WIM System Field Calibration and Validation Summary Report

Wisconsin SPS-1
SHRP ID – 550100

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1 Executive Summary

A WIM validation was performed on April 12 and 13, 2011 at the Wisconsin SPS-1 site located on route US-29 at milepost 189.8, 2 miles west of SR 49.

This site was installed on June 20, 2007. The in-road sensors are installed in the westbound lane. The site is equipped with bending plate WIM sensors and an 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 May 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 the WIM components determined that the the equipment is operating within the manufacturer's tolerances. Further equipment discussion is provided in Section 3.

During the on-site pavement evaluation, There were no pavement distresses noted that may affect the accuracies of the WIM system. A visual observation of the trucks as they approach, traverse, and leave the sensor area did not indicate any adverse dynamics that would affect the accuracy of the WIM system. The trucks appear to track down the center of the lane. 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 – 13-Apr-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	5.5 ± 9.4%	Pass
Tandem Axles	±15 percent	-1.0 ± 4.5%	Pass
GVW	±10 percent	0.1 ± 2.2%	Pass
Vehicle Length	±3.0 percent (2.2 ft)	-0.9 ± 1.0 ft	Pass
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.1 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 0.2 ± 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 -0.1 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the speeds being reported by the WIM equipment are within acceptable ranges.

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 3.0% from the 100 truck sample (Class 4 – 13) was due to the 3 cross-classifications of Class 3, 4, 5, and 8 vehicles.

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 palletized paper rolls.

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

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. Axle spacings were measured from the center hub of the each axle to the center hub of the subsequent 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	76.3	12.0	16.1	16.1	16.0	16.0	17.1	4.3	35.5	4.2	61.1	72.3
2	63.5	11.8	13.2	13.2	12.6	12.6	17.2	4.3	35.0	4.2	60.7	72.4

The posted speed limit at the site is 65 mph. During the testing, the speed of the test trucks ranged from to 52 to 64 mph, a variance of 12 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 41.3 to 81.7 degrees Fahrenheit, a range of 40.4 degrees Fahrenheit. The sunny weather conditions provided attaining the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 24 shows that there are 21 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 March 14, 2011 (Data) to the most recent Comparison Data Set (CDS) from May 22, 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 is one year of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2007 to 2009.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2007	57	2
2008	357	12
2009	196	7

As shown in the table, this site requires four additional years of data to meet the minimum of five years of research quality data. The 2007 and 2009 data does not meet the 210-day minimum requirement for a calendar year.

Table 2-2 provides a monthly breakdown of the available data for years 2007 through 2009.

Table 2-2 – LTPP Data Availability by Month

Year	Month												No. of Months
	1	2	3	4	5	6	7	8	9	10	11	12	
2007											26	31	2
2008	31	29	31	30	31	26	31	31	28	28	30	31	12
2009	31	28	31	30	29	28	19						7

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.

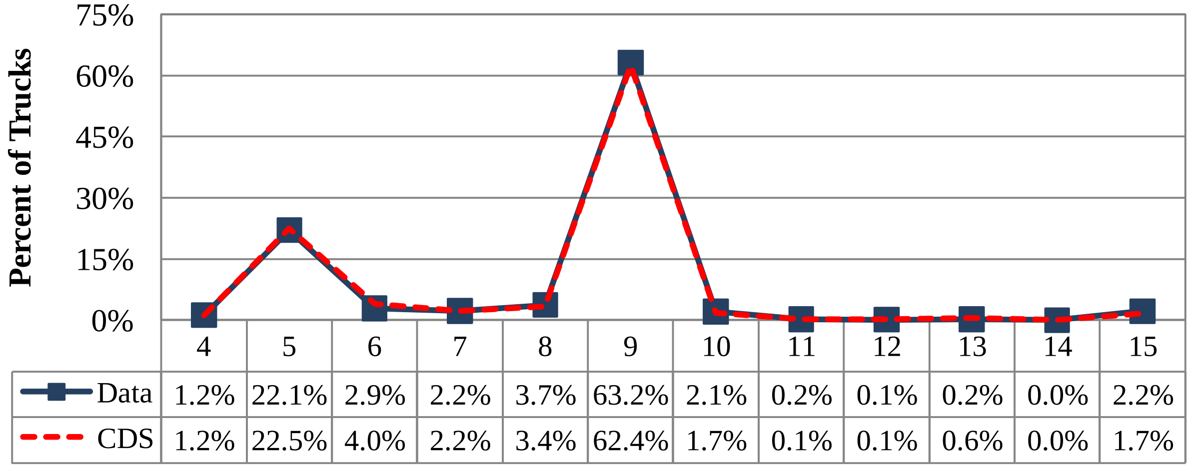


Figure 2-1 – Comparison of Truck Distribution

Table 2-3 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 (63.2%) and Class 5 (22.1%).

Table 2-3 – Truck Distribution from W-Card

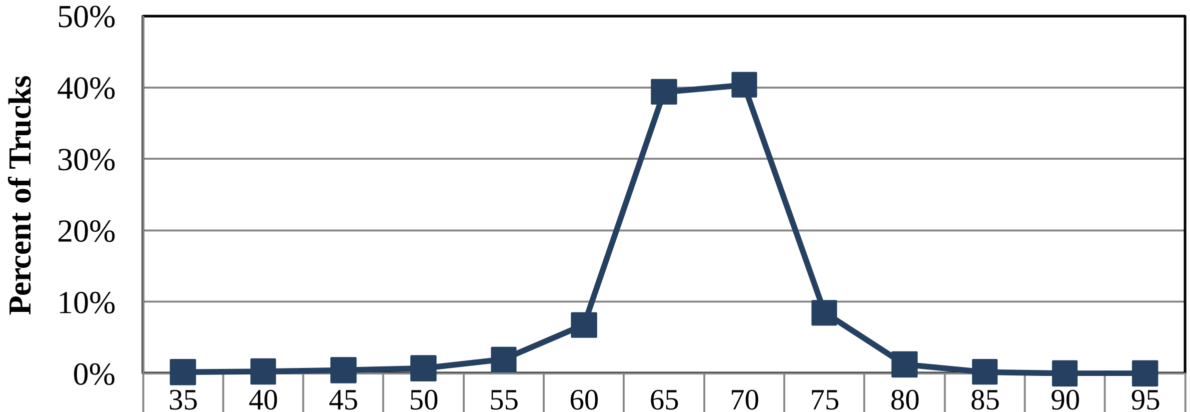
Vehicle Classification	CDS		Data		Change
	Date				
	5/22/2008		3/14/2011		
4	141	1.2%	110	1.2%	0.0%
5	2709	22.5%	2022	22.1%	-0.5%
6	485	4.0%	263	2.9%	-1.2%
7	263	2.2%	202	2.2%	0.0%
8	407	3.4%	342	3.7%	0.3%
9	7505	62.4%	5790	63.2%	0.7%
10	210	1.7%	190	2.1%	0.3%
11	15	0.1%	22	0.2%	0.1%
12	17	0.1%	9	0.1%	0.0%
13	68	0.6%	16	0.2%	-0.4%
14	0	0.0%	0	0.0%	0.0%
15	203	1.7%	200	2.2%	0.5%

Table 2-3 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 2.2 percent of the vehicles at this site are unclassified.

From the table it can be seen that the number of Class 9 vehicles has increased by 0.7 percent from May 2008 and March 2011. Changes in the number of heavier trucks may be attributed to seasonal variations in truck distributions and to natural variation in truck volumes. During the same time period, the number of Class 5 trucks decreased by 0.5 percent. These differences may be attributed changes in the use of the roadway for local deliveries as well as to natural variation 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 determining the speed of the test trucks during validation testing. The CDS distribution of speeds is shown in Figure 2-2.



	35	40	45	50	55	60	65	70	75	80	85	90	95
Data	0.2%	0.3%	0.4%	0.7%	1.9%	6.8%	39.4%	40.4%	8.5%	1.2%	0.2%	0.0%	0.0%

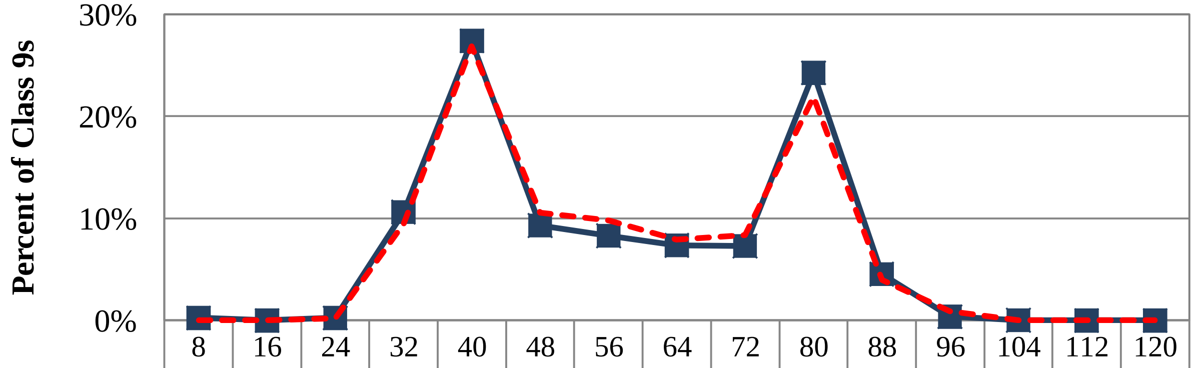
Figure 2-2 – Truck Speed Distribution – 07-Mar-11

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

2.4 GVW Data Analysis

The traffic 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 March 2011 and the Comparison Data Set from May 2008.

As shown in Figure 2-3, there is a slight increase in the percentage of fully loaded trucks between the May 2008 Comparison Data Set (CDS) and the March 2011 two-week sample W-card dataset (Data).



	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
Data	0.3%	0.0%	0.3%	10.6	27.4	9.3%	8.3%	7.4%	7.3%	24.3	4.5%	0.4%	0.0%	0.0%	0.0%
CDS	0.0%	0.0%	0.2%	9.5%	26.9	10.5	9.8%	7.9%	8.4%	21.9	4.0%	0.9%	0.0%	0.0%	0.0%

Figure 2-3 – Comparison of Class 9 GVW Distribution

Table 2-4 is provided to show the statistical comparison for Class 9 GVW between the Comparison Data Set and the sample dataset.

Table 2-4 – Class 9 GVW Distribution from W-Card

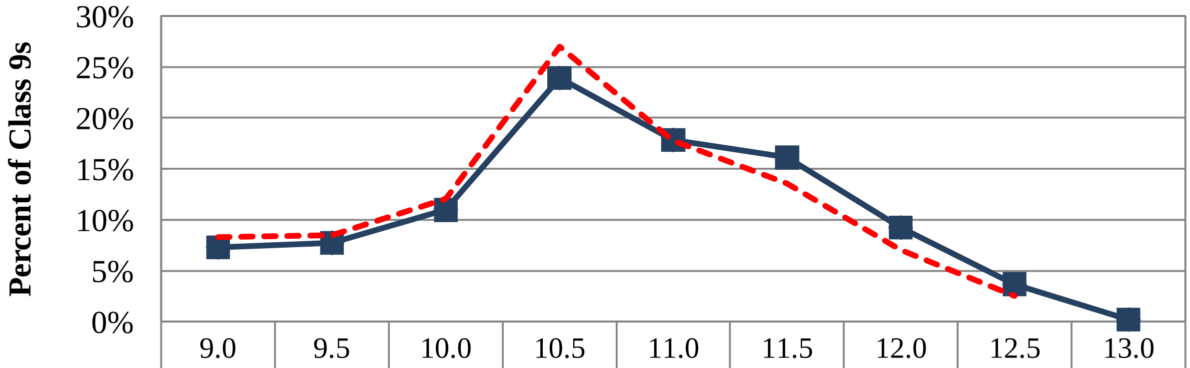
GVW weight bins (kips)	CDS		Data		Change
	Date				
	5/22/2008		3/14/2011		
8	0	0.0%	8	0.3%	0.3%
16	0	0.0%	0	0.0%	0.0%
24	14	0.2%	8	0.3%	0.1%
32	710	9.5%	338	10.6%	1.1%
40	2007	26.9%	871	27.4%	0.5%
48	787	10.5%	296	9.3%	-1.2%
56	733	9.8%	264	8.3%	-1.5%
64	590	7.9%	234	7.4%	-0.5%
72	625	8.4%	232	7.3%	-1.1%
80	1636	21.9%	771	24.3%	2.4%
88	297	4.0%	144	4.5%	0.6%
96	69	0.9%	12	0.4%	-0.5%
104	2	0.0%	1	0.0%	0.0%
112	0	0.0%	0	0.0%	0.0%
120	0	0.0%	0	0.0%	0.0%
Average =	53.4 kips		53.4 kips		0.0 kips

As shown in the table, the number of unloaded class 9 trucks in the 32 to 40 kips range increased by 0.5 percent while the number of loaded class 9 trucks in the 72 to 80 kips range increased by 2.4 percent. During this time period the number of overweight trucks did not change. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site remained 53.4 kips kips.

2.5 Class 9 Front Axle Weight Data Analysis

The traffic 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 current data sample set with the expected average front axle weight average from the Data Comparison Set.

Figure 2-4 shows a comparison between Class 9 front axle weight plots generated by using the two week W-card sample from March 2011 and the Comparison Data Set from May 2008.



	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0
Data	7.3%	7.7%	11.0%	23.9%	17.8%	16.1%	9.2%	3.7%	0.2%
CDS	8.3%	8.5%	12.1%	27.0%	17.8%	13.6%	7.0%	2.5%	

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 measuring between 10.5 and 11.0 kips. The percentage of trucks in this range has decreased between the May 2008 Comparison Data Set (CDS) and the March 2011 dataset (Data).

Table 2-5 provides the Class 9 front axle weight distribution data for the May 2008 Comparison Data Set (CDS) and the March 2011 dataset (Data).

Table 2-5 – Class 9 Front Axle Weight Distribution from W-Card

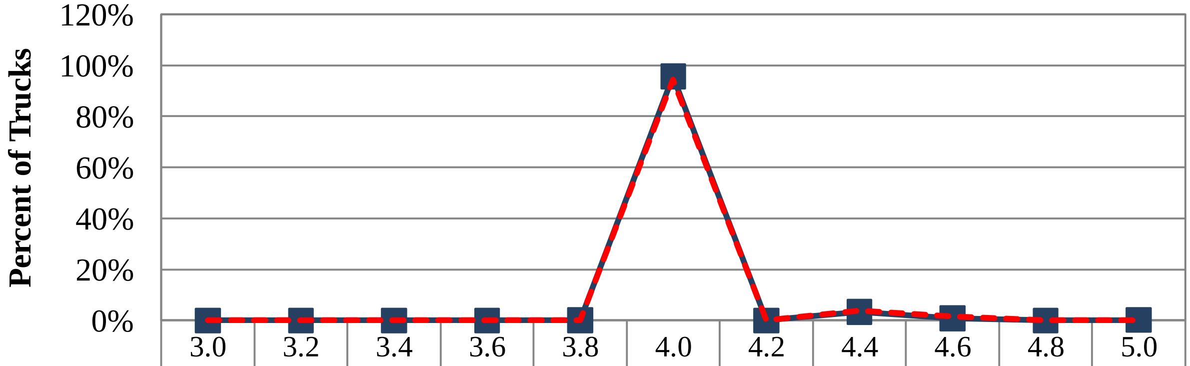
F/A weight bins (kips)	CDS		Data		Change
	Date				
	5/22/2008		3/14/2011		
9.0	207	2.8%	93	3.0%	0.1%
9.5	615	8.3%	230	7.3%	-1.0%
10.0	625	8.5%	244	7.7%	-0.7%
10.5	891	12.1%	346	11.0%	-1.1%
11.0	1991	27.0%	754	23.9%	-3.0%
11.5	1313	17.8%	562	17.8%	0.1%
12.0	1004	13.6%	508	16.1%	2.5%
12.5	519	7.0%	291	9.2%	2.2%
13.0	185	2.5%	116	3.7%	1.2%
13.5	33	0.4%	7	0.2%	-0.2%
Average =	10.9 kips		11.0 kips		0.1 kips

The table shows that the average front axle weight for Class 9 trucks has increased by 0.1 kips, or 0.9 percent. According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 11.0 kips.

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 observed average tractor tandem spacing from the sample data (Data) with the expected average tractor tandem spacing from the comparison data set (CDS).

The class 9 tractor tandem spacing plot in Figure 2-5 is 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%	95.6%	0.0%	3.4%	0.8%	0.0%	0.2%
CDS	0.1%	0.0%	0.0%	0.0%	0.1%	94.3%	0.0%	3.8%	1.7%	0.0%	0.0%

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

As seen in the figure, the Class 9 tractor tandem spacings for the May 2008 Comparison Data Set and the March 2011 Data are nearly identical.

Table 2-6 shows the Class 9 axle spacings between the second and third axles. .

Table 2-6 – Class 9 Axle 2 to 3 Spacing from W-Card

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	5/22/2008		3/14/2011		
3.0	5	0.1%	0	0.0%	-0.1%
3.2	0	0.0%	0	0.0%	0.0%
3.4	3	0.0%	0	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	4	0.1%	2	0.1%	0.0%
4.0	7046	94.3%	3040	95.6%	1.3%
4.2	0	0.0%	0	0.0%	0.0%
4.4	287	3.8%	107	3.4%	-0.5%
4.6	124	1.7%	25	0.8%	-0.9%
4.8	0	0.0%	0	0.0%	0.0%
5.0	1	0.0%	5	0.2%	0.1%
Average =	4.0 feet		4.0 feet		0.0 feet

From the table it can be seen that the drive tandem spacing of Class 9 trucks at this site is between 3.8 and 4.6 feet. Based on the average Class 9 drive tandem spacing values from the per vehicle records, the average tractor tandem spacing is 4.0 feet, which is identical to the expected average of 4.0 feet from the CDS per vehicle records. Further axle spacing 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 (May 2008) based on the last calibration with the most recent two-week WIM data sample from the site (March 2011). Comparison of vehicle class distribution data indicates a 0.7 percent increase in the number of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have increased by 0.1 kips and average Class 9 GVW has remained 53.4 kips. The data indicates an average truck tandem spacing of 4.0 feet.

3 WIM Equipment Discussion

From a comparison between the report of the most recent validation of this equipment on May 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 June 20, 2007 by International Road Dynamics. It is instrumented with bending plate weighing sensors and an 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 after 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. 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 unscheduled 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 May 04, 2010 by the North Central 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 326 in/mi and is located approximately 679 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 218 in/mi and is located approximately 121 feet prior to the WIM scale. These areas of the pavement were closely investigated during the validation visit. Core sample patches were discovered at both locations, shown in Figure 4-1and Figure 4-2.

Figure 4-1 – Core Sample Patches at 220 Feet Prior to WIM

Figure 4-2 – Core Sample Patches at 680 Feet Prior to WIM

Truck dynamics in this area were closely observed. The distresses observed at these locations did not appear to 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)	0.828	0.910	0.948			0.895
		SRI (m/km)	0.585	*0.484*	0.841			0.637
		Peak LRI (m/km)	0.938	1.004	1.037			0.993
		Peak SRI (m/km)	0.625	0.649	1.087			0.787
	RWP	LRI (m/km)	0.726	0.847	0.643			0.739
		SRI (m/km)	*0.453*	0.573	*0.452*			*0.493*
		Peak LRI (m/km)	0.806	0.870	0.679			0.785
		Peak SRI (m/km)	*0.551*	0.787	*0.692*			*0.677*
Center	LWP	LRI (m/km)	0.873	0.781	0.789	0.651	0.563	0.774
		SRI (m/km)	0.597	*0.261*	0.548	*0.498*	*0.363*	*0.476*
		Peak LRI (m/km)	0.879	0.781	0.789	0.723	0.593	0.793
		Peak SRI (m/km)	1.294	1.073	*0.660*	*0.729*	*0.455*	0.939
	RWP	LRI (m/km)	0.920	0.824	0.762	0.772	0.725	0.820
		SRI (m/km)	0.618	0.673	*0.302*	0.767	*0.471*	0.590
		Peak LRI (m/km)	**1.422**	**2.302**	**1.493**	**2.290**	**0.822**	**1.877**
		Peak SRI (m/km)	*0.695*	0.824	*0.458*	0.767	*0.600*	*0.686*
Right	LWP	LRI (m/km)	0.930	0.713	0.762			0.802
		SRI (m/km)	0.672	0.505	0.562			0.580
		Peak LRI (m/km)	2.431	0.913	1.584			1.643
		Peak SRI (m/km)	0.846	*0.632*	0.764			*0.747*
	RWP	LRI (m/km)	0.764	0.873	0.749			0.795
		SRI (m/km)	0.859	0.972	0.708			0.846
		Peak LRI (m/km)	0.831	0.896	0.891			0.873
		Peak SRI (m/km)	0.983	1.035	0.836			0.951

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 right wheel path of the center 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 April 12, 2011, beginning at approximately 11:47 AM and continuing until 2:58 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with rolls of paper, 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 paper rolls, and equipped with air 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	76.6	12.3	16.2	16.2	16.0	16.0	17.1	4.3	35.5	4.2	61.1	72.3
2	63.7	11.9	13.3	13.3	12.6	12.6	17.2	4.3	35.0	4.2	60.7	72.4

Test truck speeds varied by 11 mph, from 53 to 64 mph. The measured pre-validation pavement temperatures varied 15.8 degrees Fahrenheit, from 66.9 to 82.7. The weather conditions prevented the desired 30 degree temperature range. Table 5-2 provides a summary of the pre-validation results.

Table 5-2 – Pre-Validation Overall Results – 12-Apr-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	2.1 ± 5.0%	Pass
Tandem Axles	±15 percent	0.5 ± 3.4%	Pass
GVW	±10 percent	0.8 ± 2.8%	Pass
Vehicle Length	±3.0 percent (2.2 ft)	4.5 ± 0.8 ft	FAIL
Axle Length	± 0.5 ft [150mm]	0.1 ± 0.1 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 over all speeds was 0.2 ± 1.9 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 0.1 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the speeds being reported by the WIM equipment are 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 65 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-3.

Table 5-3 – Pre-Validation Results by Speed – 12-Apr-11

Parameter	95% Confidence Limit of Error	Low 53.0 to 56.7 mph	Medium 56.8 to 60.4 mph	High 60.5 to 64.0 mph
Steering Axles	±20 percent	2.5 ± 5.0%	0.5 ± 4.8%	3.7 ± 4.4%
Tandem Axles	±15 percent	0.2 ± 2.4%	0.0 ± 3.7%	1.5 ± 2.9%
GVW	±10 percent	0.6 ± 2.1%	0.1 ± 2.9%	1.9 ± 2.6%
Vehicle Length	±3.0 percent (2.2 ft)	4.4 ± 1.0 ft	4.4 ± 0.9 ft	4.6 ± 0.6 ft
Vehicle Speed	± 1.0 mph	0.6 ± 2.5 mph	-0.1 ± 1.9 mph	0.2 ± 0.9 mph
Axle Length	± 0.5 ft [150mm]	0.1 ± 0.1 ft	0.1 ± 0.1 ft	0.1 ± 0.1 ft

From the table, it can be seen that the equipment overestimates steering axle weights for all speed groups and the range in errors slightly decreases as speed increases. GVW and tandem axle weights are estimated with similar accuracy for all speed groups and the range in error is consistent over the entire speed range.

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 equipment estimated GVW with similar accuracy at all speeds. The range in error and bias is similar throughout the entire speed range. There does not appear to be a correlation between speed and GVW estimates at this site.

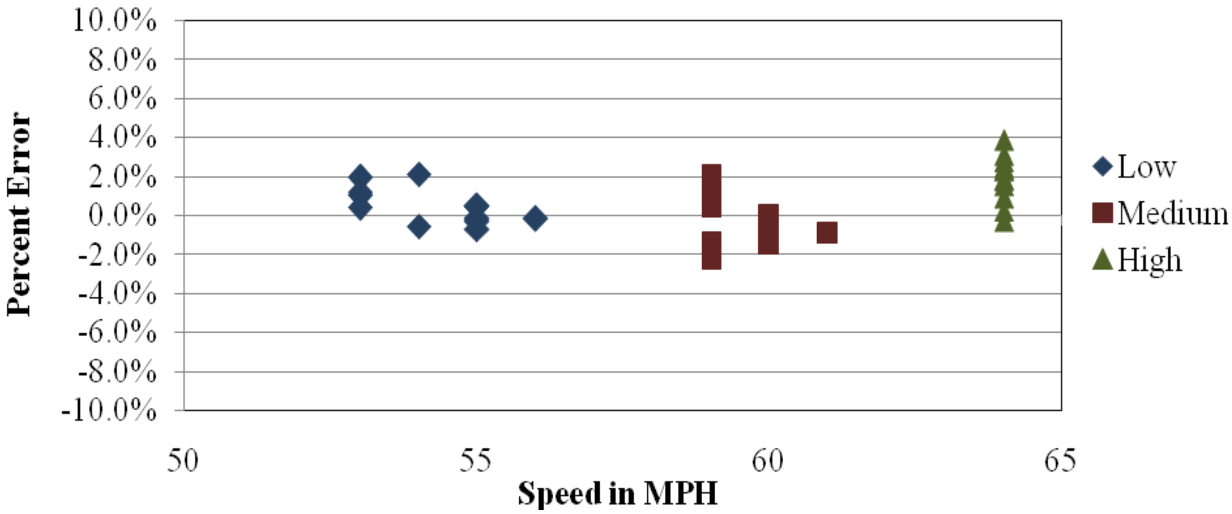


Figure 5-1 – Pre-Validation GVW Error by Speed – 12-Apr-11

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment overestimated steering axle weights at all speeds. The range in error appears to be consistent throughout the entire speed range.

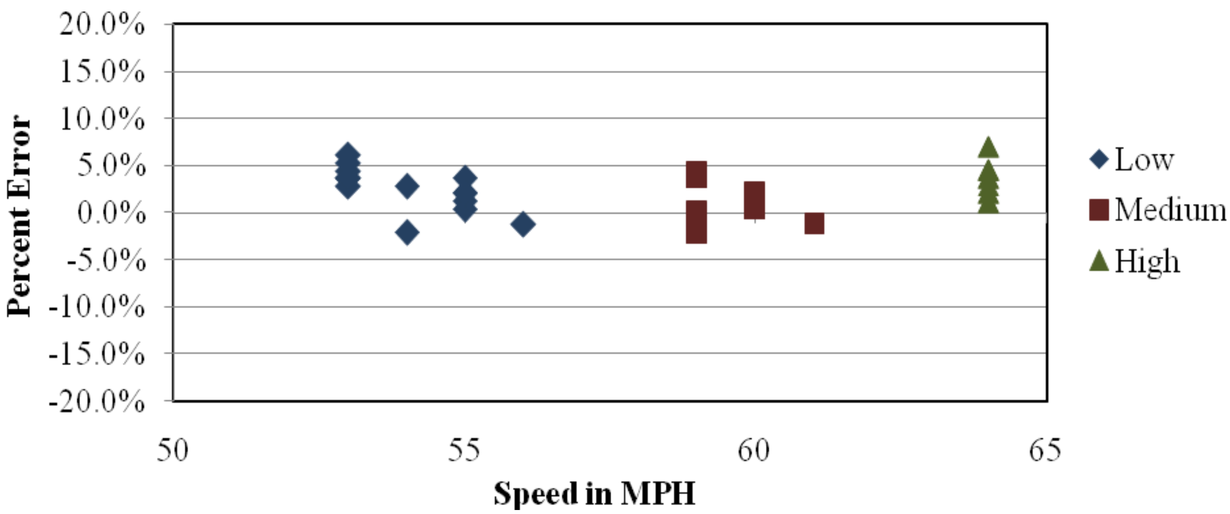


Figure 5-2 – Pre-Validation Steering Axle Weight Errors by Speed – 12-Apr-11

5.1.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-3, the equipment estimates tandem axle weights with similar accuracy at all speeds. The range in error is similar throughout the entire speed range.

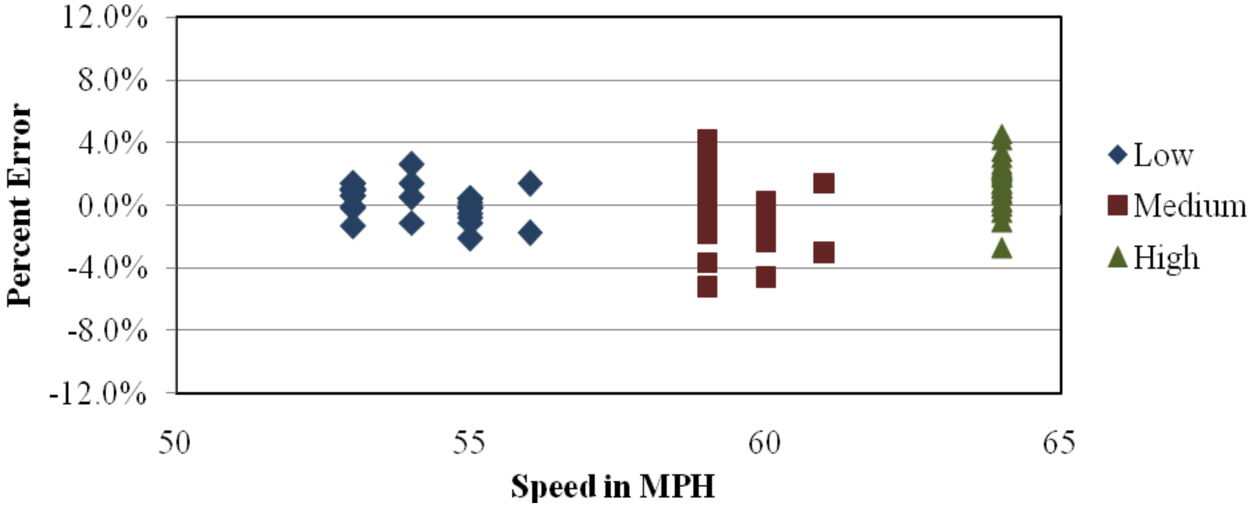


Figure 5-3 – Pre-Validation Tandem Axle Weight Errors by Speed – 12-Apr-11

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 accurately measures GVW for the Primary truck and overestimates GVW for the Secondary truck over the range of speeds. Distribution of errors is similar for both of the trucks, as shown graphically in Figure 5-4.

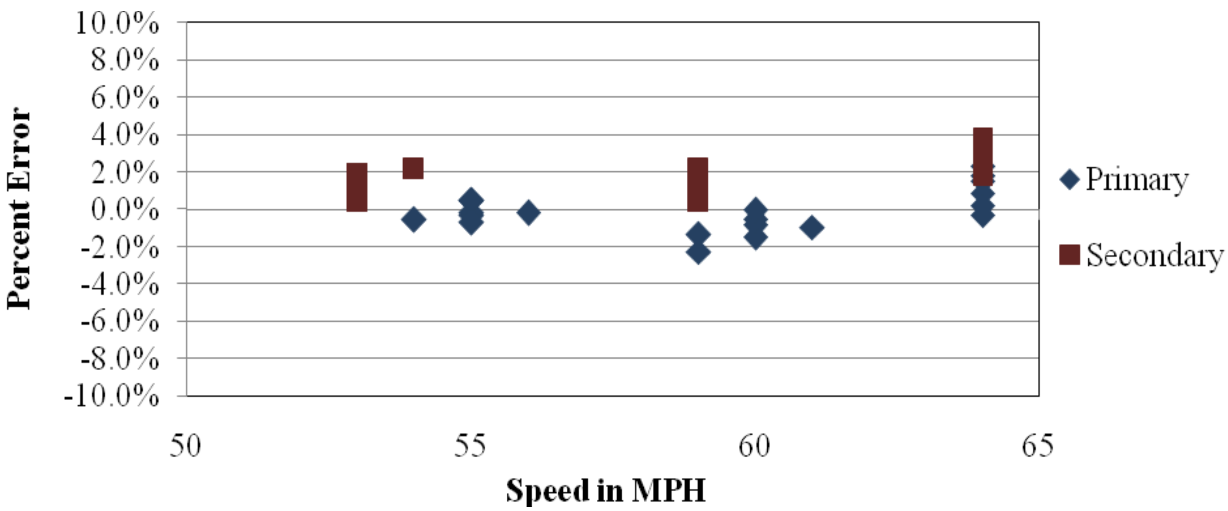


Figure 5-4 – Pre-Validation GVW Errors by Truck and Speed – 12-Apr-11

5.1.1.5 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 0.0 feet to 0.2 feet. Distribution of errors is shown graphically in Figure 5-5.

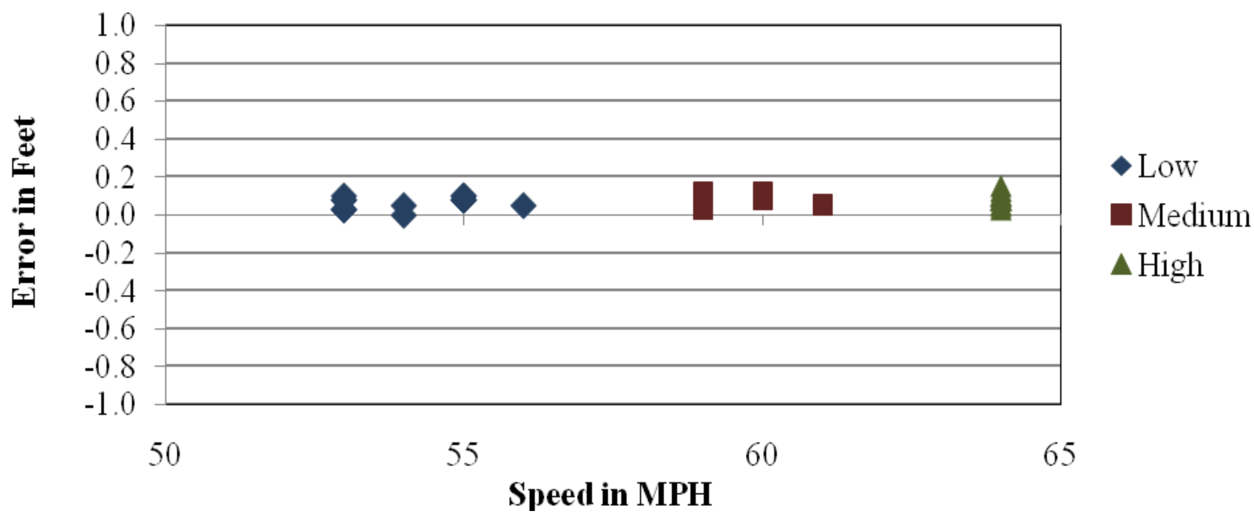


Figure 5-5 – Pre-Validation Axle Length Errors by Speed – 12-Apr-11

5.1.1.6 Overall Length Errors by Speed

For this system, the WIM equipment overestimated overall vehicle length over the entire range of speeds, with an error range of 3.6 to 4.7 feet. Distribution of errors is shown graphically in Figure 5-6.

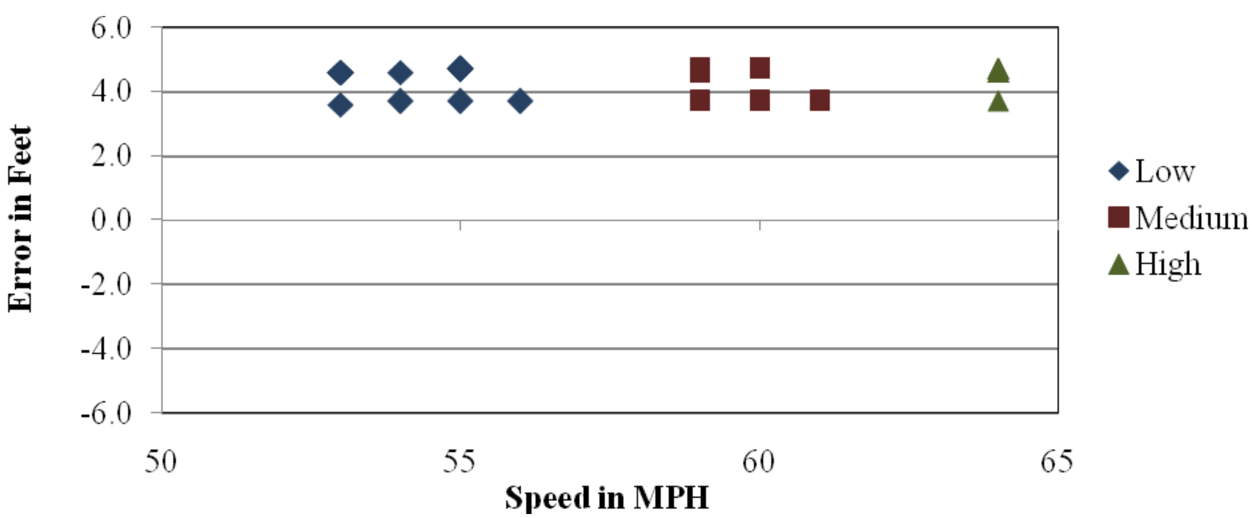


Figure 5-6 – Pre-Validation Overall Length Error by Speed – 12-Apr-11

5.1.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures varied 15.8 degrees, from 66.9 to 82.7 degrees Fahrenheit. The pre-validation test runs are being reported under two temperature groups – low and high, as shown in Table 5-4.

Table 5-4 – Pre-Validation Results by Temperature – 12-Apr-11

Parameter	95% Confidence Limit of Error	Low	High
		66.9 to 75 degF	75.1 to 82.7 degF
Steering Axles	±20 percent	2.2 ± 4.3%	2.1 ± 6.1%
Tandem Axles	±15 percent	0.6 ± 3.6%	0.5 ± 3.4%
GVW	±10 percent	0.9 ± 2.9%	0.7 ± 2.8%
Vehicle Length	±3.0 percent (2.2 ft)	4.4 ± 0.9 ft	4.5 ± 0.7 ft
Vehicle Speed	± 1.0 mph	0.2 ± 2.5 mph	0.3 ± 1.2 mph
Axle Length	± 0.5 ft [150mm]	0.1 ± 0.1 ft	0.1 ± 0.1 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 accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and weight estimates at this site.

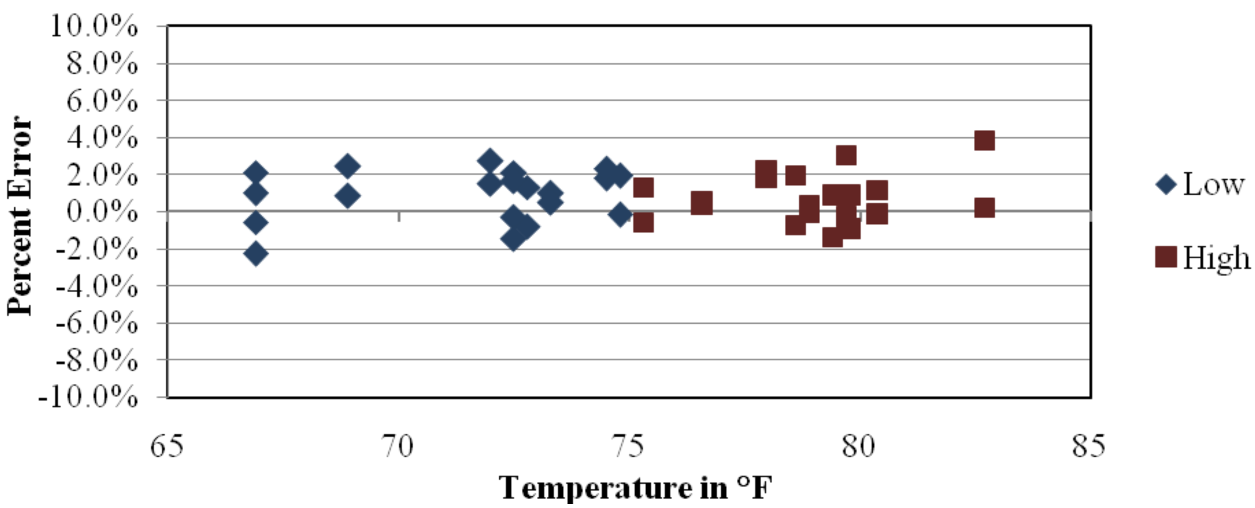


Figure 5-7 – Pre-Validation GVW Errors by Temperature – 12-Apr-11

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 illustrates that for steering axles, the WIM equipment estimated steering axle weights with similar accuracy and with similar variance across the range of temperatures observed in the field.

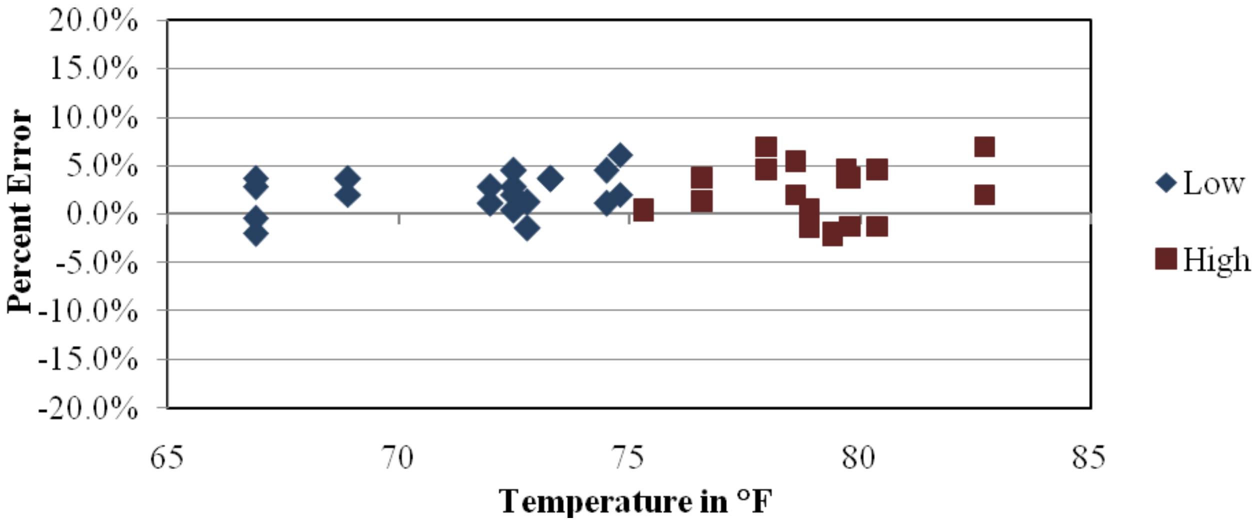


Figure 5-8 – Pre-Validation Steering Axle Weight Errors by Temperature – 12-Apr-11

5.1.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-9, the WIM equipment appears to estimate tandem axle weights with similar accuracy across the range of temperatures observed in the field. The range in tandem axle errors is consistent for the two temperature groups.

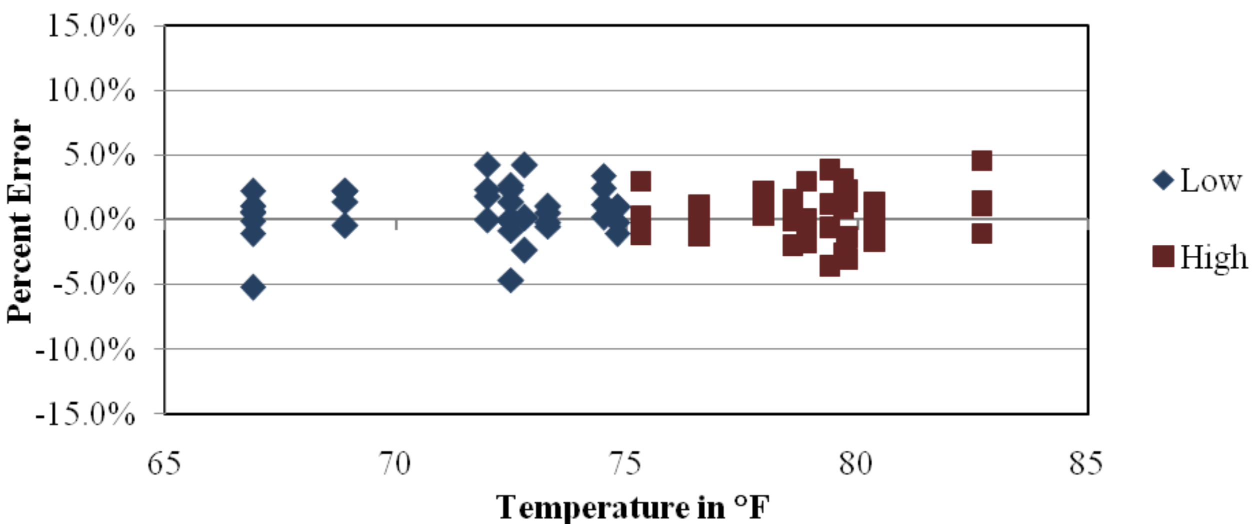


Figure 5-9 – Pre-Validation Tandem Axle Weight Errors by Temperature – 12-Apr-11

5.1.2.4 GVW Errors by Temperature and Truck Type

When the GVW error for each truck is analyzed as a function of temperature, it can be seen that the WIM equipment accurately measures GVW for the Primary truck and overestimates GVW for the Secondary truck over the range of temperatures. Distribution of errors is similar for both of the trucks, as shown graphically Figure 5-10.

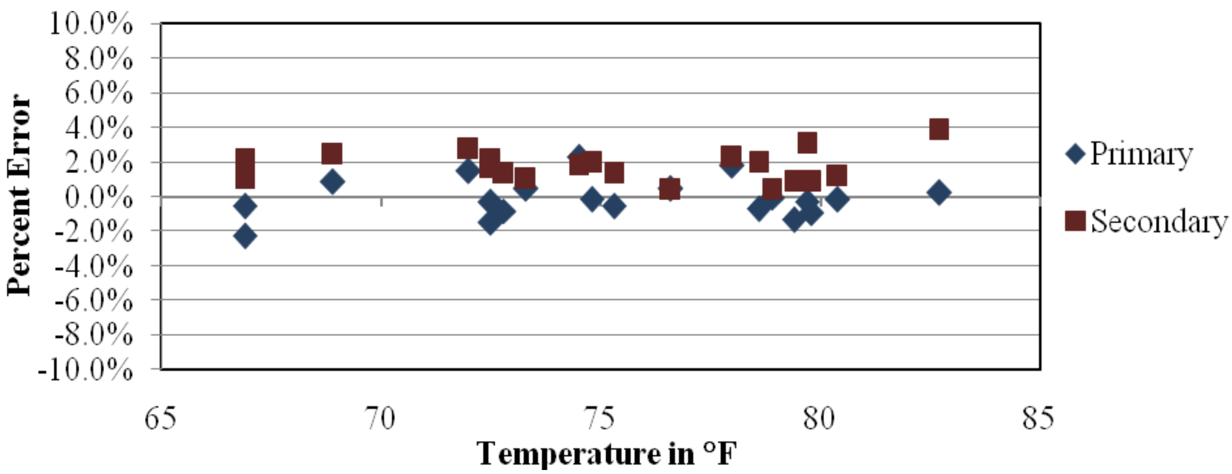


Figure 5-10 – Pre-Validation GVW Error by Truck and Temperature – 12-Apr-11

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. 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. As shown in Table 5-6, a total of two Class 5 vehicles were identified by the equipment as Class 8 and Class 9 respectively and one Class 10 identified as a Class 13.. There was one Class 8 truck reported as an unclassified vehicle by the equipment. The combined results presented an overcount of one Class 9, an over count of one Class 13 and an undercount of two Class 5 vehicles and one Class 10,as shown in Table 5-5.

Table 5-5 – Pre-Validation Classification Study Results – 12-Apr-11

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	0	0	13	1	0	6	76	4	0	0	0
WIM Count	0	0	11	1	0	6	77	3	0	0	1
Observed Percent	0.0	0.0	13.0	1.0	0.0	6.0	76.0	4.0	0.0	0.0	0.0
WIM Percent	0.0	0.0	11.0	1.0	0.0	6.0	77.0	3.0	0.0	0.0	1.0
Misclassified Count	0	0	2	0	0	0	0	1	0	0	0
Misclassified Percent	0.0	0.0	15.4	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0
Unclassified Count	0	0	0	0	0	1	0	0	0	0	0
Unclassified Percent	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0

The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. The misclassifications by pair are provided in Table 5-6.

Table 5-6 – Pre-Validation Misclassifications by Pair – 12-Apr-11

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

As shown in the table, a total of 3 vehicles, including 1 heavy truck (6 – 13) were misclassified by the equipment. Based on the vehicles observed during the pre-validation study, the misclassification percentage is 1.1% 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 3.0%.

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 – 12-Apr-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	1	12/15	0
5/15	0	9/15	0	13/15	0
6/15	0	10/15	0		

Based on the manually collected sample of the 81 trucks, 1.0% 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 single Class 8 which could not be identified by the WIM equipment.

For speed, the mean error for WIM equipment speed measurement was -0.1 mph; the range of errors was 1.9 mph.

5.2 Calibration

One calibration iteration between the pre- and post-validations was carried out. The calibration was not essential because the pre-validation results were well within the acceptability criteria for LTPP SPS WIM sites. However, considering the limited pavement temperature range during the pre-validation testing, and potential improvement in the measurement accuracies due to calibration, one calibration iteration was done. 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 – 13-Apr-11

Speed Point	MPH	Left	Right
		1	2
80	50	3302	3131
88	55	3336	3162
96	60	3338	3164
104	65	3386	3210
112	70	3269	3099
Axle Distance (cm)		372	
Dynamic Comp (%)		106	
Loop Width (cm)		200	

5.2.1 Equipment Adjustments

For GVW, the pre-validation test truck runs produced an overall GVW error of 0.8% and errors of 0.6%, 0.1%, and 1.9% at the 55, 60 and 65 mph speed points respectively. The errors for the 55 mph and 65 mph speed points were extrapolated to derive new compensation factors for the 50 mph and 70 mph speed points. To compensate for these errors, the changes shown in Table 5-9 were made to the compensation factors.

Table 5-9 – Calibration 1 Equipment Factor Changes – 13-Apr-11

Speed Points	Old Factors		Error	New Factors	
	Left	Right		Left	Right
	1	2		1	2
80	3302	3131	-0.67%	3296	3183
88	3336	3162	-0.67%	3330	3214
96	3338	3164	-1.22%	3350	3234
104	3386	3210	0.59%	3337	3222
112	3269	3099	0.59%	3222	3111
Axle Distance (cm)	372		-0.71%	369	
Dynamic Comp (%)	106		2.1%	100	
Loop Width (cm)	200		4.5 ft	336	

5.2.2 Calibration 1 Results

The results of the 14 first calibration verification runs are provided in Table 5-10 and Figure 5-11. Comparing the results given in Table 5-10 with the results given in Table 5-2, the 95% confidence interval for GVW estimates was reduced as a result of the first calibration iteration.

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

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-3.7 ± 4.4%	Pass
Tandem Axles	±15 percent	1.2 ± 2.8%	Pass
GVW	±10 percent	0.3 ± 2.0%	Pass
Vehicle Length	±3.0 percent (2.2 ft)	-0.6 ± 0.9 ft	Pass
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.1 ft	Pass

Figure 5-11 shows that the WIM equipment is estimating GVW with similar very good accuracy at all speeds.

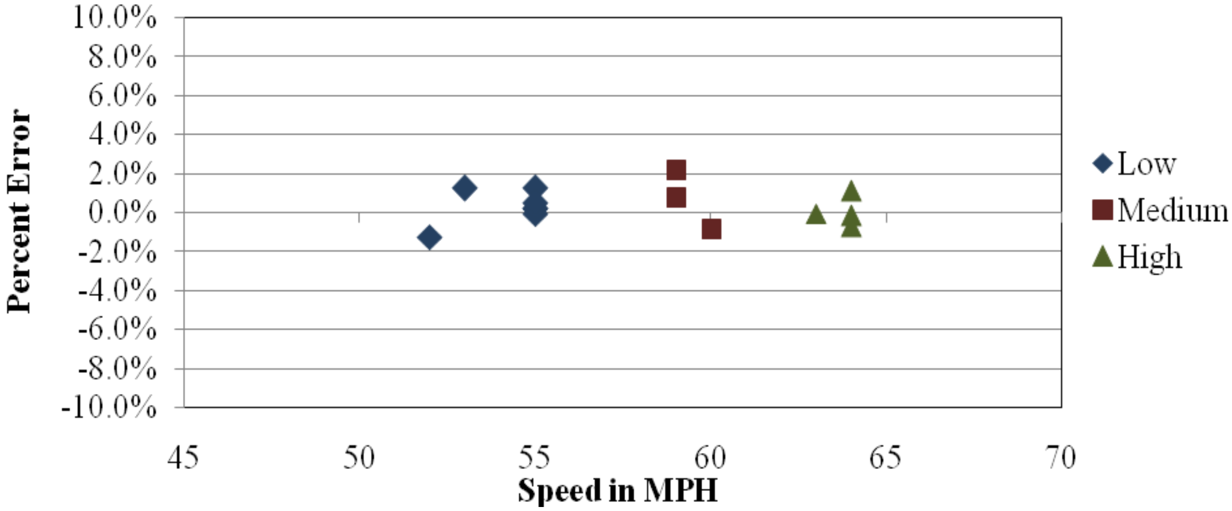


Figure 5-11 – Calibration 1 GVW Error by Speed – 12-Apr-11

Based on the results of the first calibration, where mean GVW weight error decreased to 0.3 percent, a second calibration was not considered to be necessary. The 14 calibration runs were combined with 26 additional post-validation runs to complete the WIM system validation.

5.3 Post-Validation

The 46 post-validation test truck runs were conducted on April 12, 2011, beginning at approximately 3:24 PM and continuing until 4:12 PM, and completed on April 13, 2011, beginning at 7:47 AM and continuing until 12:03 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with palletized paper rolls, 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 palletized paper rolls, and equipped with air 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 post-validation, weighed at the conclusion of day 1, and re-weighed at the conclusion of the post-validation. The average test truck weights and measurements are provided in Table 5-11.

Table 5-11 – 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	76.3	12.0	16.1	16.1	16.0	16.0	17.1	4.3	35.5	4.2	61.1	72.3
2	63.5	11.8	13.2	13.2	12.6	12.6	17.2	4.3	35.0	4.2	60.7	72.4

Test truck speeds varied by 12 mph, from 52 to 64 mph. The measured post-validation pavement temperatures varied 40.4 degrees Fahrenheit, from 41.3 to 81.7. The sunny weather conditions provided the desired minimum 30 degree temperature range. Table 5-12 is a summary of post validation results.

Table 5-12 – Post-Validation Overall Results – 13-Apr-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-3.9 ± 4.5%	Pass
Tandem Axles	±15 percent	1.0 ± 2.9%	Pass
GVW	±10 percent	0.1 ± 2.2%	Pass
Vehicle Length	±3.0 percent (2.2 ft)	-0.9 ± 1.0 ft	Pass
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.1 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 0.2 ± 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 -0.1 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 relationship exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 65 mph. The test runs were divided into three speed groups - low, medium and high, as shown in Table 5-13.

Table 5-13 – Post-Validation Results by Speed – 13-Apr-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		52.0 to 56.0 mph	56.1 to 60.1 mph	60.2 to 64.0 mph
Steering Axles	±20 percent	-4.1 ± 5.1%	-4.3 ± 5.2%	-3.4 ± 3.8%
Tandem Axles	±15 percent	0.9 ± 2.5%	1.3 ± 3.1%	0.7 ± 3.3%
GVW	±10 percent	0.0 ± 2.2%	0.4 ± 2.4%	0.0 ± 2.4%
Vehicle Length	±3.0 percent (2.2 ft)	-0.9 ± 1.1 ft	-1.0 ± 1.0 ft	-0.9 ± 1.1 ft
Vehicle Speed	± 1.0 mph	0.5 ± 1.7 mph	0.0 ± 1.1 mph	-0.1 ± 1.3 mph
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.1 ft	-0.1 ± 0.1 ft	-0.1 ± 0.1 ft

From the table, it can be seen that the WIM equipment estimates all weights with similar 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 5-12, the equipment estimated GVW with similar accuracy at all speeds. The range in error and bias was similar throughout the entire speed range.

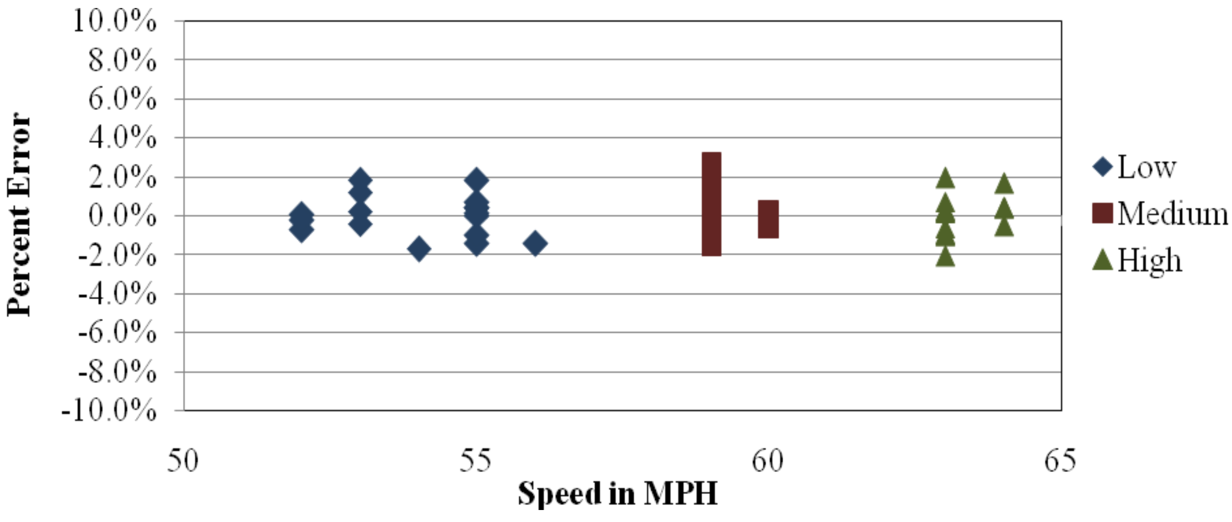


Figure 5-12 – Post-Validation GVW Errors by Speed – 13-Apr-11

5.3.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-13, the equipment underestimated steering axle weights with similar bias and variance at all speed groups.

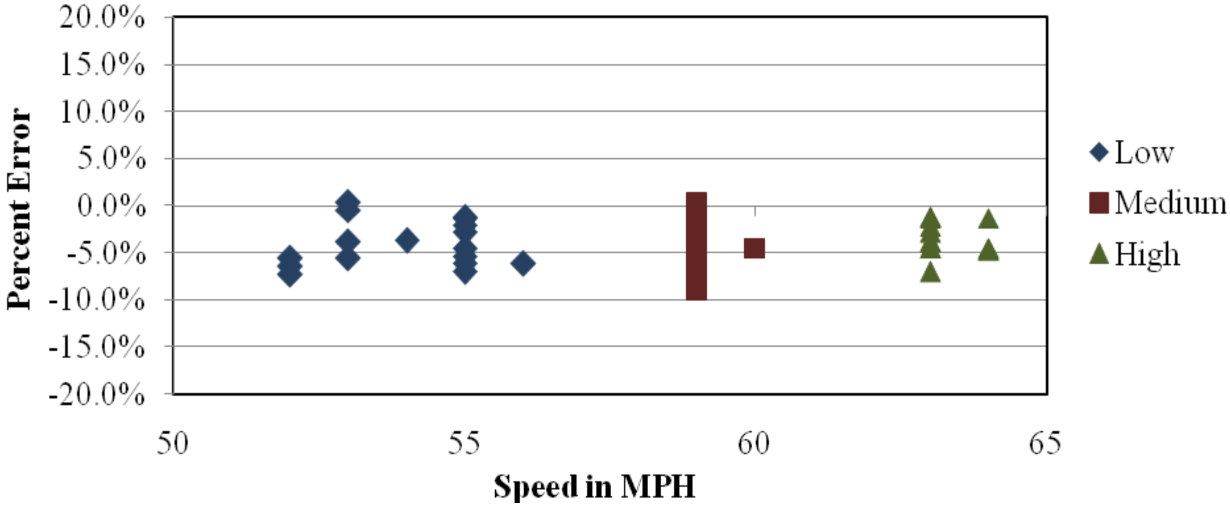


Figure 5-13 – Post-Validation Steering Axle Weight Errors by Speed – 13-Apr-11

5.3.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-14, the equipment estimated tandem axle weights with similar accuracy at all speeds. The range in error and bias was similar throughout the entire speed range.

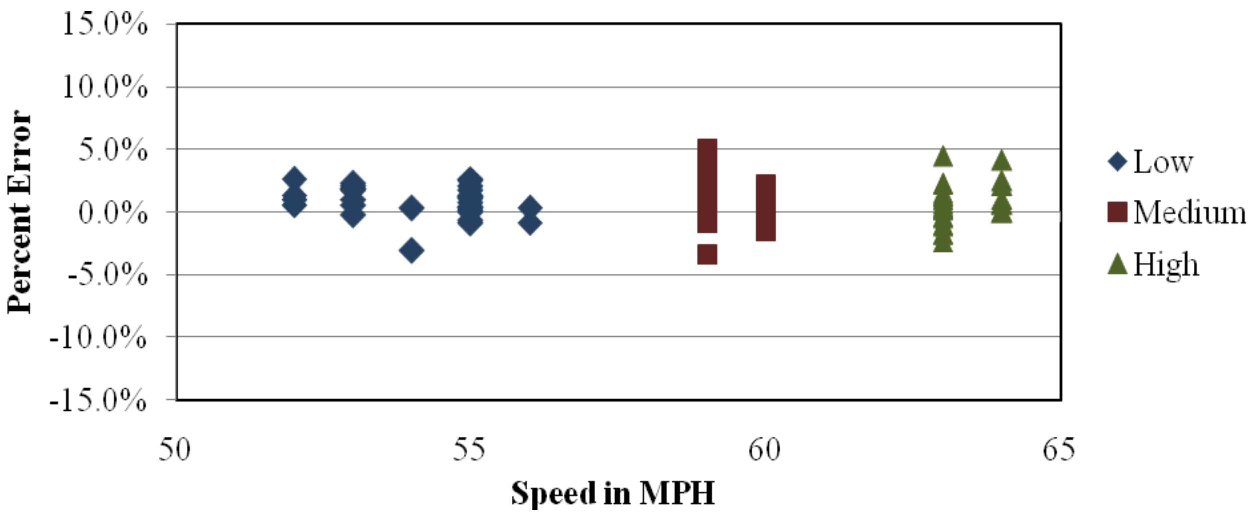


Figure 5-14 – Post-Validation Tandem Axle Weight Errors by Speed – 13-Apr-11

5.3.1.4 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-15, when the GVW error for each truck is analyzed as a function of speed, it can be seen that the WIM equipment accurately measures GVW for the Primary truck and overestimates GVW for the Secondary truck over the range of speeds. Distribution of errors is similar for both of the trucks.

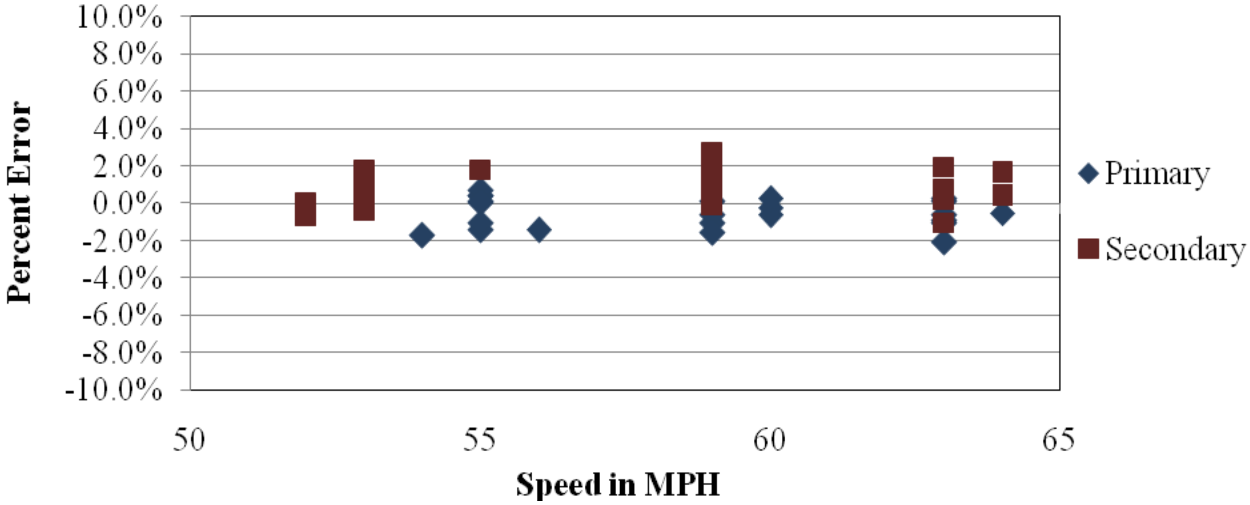


Figure 5-15 – Post-Validation GVW Error by Truck and Speed – 13-Apr-11

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 was from -0.2 feet to 0.0 feet. Distribution of errors is shown graphically in Figure 5-16.

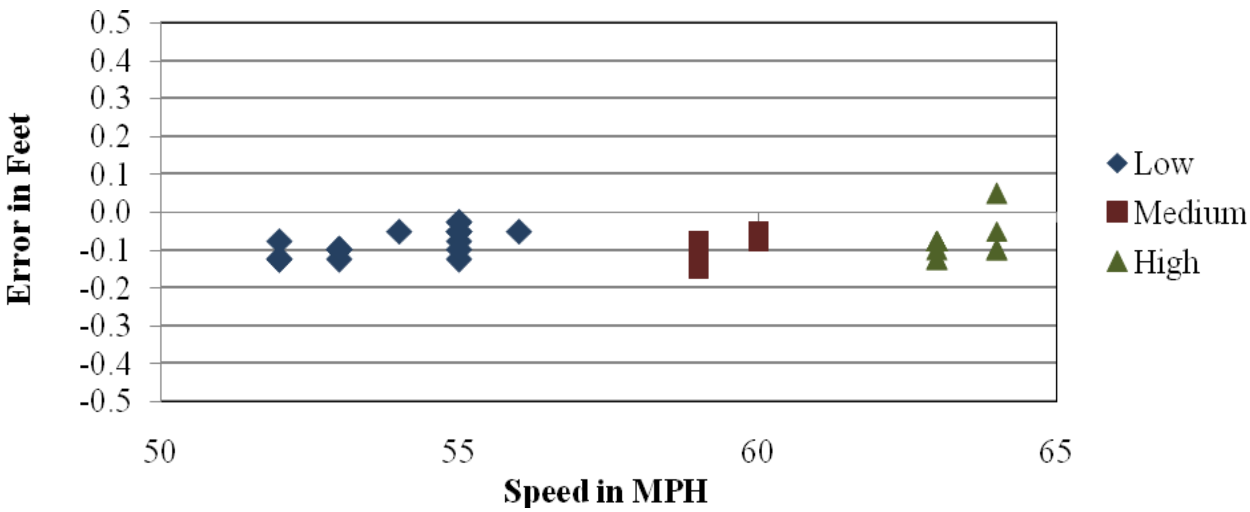


Figure 5-16 – Post-Validation Axle Length Error by Speed – 13-Apr-11

5.3.1.6 Overall Length Errors by Speed

For this system, the WIM equipment measures overall length with similar accuracy and consistently over the entire range of speeds, with errors ranging from -0.3 to -1.4 feet. Distribution of errors, reflective of small negative bias, is shown graphically in Figure 5-17.

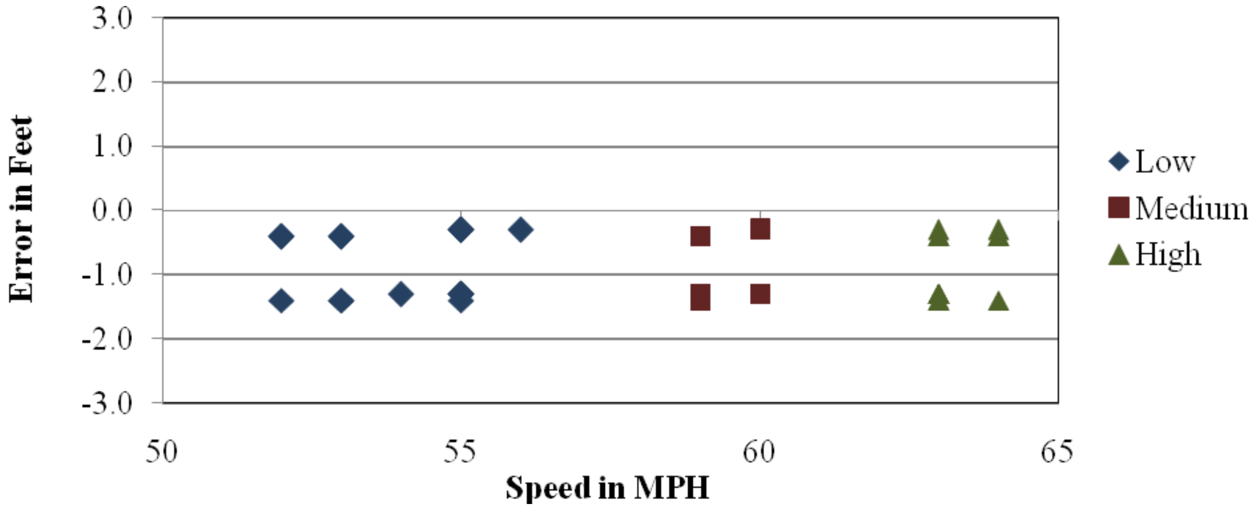


Figure 5-17 – Post-Validation Overall Length Error by Speed – 13-Apr-11

5.3.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures was 40.4 degrees, from 41.3 to 81.7 degrees Fahrenheit. Since the post-validation runs were conducted during the afternoon hours on April 12, and the morning hours of April 13, the post-validation test runs are reported under three temperature groups – low, medium and high, as shown in Table 5-14 below.

Table 5-14 – Post-Validation Results by Temperature – 13-Apr-11

Parameter	95% Confidence Limit of Error	Low 41.3 to 47 degF	Medium 47.1 to 65.0 degF	High 65.1 to 81.7 degF
Steering Axles	±20 percent	-4.5 ± 4.3%	-4.6 ± 4.2%	-2.4 ± 4.6%
Tandem Axles	±15 percent	0.5 ± 3.5%	1.0 ± 2.8%	1.3 ± 2.9%
GVW	±10 percent	-0.4 ± 2.1%	0.0 ± 2.2%	0.7 ± 2.2%
Vehicle Length	±3.0 percent (2.2 ft)	-1.0 ± 1.0 ft	-1.1 ± 0.9 ft	-0.6 ± 0.9 ft
Vehicle Speed	± 1.0 mph	-0.1 ± 1.2 mph	0.2 ± 0.9 mph	0.4 ± 2.2 mph
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.1 ft	-0.1 ± 0.1 ft	-0.1 ± 0.1 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 5-18, it can be seen that the equipment accurately estimates GVW across the range of temperatures observed in the field. There appears to be a slight correlation between temperature and GVW estimates at this site where bias transitions from an underestimation at low temperatures to an overestimation at high temperatures.

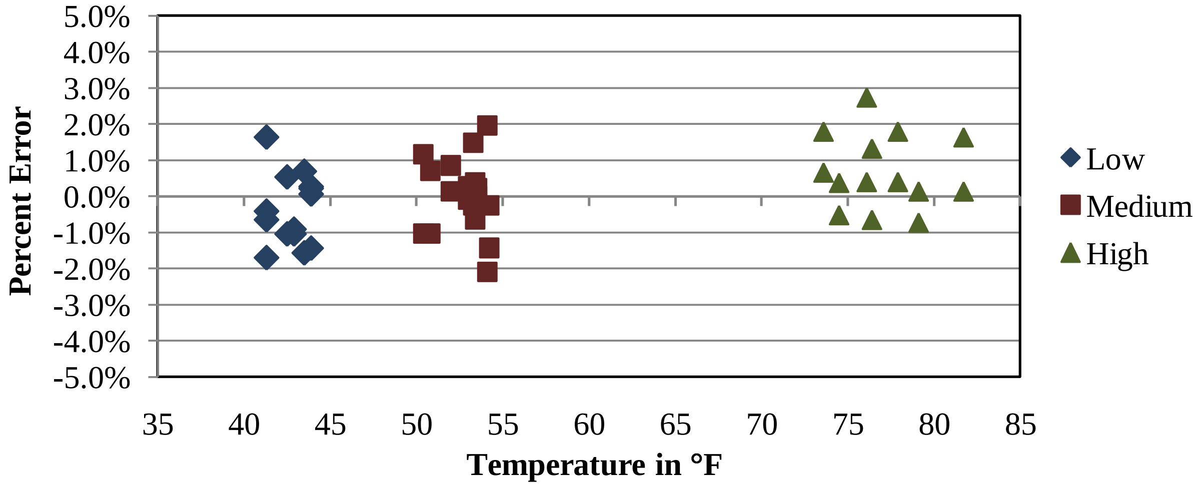


Figure 5-18 – Post-Validation GVW Errors by Temperature – 13-Apr-11

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-19 demonstrates that steering axle weights were estimated with similar accuracy and variance at both speed groups. However, WIM equipment consistently underestimates steering axle weights across the range of temperatures observed in the field.

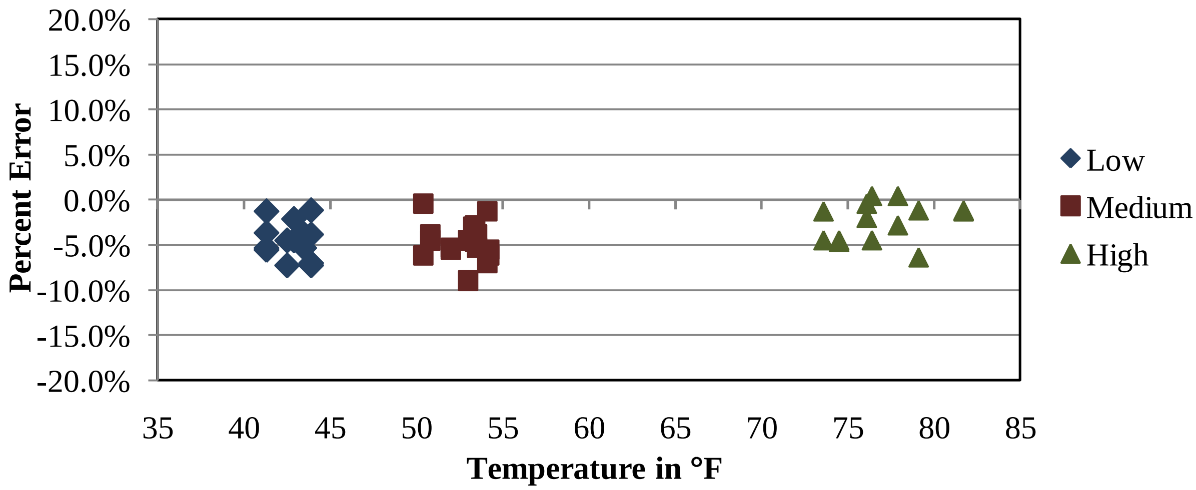


Figure 5-19 – Post-Validation Steering Axle Weight Errors by Temperature – 13-Apr-11

5.3.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-20, the WIM equipment appears to estimate tandem axle weights with reasonable accuracy across the range of temperatures observed in the field. The range in tandem axle errors is consistent for the two different temperature groups.

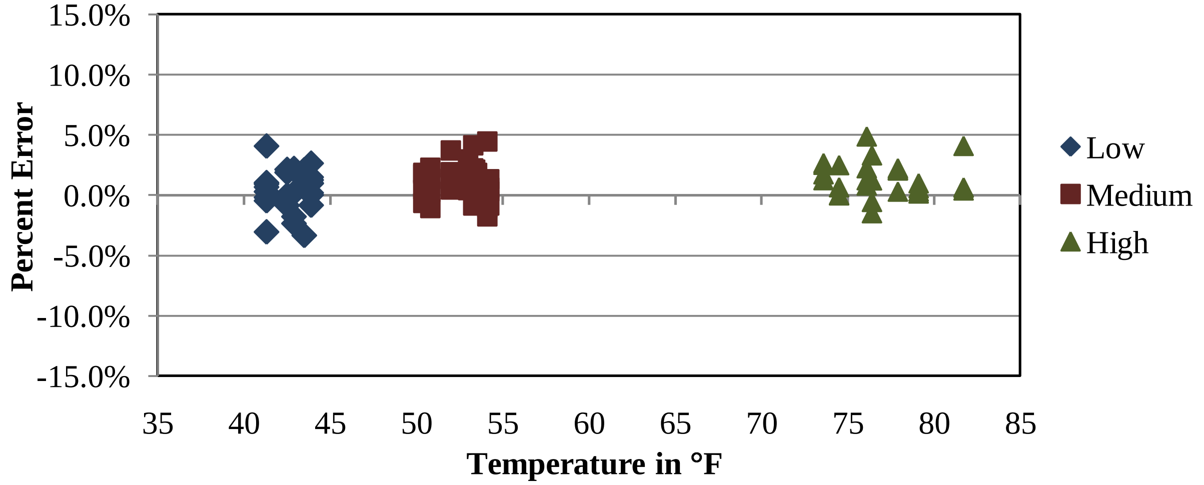


Figure 5-20 – Post-Validation Tandem Axle Weight Errors by Temperature – 13-Apr-11

5.3.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-21, when the GVW error for each truck is analyzed as a function of temperature, it can be seen that the WIM equipment accurately measures GVW for the Primary truck and overestimates GVW for the Secondary truck over the range of temperatures. Distribution of errors is similar for both of the trucks.

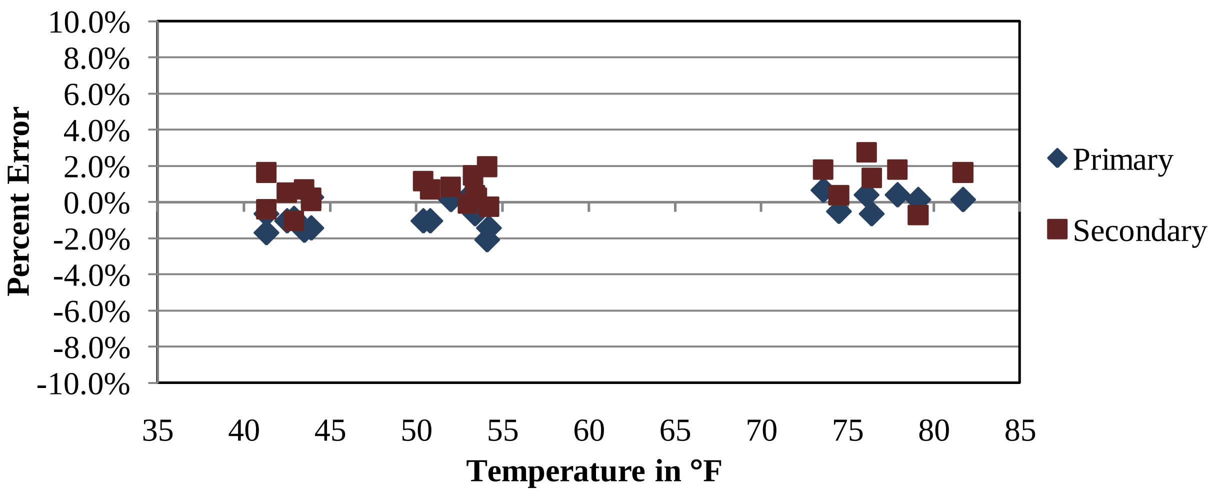


Figure 5-21 – Post-Validation GVW Error by Truck and Temperature – 13-Apr-11

5.3.3 GVW and Steering Axle Trends

Figure 5-22 is provided to illustrate the predicted GVW error with respect to the post-validation errors by speed.

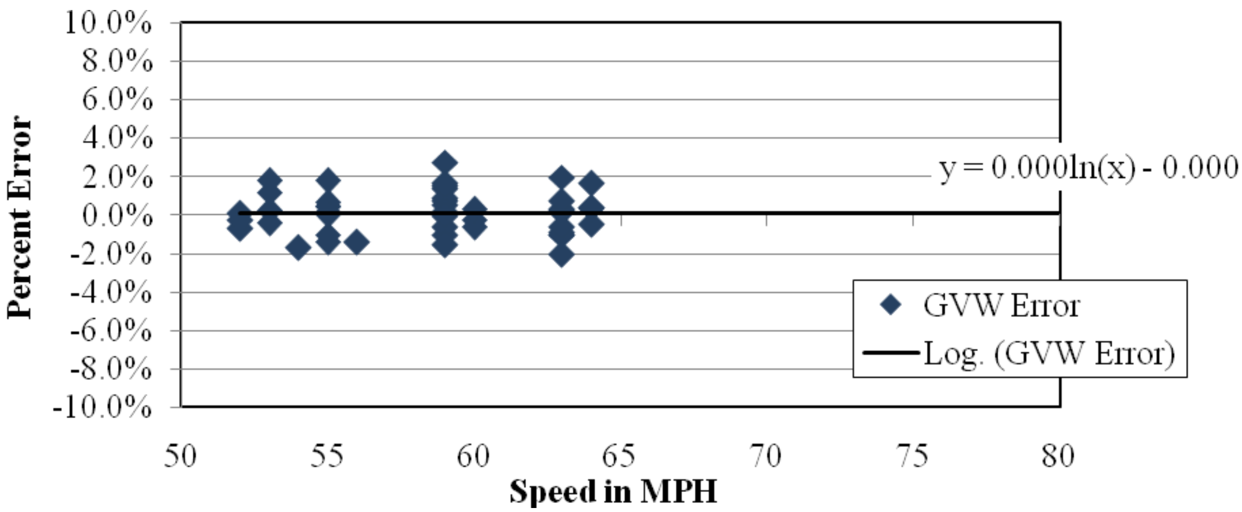


Figure 5-22 – GVW Error Trend by Speed

Figure 5-23 is provided to illustrate the predicted Steering Axle error with respect to the post-validation errors by speed.

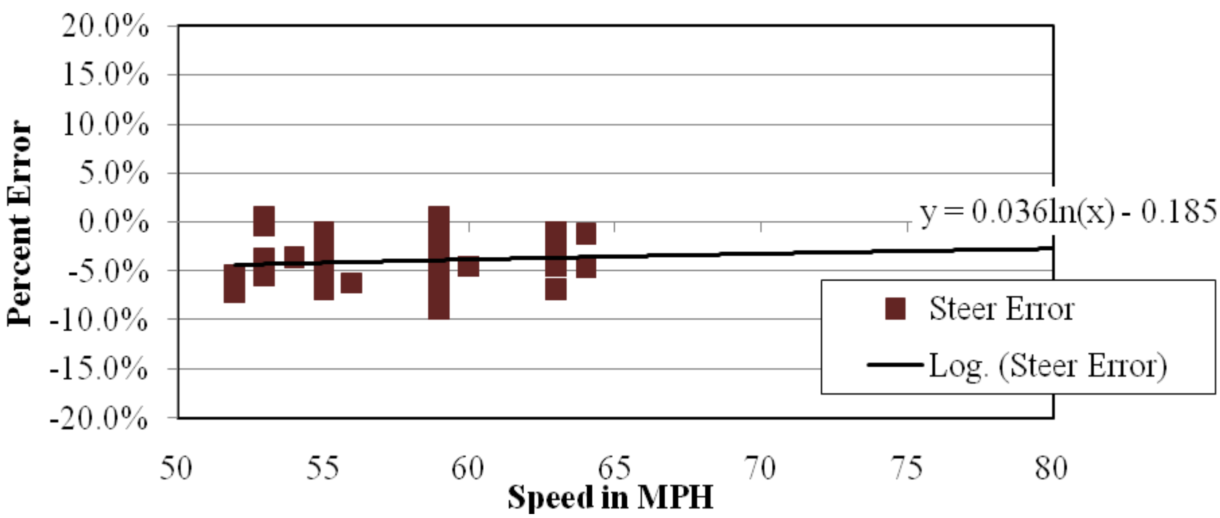


Figure 5-23 – Steering Axle Trend by Speed

5.3.4 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.

5.3.4.1 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 tandem 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 52 to 64 mph.
- Pavement temperature. Pavement temperature ranged from 41.3 to 81.7 degrees Fahrenheit.
- Interaction between the factors such as the interaction between speed and pavement temperature.

5.3.4.2 Results

For analysis of GVW weights, the value of regression coefficients and their statistical properties are summarized in Table 5-15. 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 5-15 are for the null hypothesis that assumes that the coefficients are equal to zero. The effect of pavement temperature and truck type was found to be statistically significant. The probability that the effect of temperature on the observed GVW errors occurred by chance alone was less than 1 percent.

Table 5-15 – Table of Regression Coefficients for Measurement Error of GVW

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value
Intercept	-2.5028	1.8245	-1.3718	0.1786
Speed	0.0067	0.0296	0.2278	0.8211
Temp	0.0286	0.0078	3.6737	0.0008
Truck	1.2392	0.2318	5.3472	0.0000

The relationship between temperature and GVW measurement errors is shown in Figure 5-24. The figure includes trend line for the predicted percent error. Besides the visual assessment of the relationship, Figure 5-24 provides quantification and statistical assessment of the relationship.

The quantification is provided by the value of the regression coefficient, in this case 0.0286 (in Table 5-15). This means, for example, that for a 20 degree increase in temperature, the % error is increased by about 0.57 % (0.0286 x 20). The statistical assessment of the relationship is provided by the probability value of the regression coefficient.

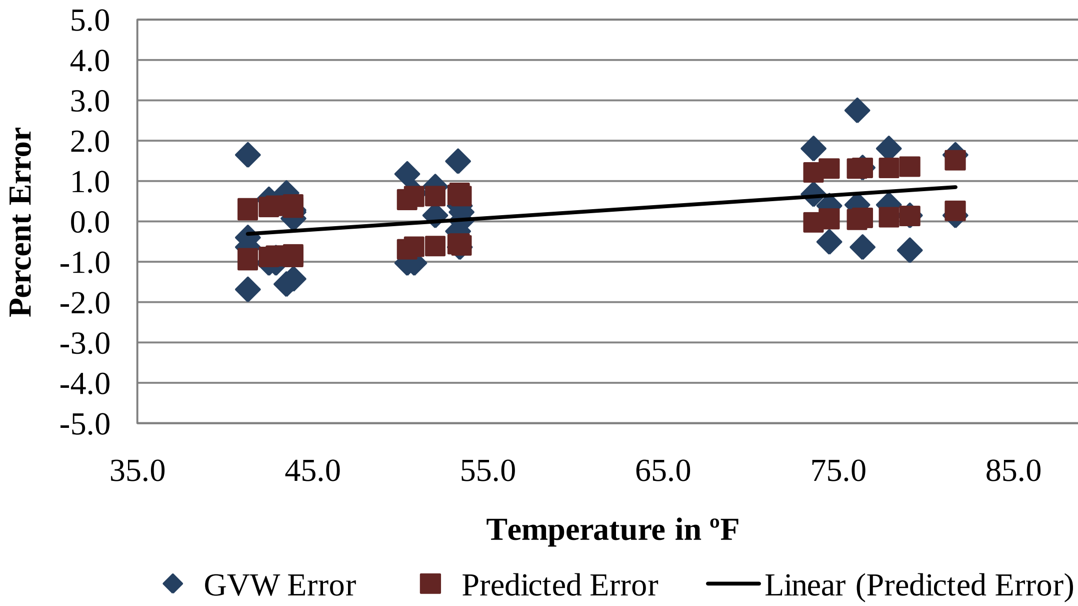


Figure 5-24 – Influence of Temperature on the Measurement Error of GVW

The effect of speed on GVW was not statistically significant. The probability that the regression coefficient for speed (0.0067 in Table 5-15) is not different from zero was 0.8211. In other words, there is about 82 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.

5.3.4.3 Summary Results

Table 5-16 lists regression coefficients and their probability values for all combinations of factors and % errors evaluated. Entries in the table are provided only if the probability value was smaller than 0.20. The dash in Table 5-16 indicates that the relationship was not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 5-16 – Summary of Regression Analysis

	Factor					
	Speed		Temperature		Truck type	
Weight, % error	Regression coefficient	Probability value	Regression coefficient	Probability value	Regression coefficient	Probability value
GVW	-	-	0.0286	0.0008	1.2392	0.0000
Steering axle	-	-	0.0632	0.0034	0.7834	0.1994
Tandem axle tractor	-	-	0.0213	0.1275	1.3452	0.0021
Tandem axle trailer	-0.0853	0.0633	0.0232	0.0555	1.6957	0.0000

5.3.4.4 Conclusions

1. Speed had no statistically significant effect on measurement errors with the possible exception of tandem axles on trailers.

2. Temperature affected measurement error of all axles and thus also the measurement error of the GVW. The regression coefficients ranged from 0.0632 for the steering axle to 0.0213 for the tandem axel on tractor. The difference between regression coefficients obtained for different axle types and GVW was not statistically significant.

3. Truck type affected all measurement errors. The regression coefficient for truck type in Table 5-16, 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 Secondary truck was about 1.24 % larger than the error for the Primary truck.

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

5.3.5 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 5-17 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study. Misclassified vehicles are defined as those vehicles that are manually classified by observation as one type of vehicle but identified by the WIM equipment as another type of vehicle. As shown in Table 5-18, a Class 4 vehicle was identified as a Class 5 vehicle by the equipment. Additionally, two Class 5 vehicles were identified as Class 4 and Class 8 respectively. One Class 8 and one Class 10 were reported as unclassified by the equipment. The combined results presented an undercount of one Class 5 vehicle and one Class 10 vehicle as shown in Table 5-17.

Table 5-17 – Post-Validation Classification Study Results – 13-Apr-11

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	0	1	14	4	7	7	64	3	0	0	0
WIM Count	0	1	13	4	7	7	64	2	0	0	0
Observed Percent	0.0	1.0	14.0	4.0	7.0	7.0	64.0	3.0	0.0	0.0	0.0
WIM Percent	0.0	1.0	13.0	4.0	7.0	7.0	64.0	2.0	0.0	0.0	0.0
Misclassified Count	0	1	2	0	0	0	0	0	0	0	0
Misclassified Percent	0.0	100.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unclassified Count	0	0	0	0	0	1	0	1	0	0	0
Unclassified Percent	0.0	0.0	0.0	0.0	0.0	14.3	0.0	50.0	0.0	0.0	0.0

The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. The misclassifications by pair are provided in Table 5-18.

Table 5-18 – Post-Validation Misclassifications by Pair – 13-Apr-11

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

As shown in the table, a total of 3 vehicles, including 0 heavy trucks (6 – 13) were misclassified by the equipment. 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 3.0%. The cause of the misclassifications was not investigated in the field.

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 5-19.

Table 5-19 – Post-Validation Unclassified Trucks by Pair – 13-Apr-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	1	12/15	0
5/15	0	9/15	0	13/15	0
6/15	0	10/15	1		

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 8 and a Class 10 which could not be identified by the WIM equipment.

For speed, the mean error for WIM equipment speed measurement was -0.7 mph; the range of errors was 2.0 mph.

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 two 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 most recent 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	
27-Nov-07	67	33	25	0	0	0	0	N/A	N/A	N/A	0.0
28-Nov-07	100	46	13	0	0	0	0	N/A	N/A	N/A	0.0
20-May-08	67	23	0	0	13	1	33	N/A	N/A	N/A	0.0
21-May-08	0	14	0	0	33	0	33	N/A	N/A	0	0.0
12-Apr-11	0	18	0	0	0	0	0	0	0	0	1.0
13-Apr-11	100	14	0	0	0	0	0	0	0	0	2.0

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 and SD		
	GVW	Single Axles	Tandem
27-Nov-07	-1.8 ± 3.2	-5.4 ± 3.7	-1.0 ± 4.1
28-Nov-07	-0.5 ± 2.8	-2.0 ± 3.7	-0.2 ± 3.9
20-May-08	3.2 ± 3.6	4.7 ± 3.7	2.9 ± 3.9
21-May-08	0.2 ± 1.1	0.8 ± 1.5	0.2 ± 2.1
12-Apr-11	0.8 ± 1.4	2.1 ± 2.5	0.5 ± 1.7
13-Apr-11	0.1 ± 1.1	-3.9 ± 2.2	1.0 ± 1.5

The variability of weight errors appears to have decreased since the site was first validated. 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 and 95% Confidence Interval)		
		28-Nov-07	**21-May-08**	**13-Apr-11**
Steering Axles	±20 percent	-2.0 ± 7.5	0.8 ± 3.0	-3.9 ± 4.5
Tandem Axles	±15 percent	-0.2 ± 7.7	0.2 ± 4.2	1.0 ± 2.9
GVW	±10 percent	-0.5 ± 5.6	0.2 ± 2.2	0.1 ± 2.2

From Table 6-3, it appears that the mean errors and the 95% confidence intervals obtained for this validation are similar to those obtained for the 2008 and 2007 validations.

The final factors left in place at the conclusion of the validation are provided in Table 6-4.

Table 6-4 – Final Factors

Speed Point	MPH	Left	Right
		1	**2**
80	50	3336	3222
88	55	3359	3242
96	60	3368	3251
104	65	3368	3252
112	70	3252	3140
Axle Distance (cm)		370	
Dynamic Comp (%)		95	
Loop Width (cm)		307	

A review of the LTPP Standard Release Database 24 shows that there is one year of level "E" WIM data for this site. This site requires four 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 – Validation 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

Wisconsin, SPS-1
SHRP ID: 550100

Validation Date: April 13, 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 – Power Service Box

Photo 9 – Telephone Service Box

Photo 10 – Downstream

Photo 11 – Upstream

Photo 12 – Truck 1

Photo 13 – Truck 1 Tractor

Photo 14 – Truck 1 Trailer and Load

Photo 15 – Truck 1 Suspension 1

Photo 16 – Truck 1 Suspension 2

Photo 17 – Truck 1 Suspension 3

Photo 18 – Truck 1 Suspension 4

Photo 19 – Truck 1 Suspension 5

Photo 20 – Truck 2

Photo 21 – Truck 2 Tractor

Photo 22 – Truck 2 Trailer and Load

Photo 23 – Truck 2 Suspension 1

Photo 24 – Truck 2 Suspension 2

Photo 25 – Truck 2 Suspension 3

Photo 26 – Truck 2 Suspension 4

Photo 27 – Truck 2 Suspension 5

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 55 SPS WIM ID: 550100 DATE (mm/dd/yyyy) 4/12/2011

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 4/12/11

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. Bending Plates
   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	air	steel spring
Truck 3:			

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

Mean Difference Between -

	Mean		Standard Deviation
Dynamic and Static GVW:	0.8%	Standard Deviation:	1.4%
Dynamic and Static Single Axle:	2.1%	Standard Deviation:	2.5%
Dynamic and Static Double Axles:	0.5%	Standard Deviation:	1.7%

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

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

			Low		High	Runs
a.	Low	-	53.0	to	57.0	14
b.	Medium	-	57.1	to	63.0	14
c.	High	-	63.1	to	64.0	12
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 55 SPS WIM ID: 550100 DATE (mm/dd/yyyy) 4/12/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3311 | 3196

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:	1.0	FHWA Class	5	-	-15.0
FHWA Class 8:	0.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 1.0%

Validation Test Truck Run Set - Pre

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

Contact Information: Phone: 717-975-3550

E-mail: dwolf@ara.com

Traffic Sheet 16	STATE CODE:	55
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	550100
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	4/13/2011

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 4/13/11

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. Bending Plates 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: 23

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

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

Mean Difference Between -

	Mean		Standard Deviation
Dynamic and Static GVW:	0.1%	Standard Deviation:	1.1%
Dynamic and Static Single Axle:	-3.9%	Standard Deviation:	2.2%
Dynamic and Static Double Axles:	1.0%	Standard Deviation:	1.5%

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

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

			Low		High	Runs
a.	Low	-	52.0	to	56.0	17
b.	Medium	-	56.1	to	60.1	15
c.	High	-	60.2	to	64.0	14
d.		-		to		
e.		-		to		

Traffic Sheet 16 **LTPP MONITORED TRAFFIC DATA** **SITE CALIBRATION SUMMARY**	STATE CODE: 55 SPS WIM ID: 550100 DATE (mm/dd/yyyy) 4/13/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3316 | 3201

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	5	-	-7.0
FHWA Class 8:	0.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 2.0%

Validation Test Truck Run Set - Post

Person Leading Calibration Effort:

Contact Information: Phone:

E-mail:

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 55 SPS WIM ID: 550100 DATE (mm/dd/yyyy) 4/12/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
72	9	10938	71	9	68	9	11024	69	9
65	9	10941	64	9	65	9	11026	65	9
64	9	10942	64	9	62	9	11027	67	9
65	9	10947	65	9	63	9	11029	64	9
67	9	10950	66	9	67	9	11031	67	9
67	8	10965	66	8	67	9	11032	61	9
69	5	10956	69	5	59	9	11033	59	9
61	9	10966	61	9	59	9	11034	57	9
62	9	10971	63	9	56	9	11036	55	9
65	9	10972	65	9	62	9	11037	62	9
67	9	10976	67	9	65	9	12610	64	9
65	9	10977	65	9	64	9	12611	64	9
68	9	10978	69	9	72	9	12612	71	9
63	9	10979	64	9	65	9	12625	66	9
65	5	10982	65	5	73	5	12630	74	5
70	9	10988	70	9	68	8	12636	68	8
64	9	10992	63	9	67	9	12638	68	9
68	10	10998	68	10	67	5	12640	67	5
58	9	11005	58	9	65	5	12648	65	5
67	9	11010	67	9	62	9	12649	62	9
68	9	11011	68	9	62	5	12655	63	5
65	9	11013	65	9	60	5	12660	59	5
65	9	11016	65	9	65	9	12663	66	9
66	9	11022	63	9	64	8	12666	64	8
66	9	11023	64	9	**72**	**9**	**12672**	**63**	**5**

Pause at 10:34
Resume at 17:47

Sheet 1 - 0 to 50 Start: 10:06:00 Stop: End at 18:04

Recorded By: sc Verified By: dw

Validation Test Truck Run Set - Pre

Traffic Sheet 20	
LTPP MONITORED TRAFFIC DATA	STATE CODE: 55
SPEED AND CLASSIFICATION STUDIES	SPS WIM ID: 550100
	DATE (mm/dd/yyyy) 4/12/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
72	9	12673	72	9	60	9	12864	62	9
65	9	12675	65	9	65	9	12866	69	9
70	9	12682	69	9	63	9	12868	63	9
64	9	12686	65	9	67	9	12880	71	9
61	9	12689	62	9	71	9	12881	71	9
67	9	12721	67	9	60	9	12886	62	9
63	9	12722	64	9					
64	9	12729	64	9					
65	9	12734	66	9					
67	**15**	**12736**	**66**	**8**					
68	9	12748	66	9					
70	5	12747	69	5					
69	9	12751	70	9					
64	9	12766	64	9					
62	9	12782	63	9					
67	**8**	**12798**	**64**	**5**					
62	9	12817	62	9					
67	9	12821	67	9					
66	9	12823	66	9					
66	10	12825	67	10					
66	10	12827	66	10					
64	9	12843	64	9					
66	9	12848	66	9					
63	9	12849	64	9					
72	5	12857	73	5					

Sheet 2 - 51 to 100 Start: 18:04:00 Stop: pause at 19:32

Recorded By: sc Verified By: dw

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)	55 550100 4/13/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
62	9	14157	70	9	63	9	15225	65	9
64	9	14159	63	9	66	9	15227	67	9
64	8	14168	65	8	60	9	15230	61	9
67	9	14168	68	9	60	6	15241	61	6
67	**8**	**14169**	**67**	**5**	62	8	15245	63	8
67	6	14171	66	6	**55**	**5**	**15250**	**55**	**4**
67	9	14180	67	9	**63**	**15**	**15255**	**68**	**10**
53	9	14181	53	9	64	9	15259	65	9
64	9	14183	65	9	67	5	15261	67	5
64	9	14184	64	9	66	9	15263	67	9
70	5	14194	71	5	66	7	15270	66	7
66	9	14195	66	9	68	9	15273	69	9
64	9	14198	64	9	62	9	15278	63	9
64	9	14199	64	9	60	6	15280	62	6
66	9	14232	66	9	64	9	15281	65	9
64	9	14239	65	9	66	9	15283	67	9
68	9	14242	69	9	63	9	15284	63	9
65	9	14247	65	9	65	9	15288	66	9
65	9	14248	66	9	60	8	15293	61	8
67	9	14249	66	9	61	5	15308	62	5
62	9	14250	62	9	66	9	15319	66	9
65	9	14257	66	9	68	6	15321	68	6
60	9	14261	61	9	62	9	15322	62	9
65	5	14267	65	5	65	9	15323	65	9
67	9	14271	67	9	58	5	15328	68	5

Sheet 1 - 0 to 50 Start: 8:57:51 Stop: 9:31:09 AM/13:58/14:28

Recorded By: sc Verified By: dw

Validation Test Truck Run Set - Post

Traffic Sheet 20	
LTPP MONITORED TRAFFIC DATA	STATE CODE: 55
SPEED AND CLASSIFICATION STUDIES	SPS WIM ID: 550100
	DATE (mm/dd/yyyy) 4/13/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
67	9	15329	67	9	63	9	15454	64	9
65	9	15330	66	9	66	9	15457	66	9
64	10	15338	66	10	66	9	15459	67	9
66	9	15340	67	9	68	5	15460	69	5
62	9	15350	63	9	57	9	15462	54	9
65	5	15355	66	5	64	9	15464	65	9
64	9	15363	61	9	58	7	15466	61	7
64	9	15370	65	9	64	7	15470	63	7
60	9	15371	60	9	59	8	15472	60	8
64	9	15380	64	9	59	9	15480	60	9
67	9	15381	69	9	62	9	15483	63	9
70	9	15382	70	9	65	5	15495	67	5
60	9	15385	60	9	64	7	15497	64	7
34	7	15387	33	7	64	7	15498	64	7
60	9	15390	60	9	67	9	15502	68	9
64	9	15402	72	9	68	5	15504	68	5
64	**15**	**15405**	**66**	**8**	70	5	15509	68	5
68	9	15410	69	9	65	9	15516	66	9
67	8	15427	67	8	69	7	15519	62	7
64	5	15429	67	5	**62**	**4**	**15520**	**63**	**5**
67	5	15430	67	5	70	9	15521	67	9
66	9	15433	66	9	64	9	15523	64	9
64	10	15435	65	10	61	9	15530	62	9
59	8	15444	61	8	65	9	15531	65	9
70	9	15446	71	9	62	9	15532	62	9

Sheet 2 - 51 to 100 Start: 14:28:00 Stop: 15:28:00

Recorded By: sc Verified By: dw