheet 1 - 0 to 50 Start: 8:50:00 Stop: 10:07:00

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 35 SPS WIM ID: 350100 DATE (mm/dd/yyyy) 1/11/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
72	9	19537	71	9	72	5	19649	71	5
64	10	19538	64	10	68	9	19651	68	9
70	9	19541	70	9	68	5	19656	69	5
59	**15**	**19545**	**59**	**5**	**67**	**9**	19666	66	9
66	6	19549	66	6	59	9	19672	59	9
65	9	19551	64	9	64	9	19674	64	9
69	9	19555	68	9	69	9	19675	68	9
64	9	19559	64	9	64	9	19676	64	9
73	9	19574	72	9	70	9	19681	63	9
73	9	19578	74	9	50	9	19683	51	9
72	6	19589	71	6	63	9	19703	62	9
75	5	19590	74	5	**73**	**8**	**19705**	**72**	**5**
76	9	19591	76	9	78	9	19708	78	9
71	5	19592	70	5	59	5	19711	56	5
78	5	19598	75	5	62	9	19712	62	9
68	9	19599	67	9	70	9	19714	69	9
65	9	19602	64	9	64	8	19715	63	8
65	9	19603	67	9	70	9	19719	70	9
64	9	19605	63	9	65	9	19724	64	9
69	8	19608	68	8	78	9	19727	77	9
62	9	19613	63	9	63	9	19730	64	9
58	5	19614	56	5	59	5	19734	58	5
68	9	19616	68	9	73	9	19735	71	9
67	9	19633	67	9	76	4	19737	75	4
58	**5**	**19640**	**59**	**4**	**68**	**5**	19744	68	5

Sheet 2 - 51 to 100 Start: 10:08:00 Stop: 11:38:00

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)	35 350100 1/0/1900

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class

Sheet 3 - 101 - 150 Start: ____________ Stop: ____________

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20	STATE CODE: 35
LTPP MONITORED TRAFFIC DATA	SPS WIM ID: 350100
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy) 1/0/1900

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class

Sheet 4 - 151 to 200 Start: ____________ Stop: ____________

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20	STATE CODE:	35
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	350100
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	1/12/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
71	9	21809	70	9	72	9	21914	72	9
65	5	21811	65	5	64	9	21922	64	9
65	9	21814	65	9	66	9	21926	65	9
70	5	21818	69	5	75	9	21934	74	9
65	9	21823	64	9	75	5	21939	75	5
50	6	21824	50	6	74	9	21941	74	9
56	9	21827	56	9	51	6	21947	50	6
55	9	21828	55	9	73	9	21958	73	9
64	9	21850	64	9	67	9	21959	66	9
78	9	21852	77	9	57	5	21960	57	5
75	5	21856	75	5	78	5	21968	77	5
63	5	21860	63	5	70	9	21975	70	9
60	9	21861	60	9	71	5	21976	71	5
63	9	21864	63	9	68	9	21977	68	9
66	9	21865	65	9	65	9	21980	65	9
63	9	21869	65	9	75	9	21981	75	9
74	5	21874	73	5	73	6	21985	72	6
68	9	21875	67	9	71	5	21987	70	5
70	9	21876	70	9	63	5	21988	63	5
62	9	21878	63	9	74	9	21989	74	9
69	6	21890	69	6	63	9	21998	63	9
75	5	21896	75	5	75	9	21999	76	9
73	9	21897	73	9	72	9	22004	71	9
75	9	21898	76	9	67	5	22009	68	5
64	9	21913	65	9	73	9	22012	71	9

Sheet 1 - 0 to 50 Start: 9:53:41 Stop: 11:19:02

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Post

Traffic Sheet 20	STATE CODE:	35
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	350100
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	1/12/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
75	9	22013	75	9	67	5	22130	67	5
78	5	22015	77	5	68	9	22134	67	9
62	5	22018	62	5	72	9	22136	72	9
57	9	22028	57	9	73	6	22137	75	6
83	5	22030	81	5	71	5	22147	70	5
77	6	22031	76	6	76	5	22156	77	5
62	9	22043	63	9	68	9	22161	67	9
58	5	22057	59	5	70	9	22165	70	9
65	9	22058	65	9	73	5	22166	74	5
65	9	22059	65	9	69	9	22171	70	9
65	9	22066	65	9	65	9	22182	65	9
78	5	22067	77	5	73	5	22183	73	5
74	9	22078	74	9	77	5	22190	76	5
72	9	22079	72	9	63	9	22193	62	9
51	**8**	**22088**	**51**	**5**	73	9	22198	72	9
64	9	22092	64	9	71	9	22200	71	9
52	6	22093	50	6	78	4	22201	77	4
70	9	22097	68	9	49	6	22202	49	6
63	9	22098	62	9	71	9	22226	71	9
63	9	22102	62	9	75	9	22227	75	9
73	9	22105	72	9	66	9	22233	66	9
70	9	22113	70	9	68	5	22244	68	5
66	9	22117	65	9	71	9	22263	71	9
73	9	22120	73	9	64	5	22267	64	5
65	9	22121	65	9	66	9	22268	65	9

Sheet 2 - 51 to 100 Start: 11:19:19 Stop: 12:54:07

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Post

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)	35 350100 1/0/1900

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class

Sheet 3 - 101 - 150 Start: __________ Stop: __________

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Post

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)	35 350100 1/0/1900

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class

Sheet 4 - 151 to 200 Start: ____________ Stop: ____________

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Post