WIM System Field Calibration and Validation Summary Report

Michigan SPS-1
SHRP ID – 260100

Validation Date: May 11, 2011
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1 Executive Summary

A WIM validation was performed on May 10 and 11, 2011 at the Michigan SPS-1 site located on route US-27 at milepost 99.1, 2.4 miles north of SR 21.

This site was installed in June, 2005. The in-road sensors are installed in the southbound lane. The site is equipped with quartz WIM sensors and IRD DAW WIM controller. The LTPP lane is identified as lane 4 in the WIM controller. From a comparison between the report of the most recent validation of this equipment on June 25, 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 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 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

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-2.1 ± 5.0%	Pass
Tandem Axles	±15 percent	-2.6 ± 6.0%	Pass
GVW	±10 percent	-2.4 ± 3.9%	Pass
Vehicle Length	±3.0 percent (2.2 ft)	-0.4 ± 1.0 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 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 1.1 ± 1.8 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 and that the speeds being reported by the WIM equipment are within acceptable ranges.

This site is not providing research quality vehicle classification data for heavy trucks (Class 6 – 13). The heavy truck misclassification rate of 6.0% is not within the 2.0% acceptability criterion for LTPP SPS WIM sites. The overall misclassification rate of 6.0% from the 100 truck sample (Class 4 – 13) was primarily due to the mis-classification of Class 10 vehicles as Class 13 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 bagged fertilizer.

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

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	77.2	10.7	16.5	16.5	16.8	16.8	20.4	4.4	34.3	4.1	63.2	75.0
2	66.9	11.5	14.0	14.0	13.7	13.7	20.0	4.2	35.3	4.0	63.5	74.2

The posted speed limit at the site is 60 mph. During the testing, the speed of the test trucks ranged from to 55.4 to 65.5 mph, a range of 10 mph. Permission to run the test trucks at speeds greater than the posted speed limit was granted by local law enforcement.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 60.7 to 90.9 degrees Fahrenheit, a range of 30.2 degrees Fahrenheit. The sunny morning to overcast afternoon weather conditions provided the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 24 shows that there are 35 consecutive months of level "E" WIM data for this site. This site requires at least 3 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 February 01, 2011 (Data) to the most recent Comparison Data Set (CDS) from November 18, 2010. 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 2 years of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2006 through 2009.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2006	357	12
2007	348	12
2008	174	7
2009	120	4

As shown in the table, this site requires 3 additional years of data to meet the minimum of five years of research quality data.

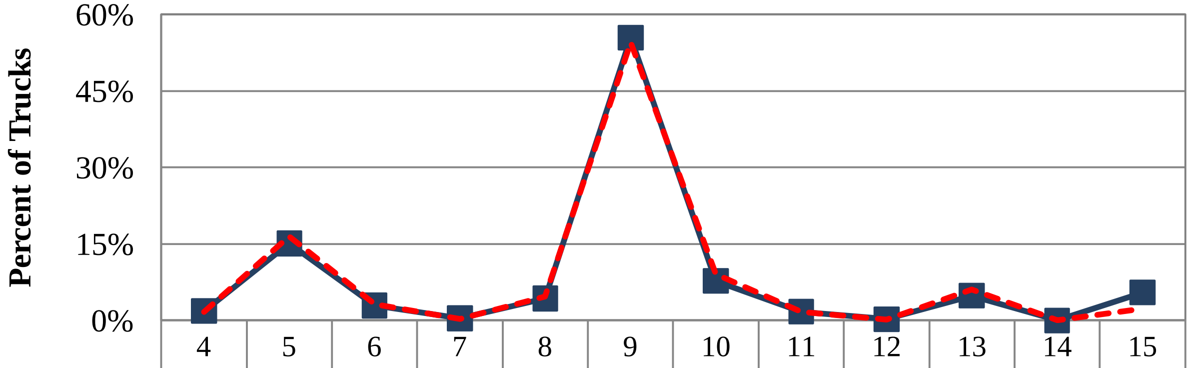
Table 2-2 provides a monthly breakdown of the available data for years 2006 through 2009.

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	
2006	31	28	31	30	30	30	31	31	23	31	30	31	12
2007	29	24	31	30	29	30	29	31	28	31	30	26	12
2008	23	19	31	27	30	28	16						7
2009	31	28	31	30									4

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 is conducted on site. Figure 2-1 provides a comparison of the truck type distributions for the two datasets. As shown in the figure, the truck distribution for the two datasets is nearly identical.



	4	5	6	7	8	9	10	11	12	13	14	15
Data	1.8%	15.1%	2.9%	0.4%	4.3%	55.4%	7.7%	1.7%	0.2%	4.8%	0.0%	5.5%
CDS	1.7%	16.4%	3.2%	0.3%	4.6%	54.5%	9.1%	1.6%	0.2%	6.0%	0.0%	2.3%

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 (55.4%) and Class 5 (15.1%). 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 vehicles changing lanes in the middle of the WIM scale area. Class 15 vehicles are unclassified vehicles. The table indicates that 5.5 percent of the vehicles at this site are unclassified.

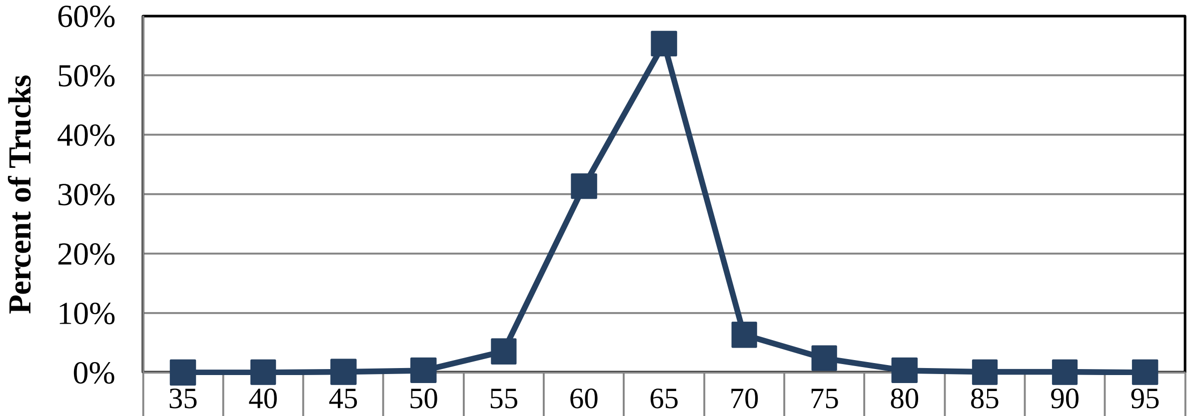
Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	11/18/20010		2/1/2011		
4	144	1.7%	345	1.8%	0.2%
5	1413	16.4%	2819	15.1%	-1.3%
6	277	3.2%	543	2.9%	-0.3%
7	25	0.3%	76	0.4%	0.1%
8	399	4.6%	809	4.3%	-0.3%
9	4695	54.5%	10372	55.4%	0.9%
10	781	9.1%	1449	7.7%	-1.3%
11	139	1.6%	318	1.7%	0.1%
12	15	0.2%	44	0.2%	0.1%
13	517	6.0%	907	4.8%	-1.2%
14	0	0.0%	0	0.0%	0.0%
15	202	2.3%	1027	5.5%	3.1%

From the table it can be seen that the number of Class 9 vehicles has increased by 0.9 percent from November 2010 and February 2011. Changes in the number of heavier trucks may be attributed to natural variations in truck volumes and to seasonal variations in truck distributions. During the same time period, the number of Class 5 trucks decreased by 1.3 percent. These differences may be attributed to changes in the use of the roadway for local deliveries and natural variations in truck volumes.

2.3 Speed Data Analysis

The two-week traffic data sample received from the Agency 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	0.0%	0.0%	0.1%	0.3%	3.5%	31.4%	55.4%	6.3%	2.4%	0.3%	0.0%	0.0%	0.0%

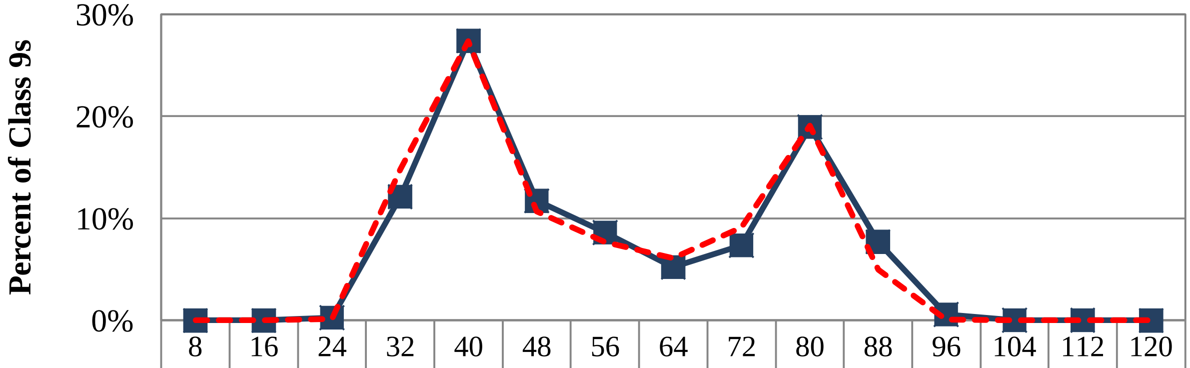
Figure 2-2 – Truck Speed Distribution

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 60 and 70 mph. The posted speed limit at this site is 60 and the 85th percentile speed for trucks at this site is 65 mph. The range of truck speeds for the validation was 50 to 60 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 February 2011 and the Comparison Data Set from November 2010.

As shown in Figure 2-3, there is a slight shift to the right of the entire weight spectrum between the November 2010 Comparison Data Set (CDS) and the February 2011 two-week sample W-card dataset (Data), indicating a calibration drift.



	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
Data	0.0%	0.0%	0.3%	12.1	27.4	11.7	8.6%	5.2%	7.4%	19.0	7.7%	0.6%	0.0%	0.0%	0.0%
CDS	0.0%	0.0%	0.1%	14.8	27.4	10.7	7.7%	6.1%	9.1%	19.1	5.0%	0.1%	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 current dataset.

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

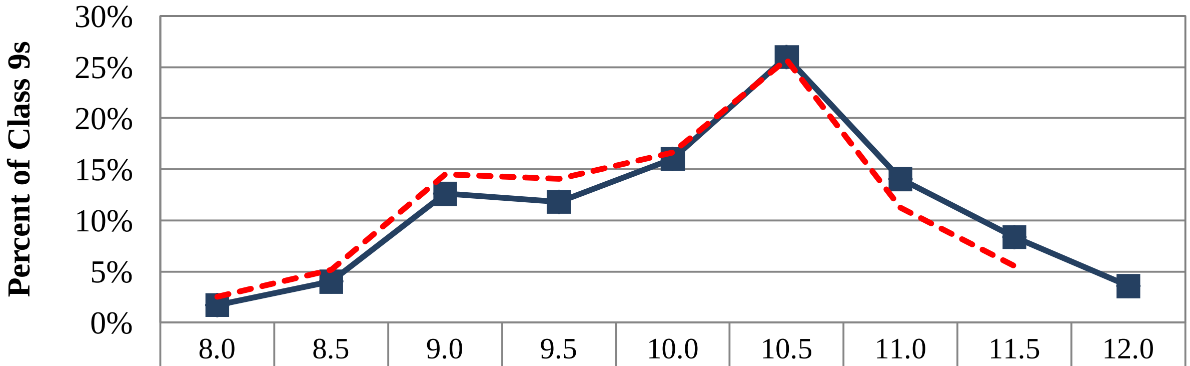
GVW weight bins (kips)	CDS		Data		Change
	Date				
	11/18/20010		2/1/2011		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	6	0.1%	29	0.3%	0.2%
32	692	14.8%	1254	12.1%	-2.7%
40	1280	27.4%	2833	27.4%	0.0%
48	500	10.7%	1212	11.7%	1.0%
56	358	7.7%	890	8.6%	1.0%
64	285	6.1%	540	5.2%	-0.9%
72	426	9.1%	761	7.4%	-1.7%
80	892	19.1%	1962	19.0%	-0.1%
88	234	5.0%	795	7.7%	2.7%
96	4	0.1%	60	0.6%	0.5%
104	1	0.0%	3	0.0%	0.0%
112	0	0.0%	1	0.0%	0.0%
120	0	0.0%	0	0.0%	0.0%
Average =	51.3 kips		52.5 kips		1.2 kips

As shown in the table, the number of unloaded class 9 trucks in the 32 to 40 kips range did not change while the number of loaded class 9 trucks in the 72 to 80 kips range decreased slightly by 0.1 percent. During this time period the number of overweight trucks increased by 3.2 percent. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site increased by 2.3 percent, from 51.3 kips to 52.5 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 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 February 2011 and the Comparison Data Set from November 2010.



	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0
Data	1.7%	4.0%	12.6%	11.8%	16.0%	26.0%	14.0%	8.4%	3.6%
CDS	2.5%	5.1%	14.5%	14.1%	16.7%	25.7%	11.2%	5.5%	

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 10.0 and 11.0 kips. There is a shift to the right of the entire weight spectrum between the November 2010 Comparison Data Set (CDS) and the February 2011 dataset (Data), indicating an increase in all front axle weights and a drift in the calibration.

Table 2-5 provides the Class 9 front axle weight distribution data for the November 2010 Comparison Data Set (CDS) and the February 2011 dataset (Data).

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

F/A weight bins (kips)	CDS		Data		Change
	Date				
	11/18/20010		2/1/2011		
8.0	115	2.5%	194	1.9%	-0.6%
8.5	118	2.5%	173	1.7%	-0.8%
9.0	239	5.1%	405	4.0%	-1.1%
9.5	674	14.5%	1275	12.6%	-1.9%
10.0	654	14.1%	1194	11.8%	-2.3%
10.5	774	16.7%	1619	16.0%	-0.7%
11.0	1194	25.7%	2628	26.0%	0.3%
11.5	521	11.2%	1421	14.0%	2.8%
12.0	257	5.5%	846	8.4%	2.8%
12.5	97	2.1%	362	3.6%	1.5%
Average =	10.2 kips		10.5 kips		0.3 kips

The table shows that the average front axle weight for Class 9 trucks has increased by 0.3 kips, or 2.9 percent. According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 10.5 kips.

2.6 Class 9 Tractor Tandem Spacing Data Analysis

The traffic 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.

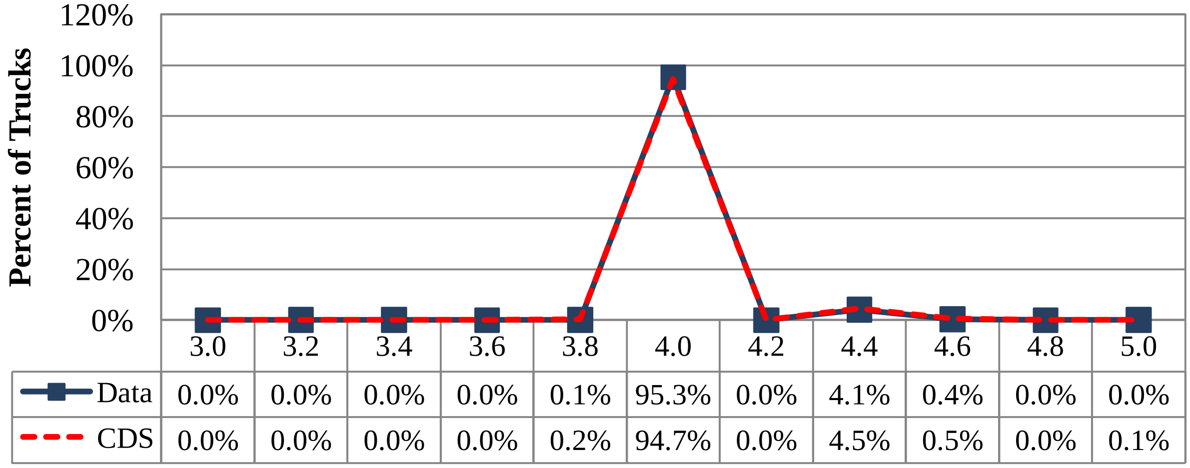


Figure 2-5 – Comparison of Class 9 Tractor Tandem Spacing

As seen in the figure, the Class 9 tractor tandem spacings for the November 2010 Comparison Data Set and the February 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				
	11/18/20010		2/1/2011		
3.0	0	0.0%	0	0.0%	0.0%
3.2	2	0.0%	2	0.0%	0.0%
3.4	0	0.0%	2	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	10	0.2%	14	0.1%	-0.1%
4.0	4432	94.7%	9857	95.3%	0.6%
4.2	0	0.0%	0	0.0%	0.0%
4.4	209	4.5%	424	4.1%	-0.4%
4.6	22	0.5%	39	0.4%	-0.1%
4.8	0	0.0%	0	0.0%	0.0%
5.0	3	0.1%	2	0.0%	0.0%
Average =	4.0 feet		4.0 feet		0.0 feet

From the table it can be seen that the highest percentage of drive tandem spacings for Class 9 trucks at this site are 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 (November 2010) based on the last calibration with the most recent two-week WIM data sample from the site (February 2011). Comparison of vehicle class distribution data indicates a 0.9 percent increase in the number of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have increased by 0.3 kips and average Class 9 GVW has increased by 2.3 percent for the February 2011 data. The data indicates an average truck tandem spacing of 4.0 feet – 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 June 25, 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 in June, 2005 by the Agency. It is instrumented with quartz weighing sensors and an IRD DAW WIM Controller. The Agency 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, several moderate transverse cracks within the WIM section were noted and are provided in Figure 4-1 through Figure 4-6.

Figure 4-1 – Transverse Crack 36 Feet Prior to WIM Scales

Figure 4-2 – Transverse Crack 61 Feet Prior to WIM Scales

Figure 4-3 – Transverse Crack 177 Feet Prior to WIM Scales

Figure 4-4 – Transverse Crack 177 Feet Prior to WIM Scales

Figure 4-5 – Transverse Crack 190 Feet Prior to WIM Scales

Figure 4-6 – Transverse Crack 270 Feet Prior to WIM Scales

Also, there is a vacated WIM sensor location within the WIM scale area that has been patched but needs to be refilled, as shown in Figure 4-7.

Figure 4-7 – Patch at Old WIM Sensor Installation

4.2 Profile and Vehicle Interaction

Profile data was collected on August 10, 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 117 in/mi and is located approximately 769 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 143 in/mi and is located approximately 317 feet prior to the WIM scale. These areas were closely investigated during the validation visit and truck dynamics in these areas were closely observed. No distresses were noted and these areas did not appear to influence truck dynamics in the WIM scale area.

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)	0.734	0.738	0.762			0.745
		SRI (m/km)	0.901	1.089	0.880			0.957
		Peak LRI (m/km)	0.739	0.739	0.767			0.748
		Peak SRI (m/km)	**1.009**	**1.104**	**1.014**			**1.042**
	RWP	LRI (m/km)	*0.000*	*0.000*	*0.000*			*0.000*
		SRI (m/km)	*0.000*	*0.000*	*0.000*			*0.000*
		Peak LRI (m/km)	*0.000*	*0.000*	*0.000*			*0.000*
		Peak SRI (m/km)	*0.000*	*0.000*	*0.000*			*0.000*
Center	LWP	LRI (m/km)	0.700	0.721	0.739	0.768	0.856	0.732
		SRI (m/km)	0.701	0.823	0.796	0.859	0.735	0.795
		Peak LRI (m/km)	0.750	0.760	0.741	0.768	0.857	0.755
		Peak SRI (m/km)	0.754	0.864	0.827	0.914	0.914	0.840
	RWP	LRI (m/km)	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
		SRI (m/km)	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
		Peak LRI (m/km)	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
		Peak SRI (m/km)	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Right	LWP	LRI (m/km)	0.781	0.830	0.800			0.804
		SRI (m/km)	0.901	0.832	1.028			0.920
		Peak LRI (m/km)	0.854	0.837	0.854			0.848
		Peak SRI (m/km)	0.936	0.889	1.083			0.969
	RWP	LRI (m/km)	*0.000*	*0.000*	*0.000*			*0.000*
		SRI (m/km)	*0.000*	*0.000*	*0.000*			*0.000*
		Peak LRI (m/km)	*0.000*	*0.000*	*0.000*			*0.000*
		Peak SRI (m/km)	*0.000*	*0.000*	*0.000*			*0.000*

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 SRI values in the left wheel path of the left shift passes, (shown in bold). The zero values indicate that the index values were not available from the WIM Smoothness Index software due to a profiling equipment configuration change where the right laser sensor was shifted to the center of the vehicle.

4.4 Recommended Pavement Remediation

Remediation of the patch at the old WIM sensor location 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 41 pre-validation test truck runs were conducted on May 10, 2011, beginning at approximately 8:31 AM and continuing until 1:47 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with palletized bagged fertilizer, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.
- A Class 9, 5-axle truck, loaded with Palletized bagged fertilizer, and equipped with air suspension on the tractor, air 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	77.9	11.0	16.7	16.7	16.8	16.8	20.4	4.4	34.3	4.1	63.2	75.0
2	67.4	11.7	14.2	14.2	13.6	13.6	20.0	4.2	35.3	4.0	63.5	74.2

Test truck speeds varied by 14 mph, from 51.7 to 65.7 mph. The measured pre-validation pavement temperatures varied 30.9 degrees Fahrenheit, from 56.0 to 86.9. The sunny weather conditions in the afternoon provided for attaining the desired 30 degree temperature range. Table 5-2 provides a summary of the pre-validation results.

Table 5-2 – Pre-Validation Overall Results – 10-May-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-5.8 ± 4.8%	Pass
Tandem Axles	±15 percent	-3.4 ± 5.1%	Pass
GVW	±10 percent	-3.8 ± 3.5%	Pass
Vehicle Length	±3.0 percent (2.2 ft)	-0.3 ± 1.1 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 over all speeds was 0.7 ± 1.6 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 distance factor is set correctly and 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 60 mph, however, test trucks were permitted to run up to speeds of 65 mph by local law enforcement. 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 – 10-May-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		51.7 to 57.5 mph	57.6 to 62.5 mph	62.6 to 65.7 mph
Steering Axles	±20 percent	-5.4 ± 6.0%	-5.7 ± 5.0%	-6.5 ± 4.0%
Tandem Axles	±15 percent	-3.6 ± 5.3%	-3.3 ± 4.7%	-3.2 ± 6.2%
GVW	±10 percent	-4.0 ± 2.9%	-3.7 ± 3.7%	-3.7 ± 5.0%
Vehicle Length	±3.0 percent (2.2 ft)	-0.5 ± 1.0 ft	0.0 ± 1.4 ft	-0.5 ± 1.0 ft
Vehicle Speed	± 1.0 mph	0.6 ± 1.7 mph	0.9 ± 1.9 mph	0.6 ± 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 underestimates all weights at all speeds. For steering axle weight estimates, the range of errors decreases as speed increases. For GVW estimates, variability increases with speed. The range in error for tandem axle weights is lesser at the medium speeds when compared with low and high 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 sections.

5.1.1.1 GVW Errors by Speed

As shown in Figure 5-1, the equipment generally underestimated GVW at all speeds. The range in error appears to increase as speed increases. It appears that there is no a significant correlation between speed and GVW estimates at this site.

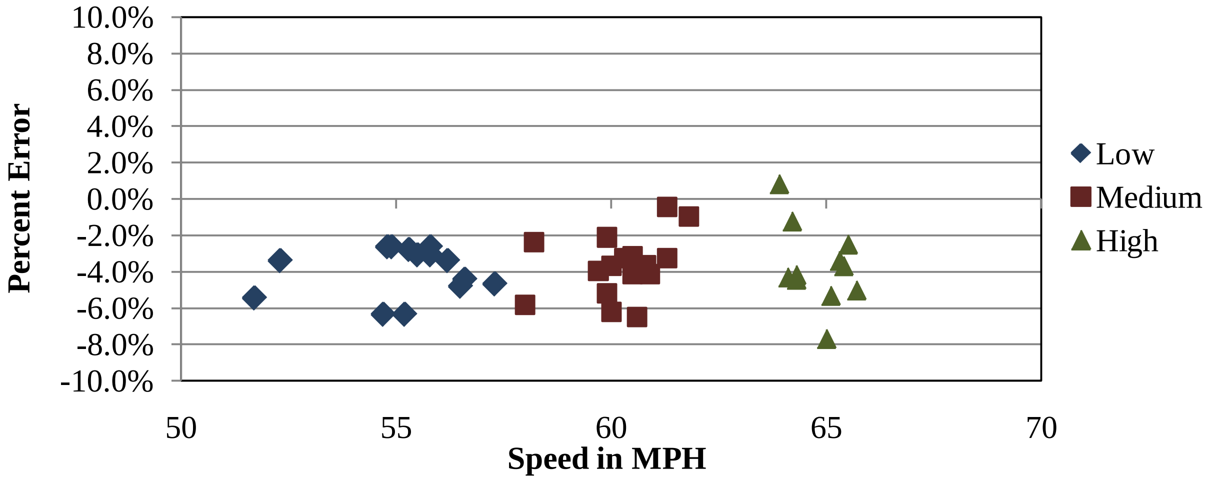


Figure 5-1 – Pre-Validation GVW Error by Speed – 10-May-11

5.1.1.2 Steering Axle Weight Errors by Speed

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

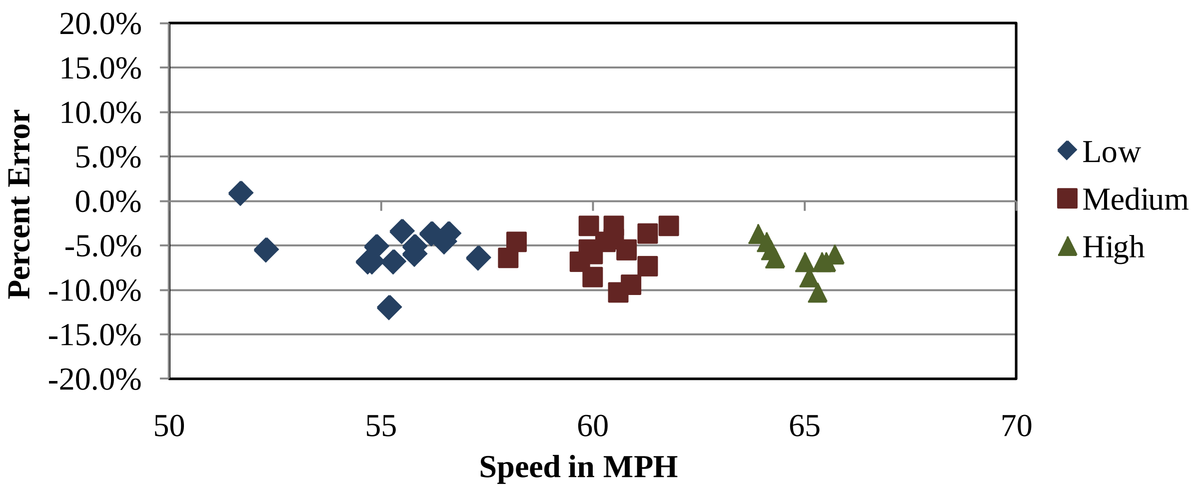


Figure 5-2 – Pre-Validation Steering Axle Weight Errors by Speed – 10-May-11

5.1.1.3 Tandem Axle Weight Errors by Speed

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

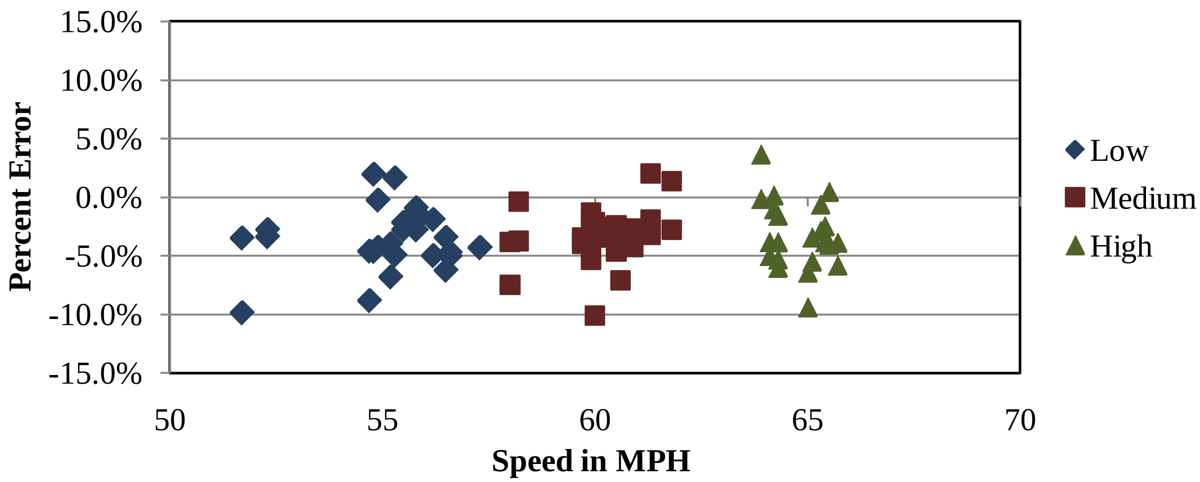


Figure 5-3 – Pre-Validation Tandem Axle Weight Errors by Speed – 10-May-11

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 precision and bias is similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck at the lower speeds. Beginning at the medium speeds, the underestimation of GVW for the Primary truck appears to decrease as speed increases. Distribution of errors is shown graphically in Figure 5-4.

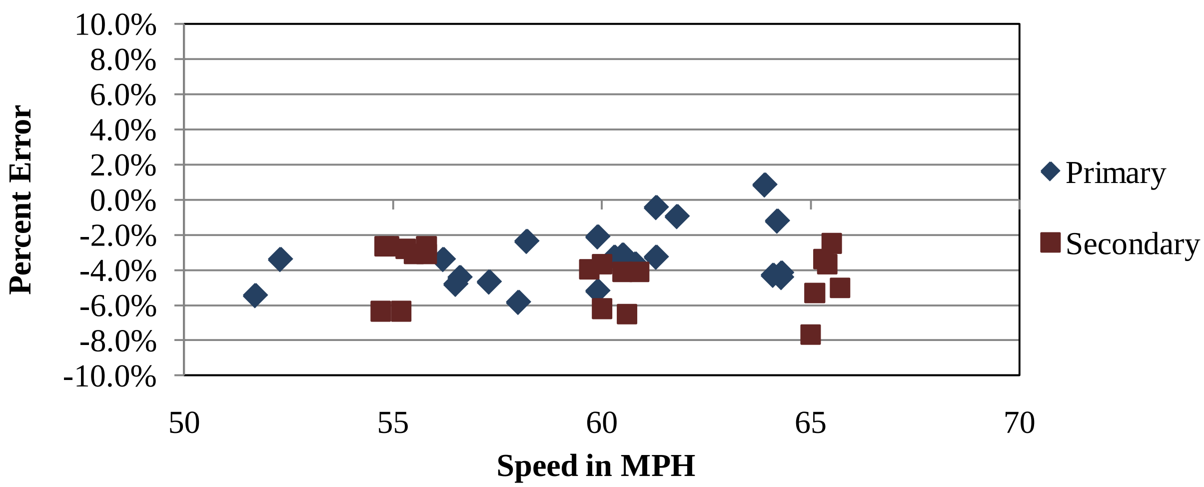


Figure 5-4 – Pre-Validation GVW Errors by Truck and Speed – 10-May-11

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.

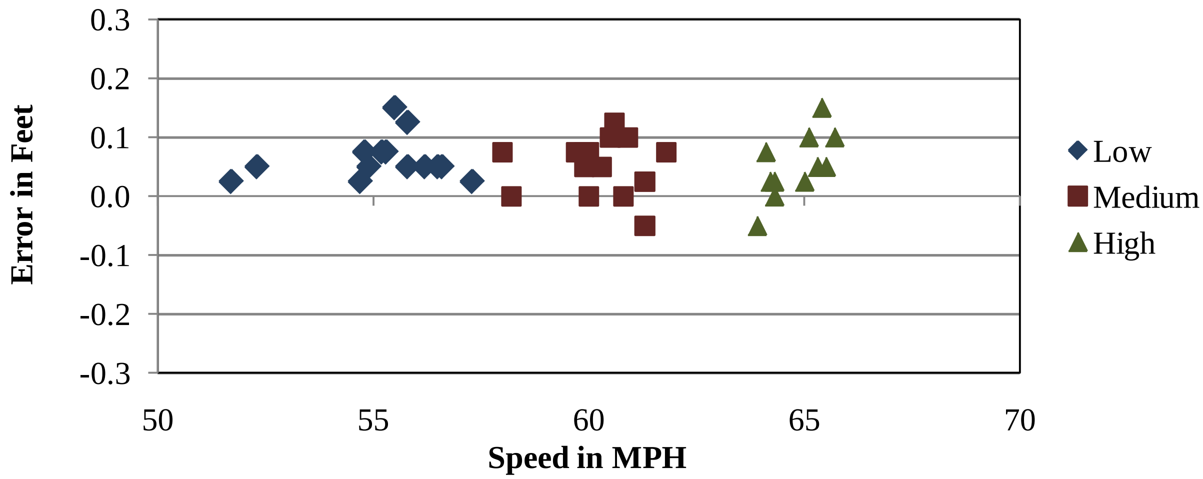


Figure 5-5 – Pre-Validation Axle Length Errors by Speed – 10-May-11

5.1.1.6 Overall Length Errors by Speed

For this system, the WIM equipment measured overall vehicle length consistently over the entire range of speeds, with an error range of 1.2 to -1.3 feet. Distribution of errors is shown graphically in Figure 5-6.

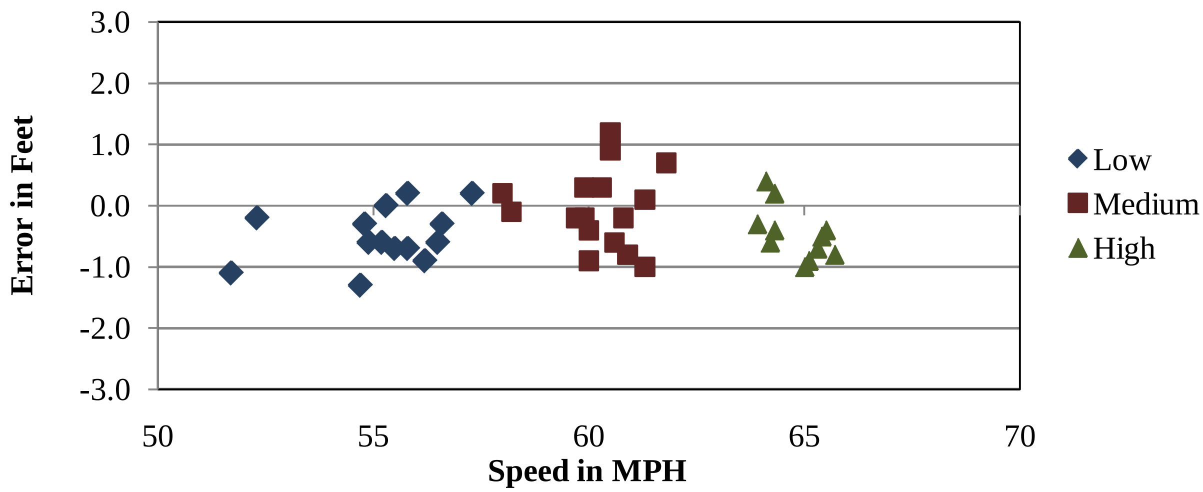


Figure 6-6 – Pre-Validation Overall Length Error by Speed – 10-May-11

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 30.9 degrees, from 56.0 to 86.9 degrees Fahrenheit. The pre-validation test runs are being reported under three temperature groups – low, medium and high, as shown in Table 5-4.

Table 5-4 – Pre-Validation Results by Temperature – 10-May-11

Parameter	**95% Confidence Limit of Error**	**Low**	**Medium**	**High**
		56.0 to 63 degF	**63.1 to 78.0 degF**	**78.1 to 86.9 degF**
Steering Axles	±20 percent	-5.4 ± 5.7%	-6.4 ± 5.3%	-5.6 ± 4.2%
Tandem Axles	±15 percent	-4.1 ± 4.6%	-4.2 ± 4.8%	-1.7 ± 5.3%
GVW	±10 percent	-4.4 ± 3.2%	-4.5 ± 3.0%	-2.3 ± 3.3%
Vehicle Length	±3.0 percent (2.2 ft)	-0.5 ± 1.3 ft	-0.2 ± 1.4 ft	-0.2 ± 1.0 ft
Vehicle Speed	± 1.0 mph	0.5 ± 1.2 mph	0.8 ± 2.1 mph	1.0 ± 1.7 mph
Axle Length	± 0.5 ft [150mm]	0.1 ± 0.1 ft	0.1 ± 0.1 ft	0.0 ± 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 generally underestimates GVW across the range of temperatures observed in the field. There appears to be a slight correlation between temperature and weight estimates where an increase in temperature causes a minor increase in average GVW estimates. The bias in estimates is the highest at low temperatures.

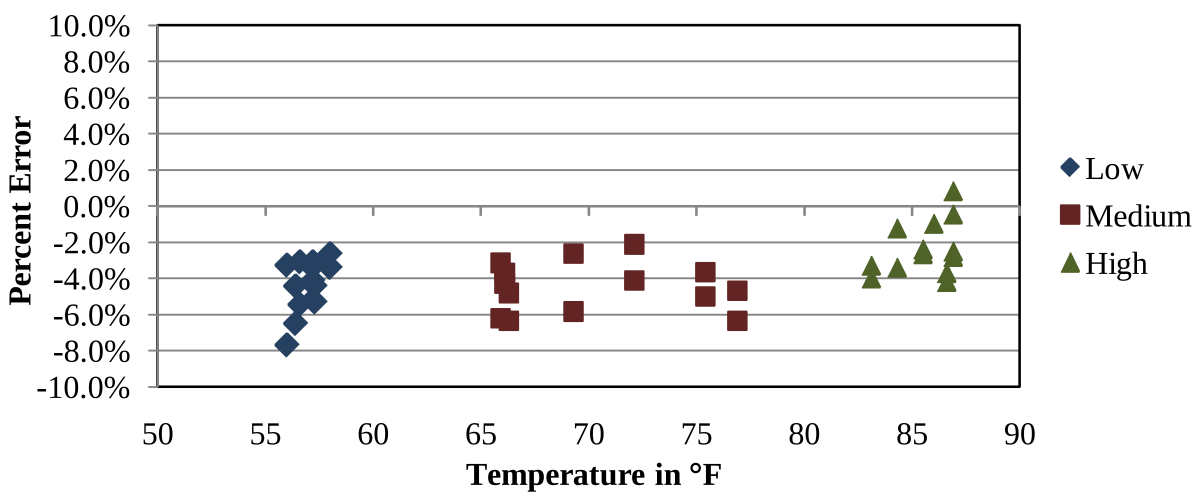


Figure 5-7 – Pre-Validation GVW Errors by Temperature – 10-May-11

5.1.2.2 Steering Axle Weight Errors by Temperature

As shown in Figure 5-8, the WIM equipment generally underestimated steering axle weights across the range of temperatures observed in the field. The range in error is similar for different temperature groups.

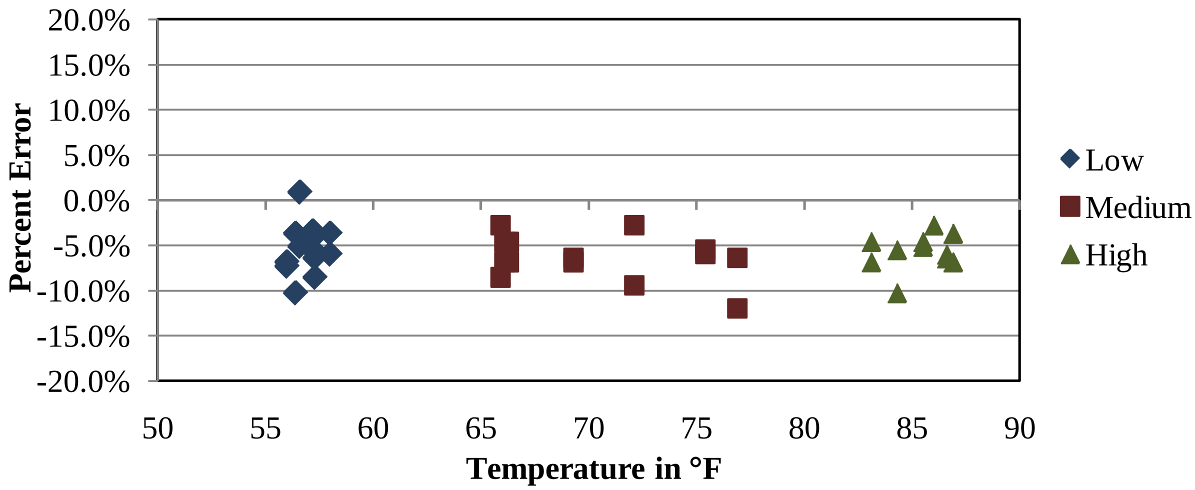


Figure 5-8 – Pre-Validation Steering Axle Weight Errors by Temperature – 10-May-11

5.1.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-9, the WIM equipment appears to generally underestimate tandem axle weights across the range of temperatures observed in the field. There appears to be a slight correlation between temperature and weight estimates where an increase in temperature causes a minor increase in tandem axle weight estimates. The bias in estimates is highest at low temperatures.

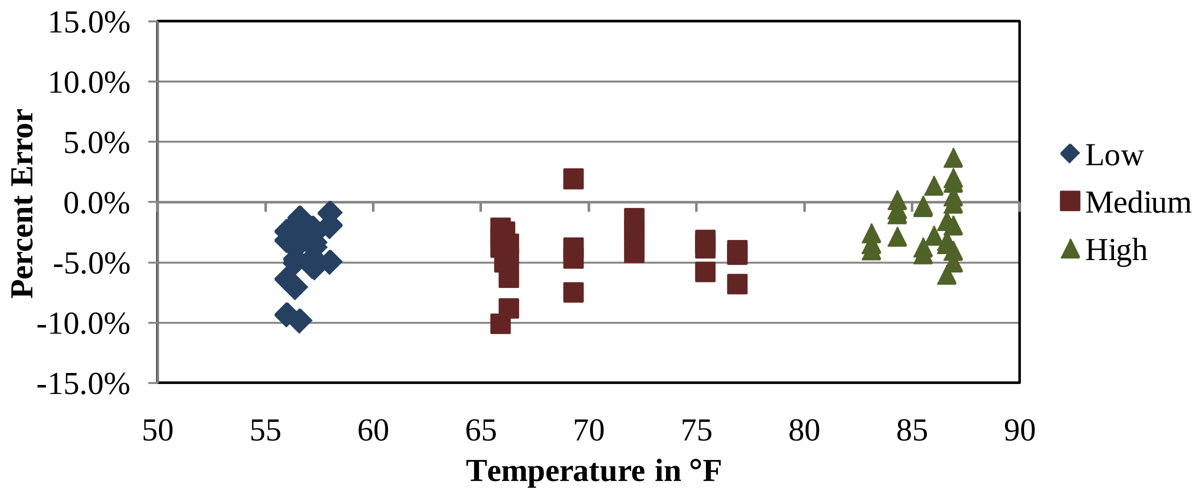


Figure 5-9 – Pre-Validation Tandem Axle Weight Errors by Temperature – 10-May-11

5.1.2.4 GVW Errors by Temperature and Truck Type

When analyzed for each test truck, GVW measurement errors for both trucks follow similar patterns. For both trucks, the range of errors and bias are consistent over the range of temperatures. The bias in estimates is the highest at low temperatures. Distribution of errors is shown graphically in Figure 5-10.

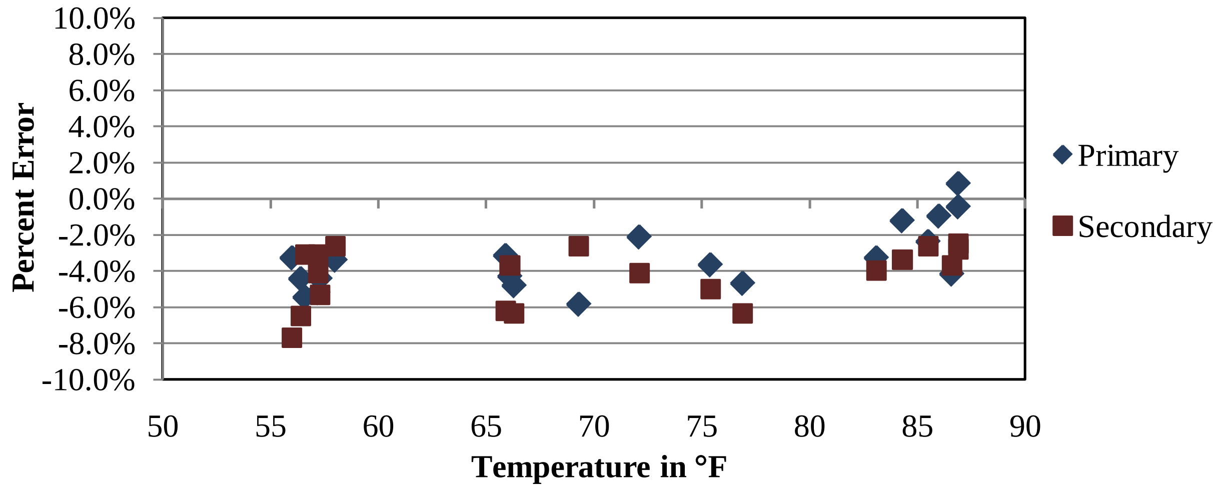


Figure 5-10 – Pre-Validation GVW Error by Truck and Temperature – 10-May-11

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, one Class 5 vehicle was identified as a Class 9 vehicle by the equipment. Additionally, five Class 10 vehicles were identified as Class 13 vehicles. There were two unclassified vehicles reported by the equipment – one Class 5 and one Class 9. The combined results presented an undercount of two Class 5s and five Class 10s, and an over count of five Class 13s, as shown in Table 5-5.

Table 5-5 – Pre-Validation Classification Study Results – 10-May-11

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	0	0	17	3	0	7	56	14	0	1	2
WIM Count	0	0	15	3	0	7	56	9	0	1	7
Observed Percent	0%	0%	17%	3%	0%	7%	56%	14%	0%	1%	2%
WIM Percent	0%	0%	15%	3%	0%	7%	56%	9%	0%	1%	7%
Misclassified Count	0	0	1	0	0	0	0	5	0	0	0
Misclassified Percent	0%	0%	6%	0%	0%	0%	0%	36%	0%	0%	0%
Unclassified Count	0	0	1	0	0	0	1	0	0	0	0
Unclassified Percent	0%	0%	7%	0%	0%	0%	2%	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 – 10-May-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	5
5/6	0	7/6	0	11/12	0
5/7	0	8/3	0	12/11	0
5/8	0	8/5	0	13/10	0
5/9	1	8/9	0	13/11	0

As shown in the table, a total of 6 vehicles, including 5 heavy trucks (6 – 13) were misclassified by the equipment. Based on the vehicles observed during the pre-validation study, the misclassification percentage is 6.0% for heavy trucks (6 – 13), which is not within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 6.0%.

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 – 10-May-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	0		

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. For speed, the mean error for WIM equipment speed measurement was 0.8 mph; the range of errors was 1.0 mph.

Based on these findings, it is recommended that an expanded investigation focusing on vehicle classification issues indicated in this report be conducted. The study shall focus on the identification of the cause for the Class 10 misclassifications and the development of recommendations to remedy these causes. This study may be conducted in conjunction with the next calibration and validation visit.

5.2 Calibration

The WIM equipment required one calibration iteration 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 – 11-May-11

Speed Points		
SP1	55	965
SP2	60	961
SP3	65	961
Other		
Overall -		947
Front Axle -		973
Left -		901
Right -		910
Distance -		1006
Loop Width -		803

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 -3.8% and errors of -4.0%, -3.7%, and -3.7% at the 55, 60 and 65 mph speed points respectively. To compensate for these errors, the changes in Table 5-9 were made to the compensation factors.

At the request of the Agency, the equipment was calibrated so that the final error would be approximately -2.0%. This is because the equipment is being used as a pre-screening tool for the Motor Carrier Enforcement team and they want to avoid false overweight vehicle reports.

Table 5-9 – Calibration 1 Equipment Factor Changes – 11-May-11

Speed Points		**Error**	**Old**	**New**
SP1	55	-0.80%	965	969
SP2	60	-1.30%	961	970
SP3	65	-0.20%	961	959
Other				
Overall -		-1.00%	947	953
Front Axle -		-2.50%	973	998
Left -			901	901
Right -			910	910
Distance -		-0.20%	1006	1004
Loop Width -		-0.39%	803	803

5.2.1.2 Calibration 1 Results

The results of the 13 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 all weight estimates was reduced as a result of the first calibration iteration.

Table 5-10 – Calibration 1 Results – 11-May-11

Parameter	**95% Confidence Limit of Error**	**Site Values**	**Pass/Fail**
Steering Axles	±20 percent	-2.7 ± 4.3%	Pass
Tandem Axles	±15 percent	-3.1 ± 5.2%	Pass
GVW	±10 percent	-3.0 ± 2.5%	Pass
Vehicle Length	±3.0 percent (2.2 ft)	-0.2 ± 0.7 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	Pass

Figure 5-11 shows that the WIM equipment is estimating GVW with reasonable accuracy at all speeds, with average error 1.0 percent over the agency's preferred error of +/-2.0 percent.

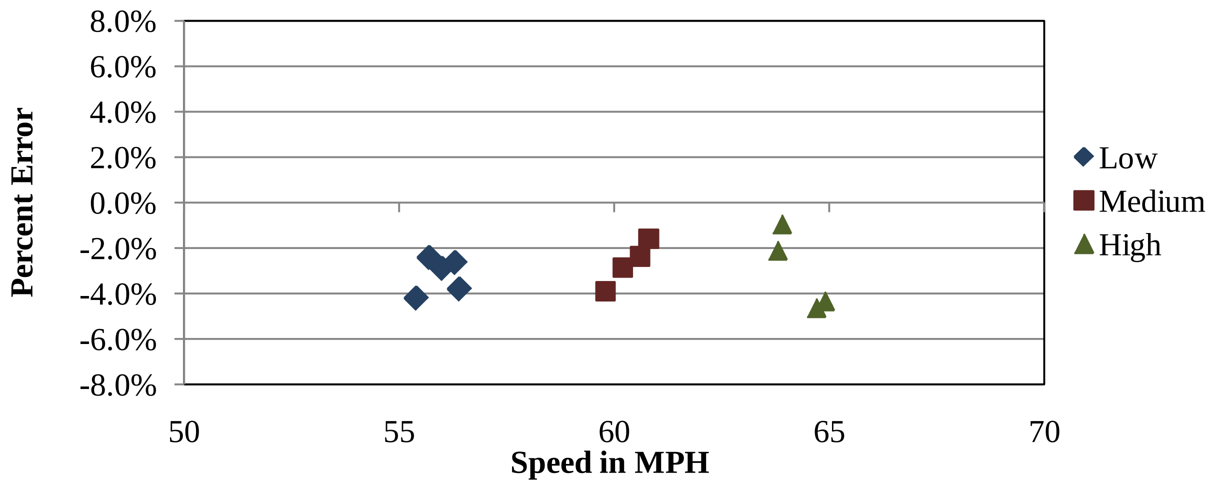


Figure 5-11 – Calibration 1 GVW Error by Speed – 11-May-11

Based on the results of the first calibration, where average weight estimate bias decreased to -3.0 percent, a second calibration was not considered to be necessary. The 13 calibration runs were combined with 27 additional post-validation runs to complete the WIM system validation.

5.3 Post-Validation

The 41 post-validation test truck runs were conducted on May 11, 2011, beginning at approximately 7:54 AM and continuing until 12:03 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with palletized bagged fertilizer, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.

- A Class 9, 5-axle truck, loaded with palletized bagged fertilizer, and equipped with air suspension on the tractor, air 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 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	77.2	10.7	16.5	16.5	16.8	16.8	20.4	4.4	34.3	4.1	63.2	75.0
2	66.9	11.5	14.0	14.0	13.7	13.7	20.0	4.2	35.3	4.0	63.5	74.2

Test truck speeds varied by 10 mph, from 55.4 to 65.5 mph. The measured post-validation pavement temperatures varied 30.2 degrees Fahrenheit, from 60.7 to 90.9. The sunny morning weather conditions provided the desired minimum 30 degree temperature range. The overcast conditions in the afternoon prevented any further increase in the temperature range. Table 5-12 is a summary of post validation results.

Table 5-12 – Post-Validation Overall Results – 11-May-11

Parameter	**95% Confidence Limit of Error**	**Site Values**	**Pass/Fail**
Steering Axles	±20 percent	-2.1 ± 5.0%	Pass
Tandem Axles	±15 percent	-2.6 ± 6.0%	Pass
GVW	±10 percent	-2.4 ± 3.9%	Pass
Vehicle Length	±3.0 percent (2.2 ft)	-0.4 ± 1.0 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 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 1.1 ± 1.8 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 relationship exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 60 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-13.

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

Parameter	95% Confidence Limit of Error	Low	Medium	High
		55.4 to 58.8 mph	58.9 to 62.2 mph	62.3 to 65.5 mph
Steering Axles	±20 percent	-2.0 ± 4.9%	-1.9 ± 7.3%	-2.4 ± 3.8%
Tandem Axles	±15 percent	-2.0 ± 3.6%	-2.1 ± 5.1%	-3.4 ± 7.3%
GVW	±10 percent	-2.0 ± 2.4%	-2.0 ± 3.8%	-3.1 ± 5.3%
Vehicle Length	±3.0 percent (2.2 ft)	-0.1 ± 1.0 ft	-0.5 ± 1.2 ft	-0.5 ± 0.8 ft
Vehicle Speed	± 1.0 mph	1.2 ± 2.0 mph	1.2 ± 1.8 mph	1.0 ± 2.1 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	0.0 ± 0.1 ft	0.0 ± 0.1 ft

From the table, it can be seen that the WIM equipment underestimates all weights with similar bias at all speeds. The range of steering axle errors is higher at the medium speeds. For GVW and tandem axle estimates, the variability increases with speed. There does not appear to be a significant 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 underestimated GVW with similar bias at all speeds. The range in error is similar throughout the entire speed range.

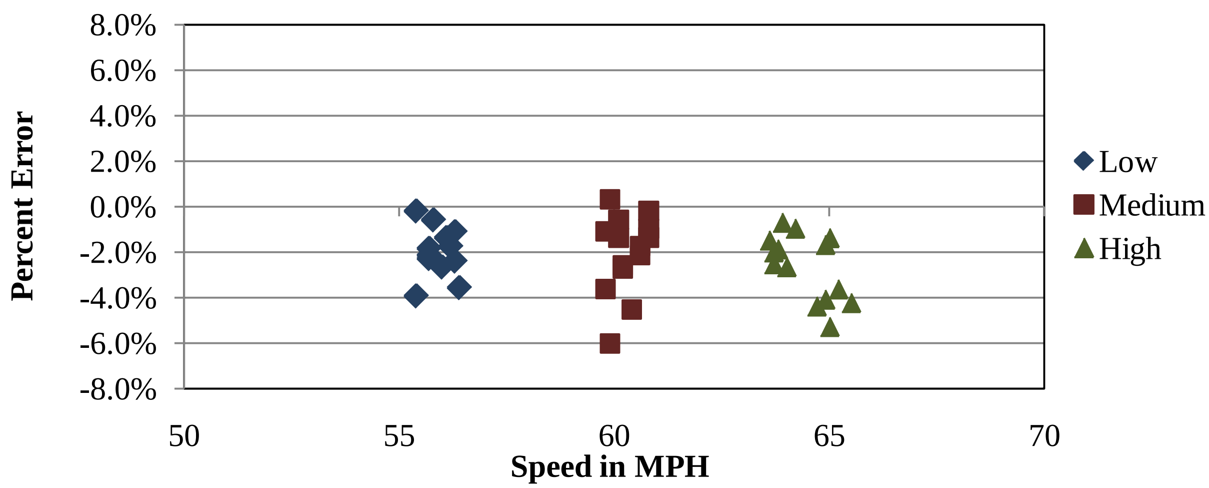


Figure 5-12 – Post-Validation GVW Errors by Speed – 11-May-11

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 at all speeds. The range in error is greater for the medium speeds. There does not appear to be a correlation between speed and weight estimates at this site.

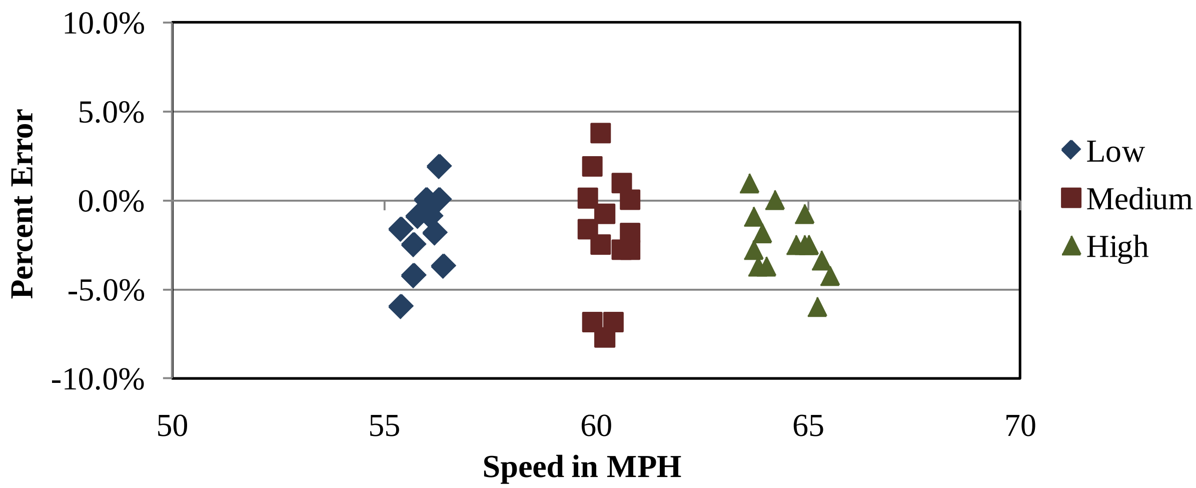


Figure 5-13 – Post-Validation Steering Axle Weight Errors by Speed – 11-May-11

5.3.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-14, the equipment underestimated tandem axle weights with similar bias at all speeds. The range in error appears to be lesser for the lower speeds.

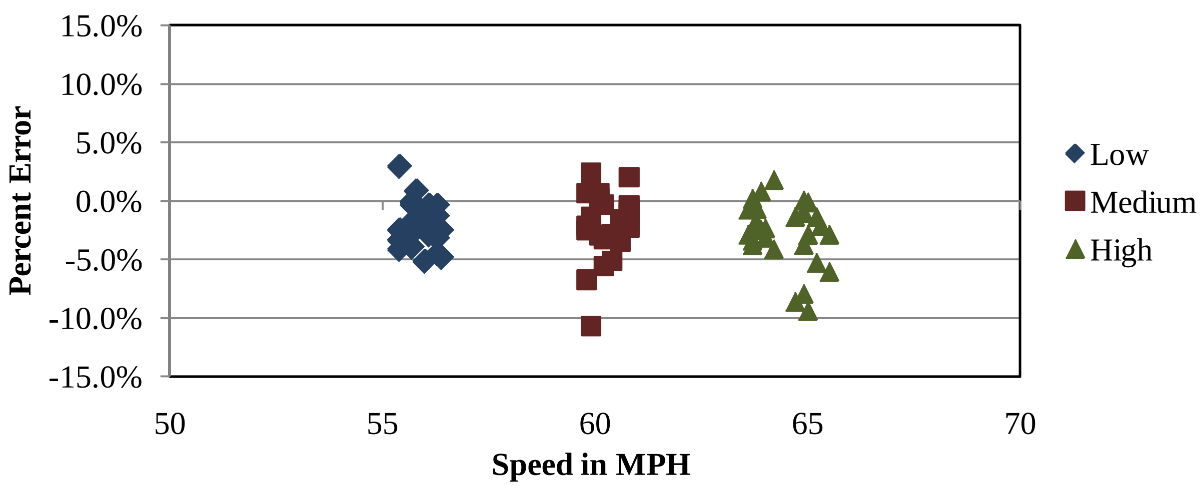


Figure 5-14 – Post-Validation Tandem Axle Weight Errors by Speed – 11-May-11

5.3.1.4 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-15 that when the GVW errors are analyzed by truck type, the WIM equipment precision and bias is similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck at the lower speeds. The equipment appears to underestimate GVW with greater variability for the Secondary truck, especially at the medium and high speeds.

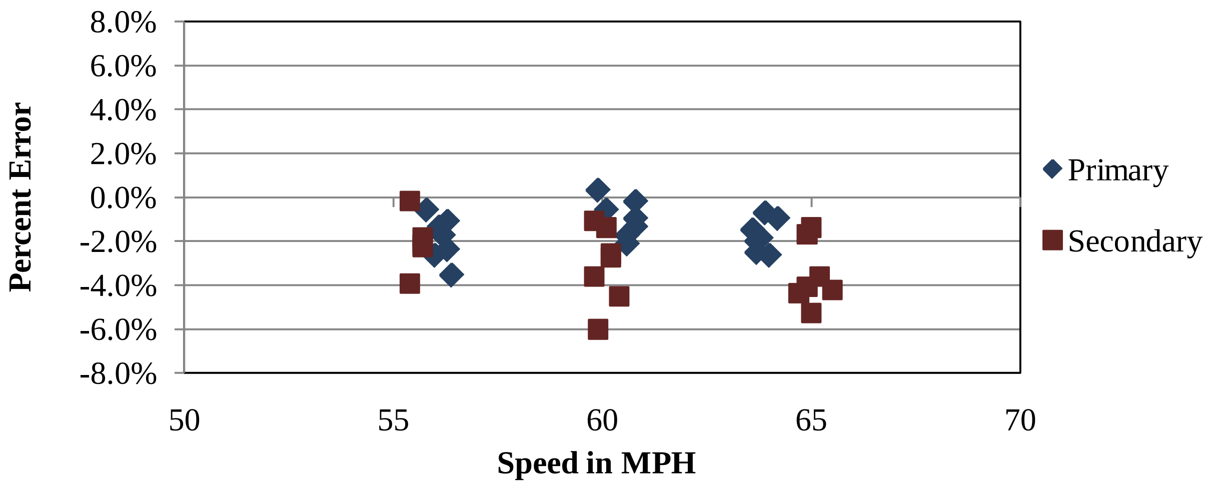


Figure 5-15 – Post-Validation GVW Error by Truck and Speed – 11-May-11

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 -0.1 feet to 0.1 feet. Distribution of errors is shown graphically in Figure 5-16.

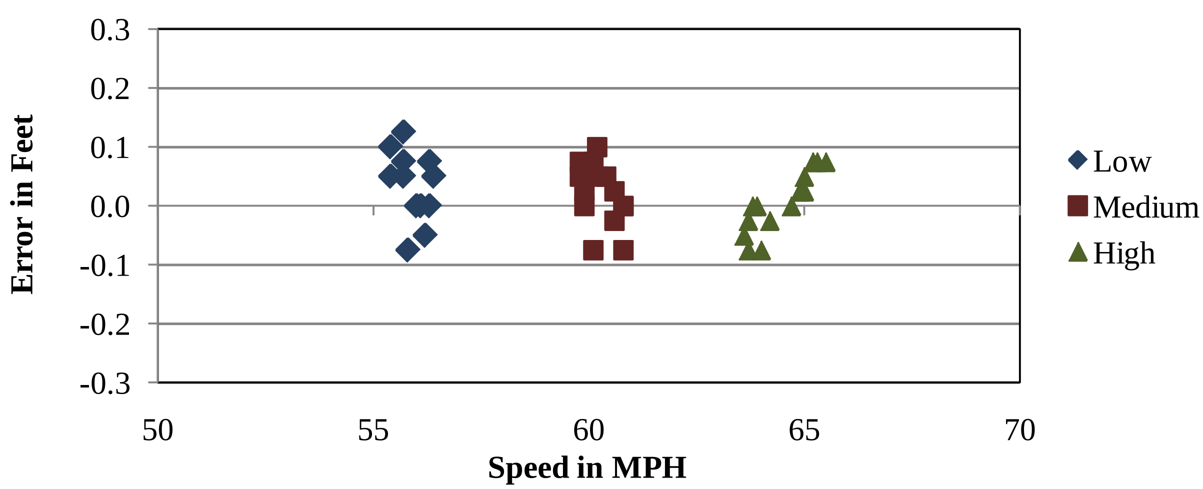


Figure 5-16 – Post-Validation Axle Length Error by Speed – 11-May-11

5.3.1.6 Overall Length Errors by Speed

For this system, the WIM equipment appears to underestimate overall length at the medium and high speeds. The range in overall length measurement error was from 1.0 to -1.4 feet. Distribution of errors is shown graphically in Figure 5-17.

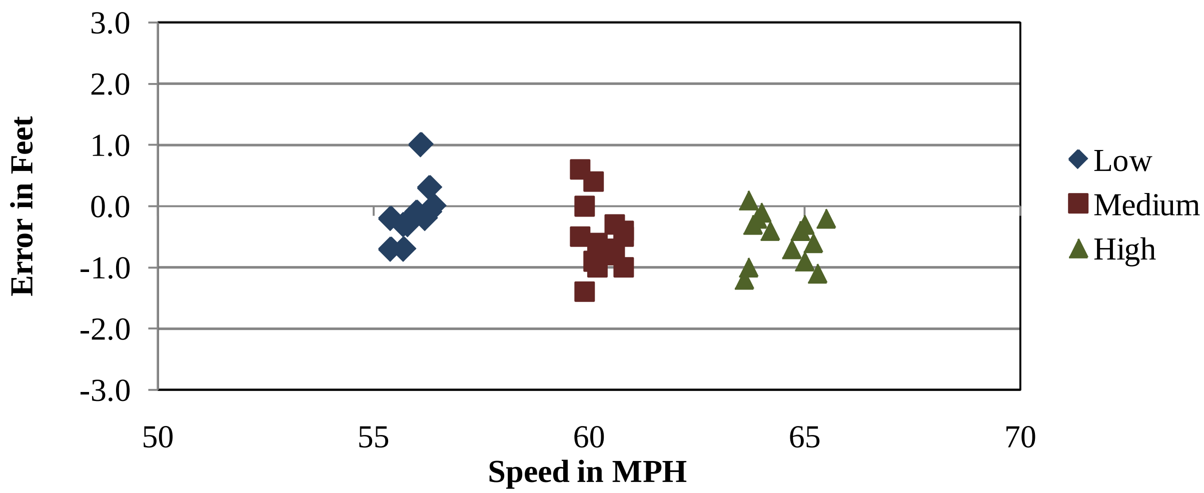


Figure 5-17 – Post-Validation Overall Length Error by Speed – 11-May-11

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 30.2 degrees, from 60.7 to 90.9 degrees Fahrenheit. 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 – 11-May-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		60.7 to 70 degF	70.1 to 81.0 degF	81.1 to 90.9 degF
Steering Axles	±20 percent	-1.7 ± 4.4%	-1.3 ± 6.7%	-3.0 ± 4.8%
Tandem Axles	±15 percent	-3.0 ± 5.2%	-2.3 ± 4.4%	-2.4 ± 7.9%
GVW	±10 percent	-2.7 ± 2.4%	-2.1 ± 3.7%	-2.4 ± 5.5%
Vehicle Length	±3.0 percent (2.2 ft)	-0.2 ± 0.7 ft	-0.4 ± 1.0 ft	-0.5 ± 1.3 ft
Vehicle Speed	± 1.0 mph	1.1 ± 1.5 mph	1.0 ± 2.1 mph	1.2 ± 2.2 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	0.0 ± 0.1 ft	0.0 ± 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 appears to estimate GVW with similar bias 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.

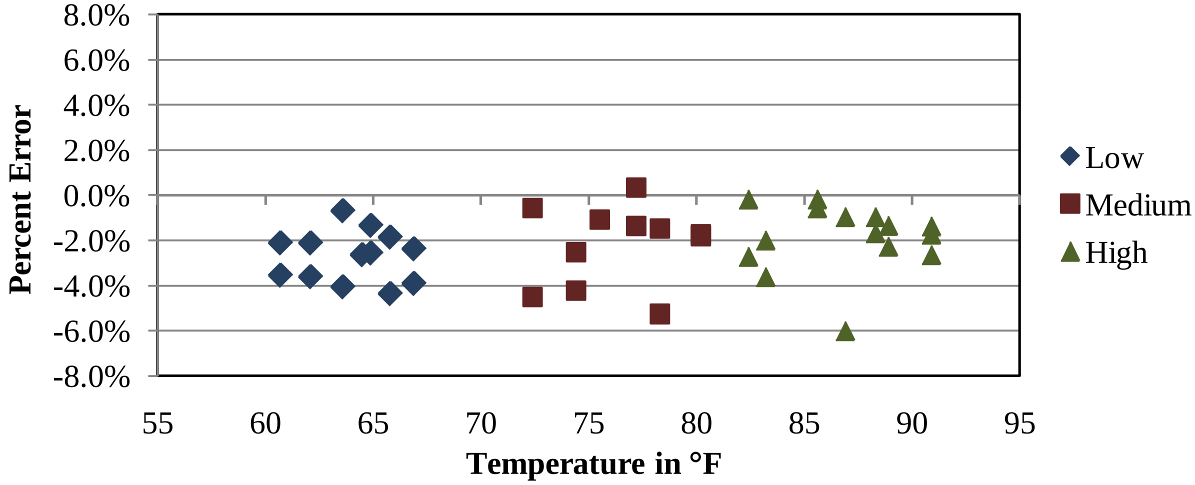


Figure 5-18 – Post-Validation GVW Errors by Temperature – 11-May-11

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-19 demonstrates that for steering axles, the WIM equipment appears to estimate steering axle weights with similar bias across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and steering axle weight estimates at this site. The range in error is similar for different temperature groups.

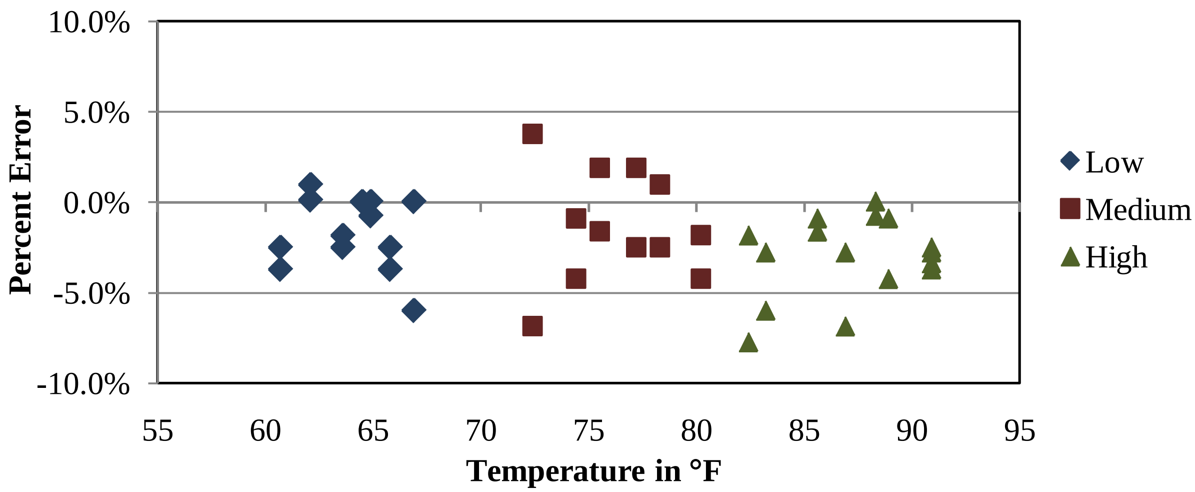


Figure 5-19 – Post-Validation Steering Axle Weight Errors by Temperature – 11-May-11

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 similar bias across the range of temperatures observed in the field. There does appear to be a slight correlation between temperature and tandem axle weight estimates at this site where the estimation of tandem axle weights increases as temperature increases. The range in tandem axle errors is consistent for the three temperature groups.

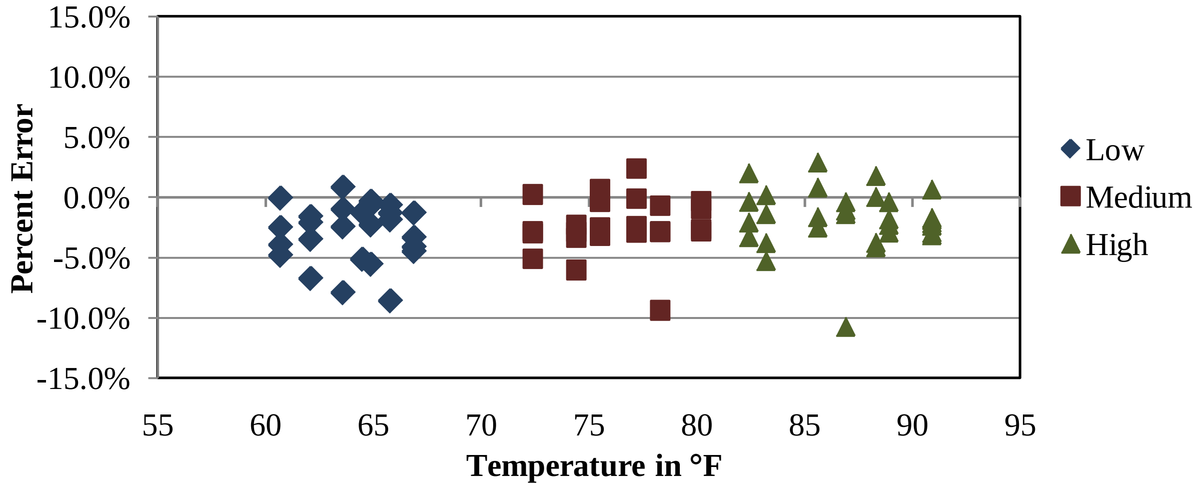


Figure 5-20 – Post-Validation Tandem Axle Weight Errors by Temperature – 11-May-11

5.3.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-21, when analyzed by truck type, GVW measurement errors for both trucks are similar at all temperatures; secondary truck shows slightly larger bias values at high temperatures.

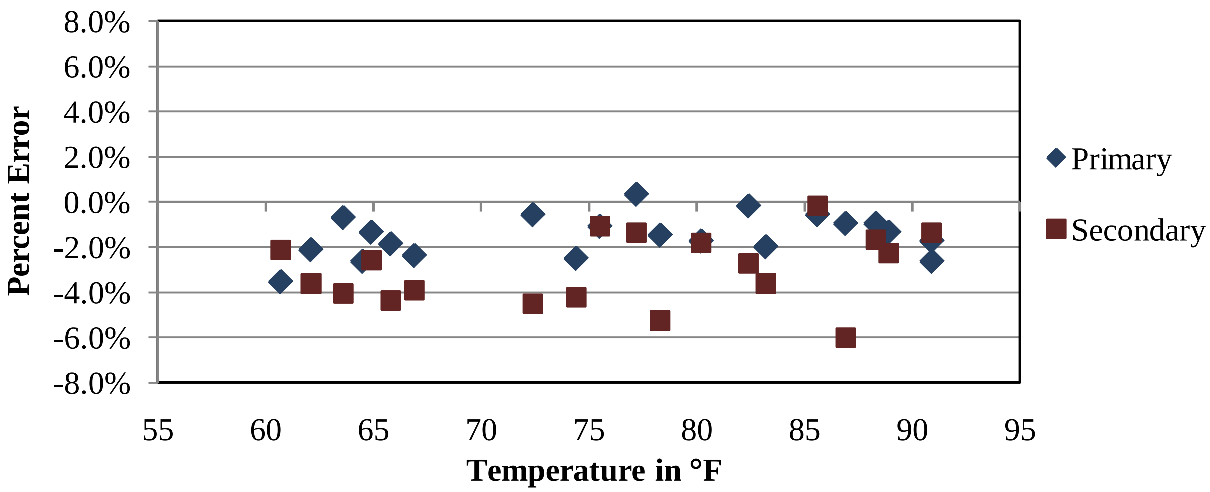


Figure 5-21 – Post-Validation GVW Error by Truck and Temperature – 11-May-11

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.

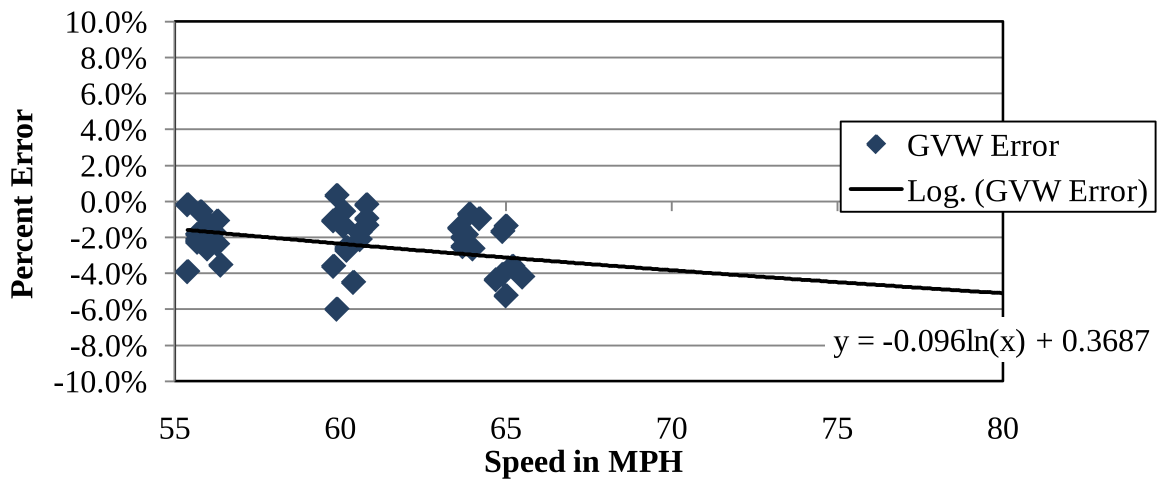


Figure 5-22 – GVW Error Trend by Speed

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

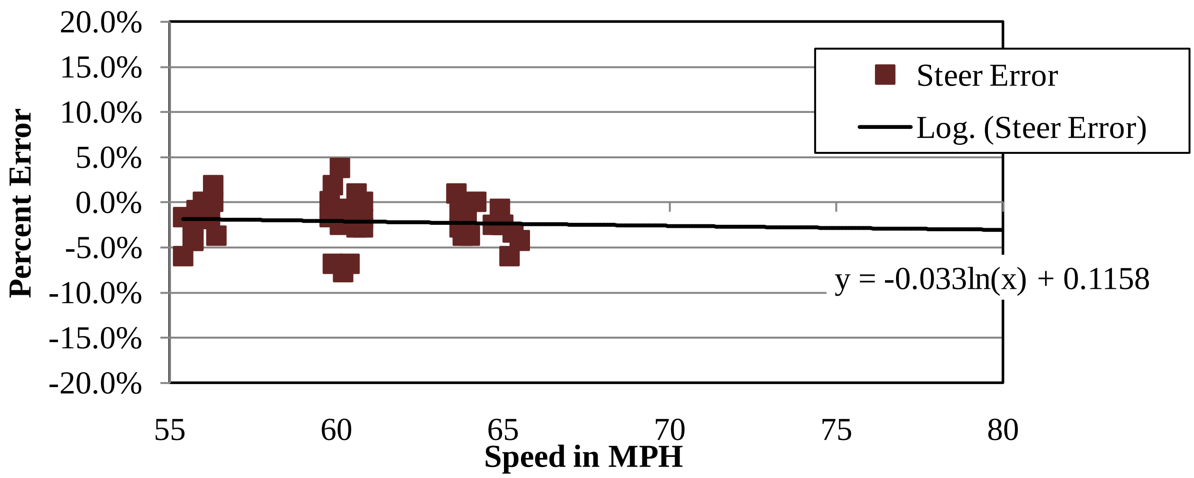


Figure 5-23 – Steering Axle Trend by Speed

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 55.4 to 65.5 mph.
- Pavement temperature. Pavement temperature ranged from 60.7 to 90.9 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 effects of temperature and truck type were found to be statistically significant. For example, the probability that the effect of temperature on the observed GVW errors occurred by chance alone was about 7 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	0.3647	3.6488	0.0999	0.9209
Speed	-0.0776	0.0564	-1.3749	0.1777
Temp	0.0363	0.0197	1.8447	0.0733
Truck	-1.4117	0.3901	-3.6191	0.0009

The relationship between temperature and 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 0.0363 (in Table 5-15). This means, for example, that for a 20 degree increase in temperature, the % error is increased by about 0.73% (0.0363 x 20). The statistical assessment of the relationship is provided by the probability value of the regression coefficient.

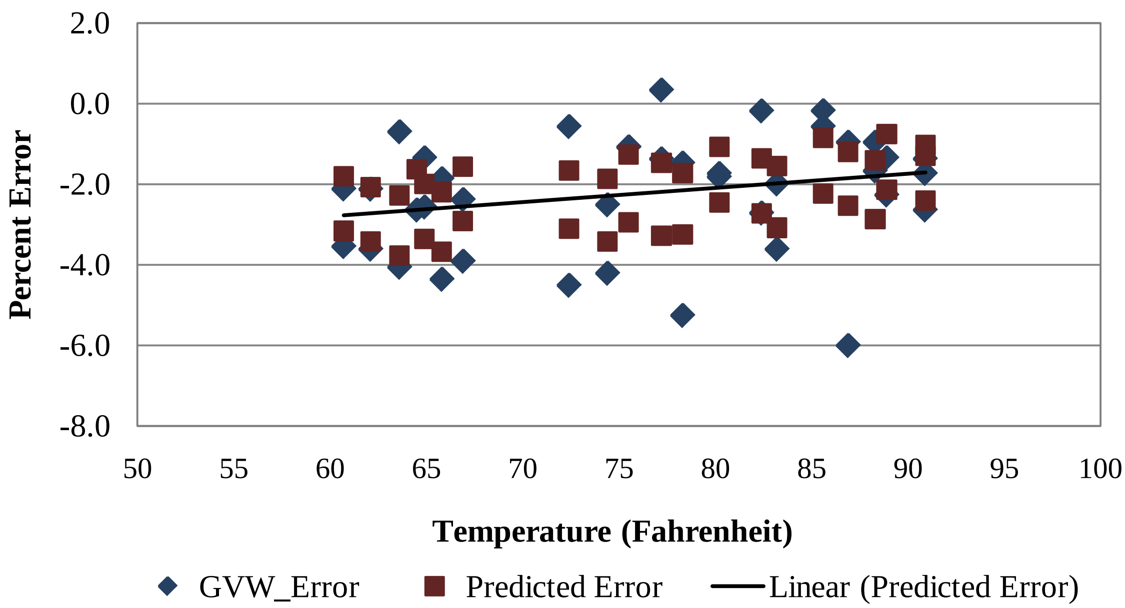


Figure 5-24 – Influence of Temperature on Measurement of GVW

The effect of speed on GVW was not statistically significant. The probability that the regression coefficient for speed (-0.0776 in Table 5-15) is not different from zero was 0.1777. In other words, there is about 18 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	-0.0776	0.1777	0.0363	0.0733	-1.4117	0.0009
Steering axle	-	-	-0.0493	0.1662	-2.6008	0.0006
Tandem axle tractor	0.2058	0.0017	0.0494	0.0247	--	-
Tandem axle trailer	-0.3954	0.0021	-	-	-2.3043	0.0082

5.3.4.4 Conclusions

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

2. Temperature had statistically significant effect on the measurement errors of GVW and tandem axles on tractors.

3. Truck type had statistically significant effect on GVW, steering axle weight, and tandem axle trailer weight 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 1.4 % lower than the error for the Primary truck.

4. Even though speed, temperature, and truck type had statistically significant effect on measurement errors of some of the weights, the practical significance of these errors 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, one Class 4 vehicle was identified as a Class 5 by the equipment and one Class 5 vehicle was identified as a Class 4. For heavy trucks, a Class 6 vehicle was identified as a Class 4 and a Class 7 truck was identified as a Class 6 by the equipment. Additionally, five Class 10s were identified as Class 13s by the equipment. There was one Class 13 vehicle that was reported as unclassified by the equipment. The combined results presented an undercount of one Class 7 and five Class 10s and an overcount of one Class 4 and four Class 13s, as shown in Table 5-17.

Table 5-17 – Post-Validation Classification Study Results – 11-May-11

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	0	2	14	5	1	1	59	13	0	0	5
WIM Count	0	3	14	5	0	1	59	8	0	0	9
Observed Percent	0%	2%	14%	5%	1%	1%	59%	13%	0%	0%	5%
WIM Percent	0%	3%	14%	5%	0%	1%	59%	8%	0%	0%	9%
Misclassified Count	0	1	1	1	1	0	0	5	0	0	0
Misclassified Percent	0%	50%	7%	20%	100%	0%	0%	38%	0%	0%	0%
Unclassified Count	0	0	0	0	0	0	0	0	0	0	1
Unclassified Percent	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	11%

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 – 11-May-11

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

As shown in the table, a total of 9 vehicles, including 7 heavy trucks (6 – 13) were misclassified by the equipment. Based on the vehicles observed during the post-validation study, the misclassification percentage is 8.3% for heavy trucks (6 – 13), which is not within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 9.0%.

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 5-19.

Table 5-19 – Post-Validation Unclassified Trucks by Pair – 11-May-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	1
6/15	0	10/15	0		

Based on the manually collected sample of the 100 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 vehicle was a Class 13 truck which could not be identified by the WIM equipment.

For speed, the mean error for WIM equipment speed measurement was 0.4 mph; the range of errors was 0.8 mph.

Based on these findings, it is recommended that an expanded investigation focusing on vehicle classification issues indicated in this report be conducted. The study shall focus on the identification of the cause for the Class 10 misclassifications and the development of recommendations to remedy these causes. This study may be conducted in conjunction with the next calibration and validation visit.

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 four 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										Percent Unclass
	4	5	6	7	8	9	10	11	12	13	
6-Dec-05	N/A	0	0	N/A	0	2	8	N/A	N/A	0	0
7-Dec-05	100	4	50	50	0	0	0	N/A	N/A	0	0
11-Jul-06	100	18	0	0	0	0	0	N/A	N/A	0	0
2-Oct-07	100	17	0	100	0	0	13	N/A	N/A	N/A	2
3-Oct-07	50	4	14	N/A	0	2	25	N/A	N/A	17	0
24-Jun-08	100	10	0	N/A	0	2	5	N/A	N/A	N/A	1
25-Jun-08	100	33	0	N/A	33	4	0	N/A	N/A	N/A	2
10-May-11	0	6	0	0	0	0	36	0	0	0	0
11-May-11	50	7	20	100	0	0	38	0	0	0	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	Steering Axles	Tandem
6-Dec-05	19.8 ± 7.6	19.6 ± 3.6	19.7 ± 9.7
7-Dec-05	-2.1 ± 3.4	-4.2 ± 4.0	-1.7 ± 4.3
11-Jul-06	-0.6 ± 1.7	0.5 ± 4.7	-1.2 ± 2.1
2-Oct-07	-10.8 ± 2.1	-7.3 ± 3.1	-11.4 ± 3.4
3-Oct-07	-0.5 ± 2.1	5.5 ± 3.5	-1.5 ± 3.1
24-Jun-08	-0.5 ± 4.3	-0.9 ± 4.3	-0.2 ± 5.3
25-Jun-08	-1.1 ± 1.9	-0.3 ± 4.4	-1.5 ± 2.7
10-May-11	-3.8 ± 1.7	-5.8 ± 2.4	-3.4 ± 2.5
11-May-11	-2.4 ± 1.9	-2.1 ± 2.5	-2.6 ± 3.0

The variability of the weight errors appears to have remained reasonably consistent 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 and 95% Confidence Interval)				
		7-Dec-05	11-Jul-06	3-Oct-07	25-Jun-08	11-May-11
Steering Axles	±20 percent	-4.2 ± 8.1	0.5 ± 9.4	5.5 ± 7.0	-0.3 ± 8.7	-2.1 ± 5.1
Tandem Axles	±15 percent	-1.7 ± 8.6	-1.2 ± 4.1	-1.5 ± 6.1	-1.5 ± 5.4	-2.5 ± 6.6
GVW	±10 percent	-2.1 ± 6.9	-0.6 ± 3.5	-0.5 ± 4.3	-1.1 ± 3.9	-2.4 ± 3.9

From Table 6-3, it appears that the mean error and the 95% confidence interval have generally decreased for all weights since the equipment was installed.

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

Table 6-4 – Final Factors

Speed Points		
SP1	55	969
SP2	60	970
SP3	65	959
Other		
Overall -		953
Front Axle -		998
Left -		901
Right -		910
Distance -		1004
Loop Width -		803

A review of the LTPP Standard Release Database 24 shows that there are 2 years of level "E" WIM data for this site. This site requires 3 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/C – Site Photograph Logs
- Updated Handout Guide

WIM System Field Calibration and Validation - Photos

Michigan, SPS-1
SHRP ID: 260100

Validation Date: May 10, 2011

Photo 1 – Cabinet Exterior

Photo 2 – Cabinet Interior (Front)

Photo 3 –Loop Sensor

Photo 4 – Leading WIM Sensor

Photo 5 – Trailing WIM Sensor

Photo 6 – Power Service Box

Photo 7 – Telephone Service Box

Photo 8 – Downstream

Photo 9 – Upstream

Photo 10 – Truck 1 Tractor

Photo 11 – Truck 1 Trailer

Photo 12 – Truck 1 Suspension 1

Photo 13 – Truck 1 Suspension 2

Photo 14 – Truck 1 Suspension 3

Photo 15 – Truck 1 Suspension 4

Photo 16 – Truck 1 Suspension 5

Photo 17 – Truck 2 Tractor

Photo 18 – Truck 2 Trailer

Photo 19 – Truck 2 Suspension 1

Photo 20 – Truck 2 Suspension 2

Photo 21 – Truck 2 Suspension 3

Photo 22 – Truck 2 Suspension 4

Photo 23 – Truck 2 Suspension 5

Traffic Sheet 16 **LTPP MONITORED TRAFFIC DATA** **SITE CALIBRATION SUMMARY**	STATE CODE: 26 SPS WIM ID: 260100 DATE (mm/dd/yyyy) 5/10/2011

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 5/10/11

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 DAW

WIM SYSTEM CALIBRATION SPECIFICS

6. CALIBRATION TECHNIQUE USED: Test Trucks

Number of Trucks Compared: ______
Number of Test Trucks Used: 2
Passes Per Truck: 21

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

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

Mean Difference Between -

Dynamic and Static GVW:	-3.8%	Standard Deviation:	1.7%
Dynamic and Static Single Axle:	-5.8%	Standard Deviation:	2.4%
Dynamic and Static Double Axles:	-3.4%	Standard Deviation:	2.5%

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

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	51.7	to	56.4	11
b.	Medium	-	56.5	to	61.1	16
c.	High	-	61.2	to	65.7	14
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 26 SPS WIM ID: 260100 DATE (mm/dd/yyyy) 5/10/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 959

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:	0.0	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: 717-975-3550

E-mail: dwolf@ara.com

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 26 SPS WIM ID: 260100 DATE (mm/dd/yyyy) 5/11/2011

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 5/11/11

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 c. ______
   b. Quartz Piezo d. ______

5. **EQUIPMENT MANUFACTURER:** IRD DAW

WIM SYSTEM CALIBRATION SPECIFICS

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

Number of Trucks Compared: ______
Number of Test Trucks Used: 2
Passes Per Truck: 21

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

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

Mean Difference Between -

Dynamic and Static GVW:	-2.4%	Standard Deviation:	1.9%
Dynamic and Static Single Axle:	-2.1%	Standard Deviation:	2.5%
Dynamic and Static Double Axles:	-2.6%	Standard Deviation:	3.0%

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

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

			Low		High	Runs
a.	Low	-	55.4	to	58.8	12
b.	Medium	-	58.9	to	62.2	14
c.	High	-	62.3	to	65.5	15
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 26 SPS WIM ID: 260100 DATE (mm/dd/yyyy) 5/11/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 959

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:	0.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 1.0%

Validation Test Truck Run Set - Post

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

Contact Information: Phone: 717-975-3550

E-mail: dwolf@ara.com

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 26 SPS WIM ID: 260100 DATE (mm/dd/yyyy) 5/10/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
56	5	7563	54	5	59	9	8072	59	9
62	5	7589	61	5	53	10	8087	53	10
61	10	7612	61	10	60	9	8098	60	9
53	10	7665	53	10	61	6	8100	60	6
53	9	7667	55	9	59	9	8156	59	9
79	9	7670	78	9	**60**	**13**	**8170**	**62**	**10**
62	9	7727	62	9	61	9	8175	60	9
62	**15**	**7744**	**62**	**9**	60	5	8204	59	5
62	9	7760	62	9	59	9	8239	58	9
58	9	7776	58	9	**59**	**13**	**8202**	**59**	**10**
63	10	7776	63	10	**58**	**13**	**8203**	**58**	**10**
54	8	7814	53	8	63	9	8283	62	9
58	8	7816	57	8	58	9	8289	58	9
59	9	7843	58	9	58	9	8314	57	9
61	5	7853	61	5	55	9	8341	53	9
61	8	7864	59	8	56	8	8404	56	8
57	9	7874	56	9	55	10	8442	53	10
54	5	7879	53	5	**56**	**13**	**8453**	**55**	**10**
57	10	7899	57	10	**59**	**15**	**8459**	**56**	**5**
60	9	7902	58	9	55	9	8477	55	9
69	5	7954	67	5	59	13	8562	59	13
53	9	7967	53	9	58	9	8607	57	9
59	**13**	**8000**	**59**	**10**	60	10	8623	59	10
57	5	8045	54	5	60	9	8629	59	9
61	5	8063	61	5	60	9	8632	60	9

Sheet 1 - 0 to 50 Start: 13:55:27 Stop: 14:58:04

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: 26 SPS WIM ID: 260100 DATE (mm/dd/yyyy) 5/10/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
61	9	8644	60	9	65	9	9192	63	9
56	9	8682	56	9	61	9	9230	59	9
58	9	8704	57	9	60	9	9247	58	9
62	5	8716	60	5	58	9	9261	58	9
60	9	8791	59	9	63	9	9263	62	9
60	13	8815	58	13	64	9	9289	63	9
59	9	8840	58	9	62	9	9291	61	9
56	9	8842	54	9	66	5	9322	66	5
59	5	8854	58	5	65	9	9348	63	9
58	9	8855	58	9	63	9	9353	63	9
57	8	8879	56	8	63	9	9363	62	9
60	10	8882	59	10	65	9	9423	63	9
57	9	8890	58	9	59	9	9448	57	9
57	9	8919	58	9	62	9	9452	60	9
59	5	8953	58	5	58	9	9456	58	9
59	5	8976	58	5	58	5	9475	59	5
57	5	8985	55	5	56	8	9489	55	8
55	9	9016	54	9	56	9	9491	56	9
57	6	9042	56	6	62	9	9497	61	9
60	9	9066	59	9	63	9	9498	63	9
59	9	9068	58	9	60	9	9516	60	9
56	9	9072	57	9	55	12	9530	54	12
70	8	9101	69	8	62	9	9534	61	9
52	9	9145	51	9	57	10	9581	55	10
68	**9**	**9150**	**66**	**5**	55	6	9612	56	6

Sheet 2 - 51 to 100 Start: 14:59:00 Stop: 15:53:54

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20	STATE CODE: 26
LTPP MONITORED TRAFFIC DATA	SPS WIM ID: 260100
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy) 5/11/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
62	9	6427	60	9	57	9	6960	57	9
61	9	6438	60	9	52	9	6967	52	9
62	5	6445	61	5	59	9	6995	58	9
60	9	6463	59	9	64	9	6996	64	9
61	9	6488	61	9	61	9	7018	61	9
62	13	6495	62	13	58	6	7020	58	6
60	6	6510	58	6	59	5	7023	59	5
59	9	6528	58	9	57	10	7030	57	10
59	10	6531	58	10	57	9	7033	57	9
59	5	6582	59	5	62	10	7042	62	10
57	13	6698	57	13	61	9	7044	60	9
63	9	6722	63	9	62	9	7045	61	9
61	9	6723	61	9	57	6	7065	57	6
61	9	6733	61	9	69	4	7068	69	4
57	9	6760	58	9	61	9	7073	61	9
56	**4**	**6766**	**56**	**6**	62	9	7095	62	9
58	9	6819	58	9	61	9	7012	60	9
62	9	6830	61	9	53	13	7147	53	13
58	5	6840	58	5	62	9	7193	60	9
58	**5**	**6842**	**58**	**4**	65	9	7196	63	9
64	9	6873	63	9	59	9	7198	59	9
60	9	6879	61	9	**57**	**6**	**7202**	**56**	**7**
62	9	6913	62	9	60	13	7206	60	13
58	**13**	**6914**	**58**	**10**	66	5	7221	63	5
57	**13**	**6918**	**57**	**10**	58	9	7239	57	9

Sheet 1 - 0 to 50 Start: 12:17:39 Stop: 13:11:22

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: 26 SPS WIM ID: 260100 DATE (mm/dd/yyyy) 5/11/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
57	10	7247	57	10	62	5	7772	60	5
61	**4**	**7285**	**60**	**5**	45	5	7776	44	5
64	**13**	**7287**	**64**	**10**	58	9	7785	56	9
65	5	7295	64	5	54	9	7792	53	9
55	9	7301	56	9	59	9	7809	58	9
70	5	7314	70	5	57	8	7831	55	8
58	5	7337	57	5	61	9	7836	60	9
62	9	7381	61	9	66	9	7838	66	9
64	9	7445	62	9	**64**	**13**	**7847**	**64**	**10**
59	9	7495	58	9	61	9	7861	62	9
61	9	7496	60	9	60	9	7903	61	9
59	9	7505	58	9	59	9	7906	60	9
60	10	7519	61	10	62	10	7909	61	10
59	**13**	**7520**	**58**	**10**	**57**	**15**	**7915**	**57**	**13**
70	5	7547	68	5	58	6	7938	58	6
60	9	7573	60	9	61	9	7944	61	9
61	9	7586	60	9	59	9	7946	58	9
53	10	7595	54	10	57	9	7948	57	9
69	5	7627	69	5	61	9	7964	61	9
61	10	7629	60	10	62	9	7978	62	9
61	9	7648	61	9	62	9	8006	63	9
61	9	7664	60	9	61	9	8012	61	9
62	9	7722	62	9	64	5	8013	63	5
60	9	7758	60	9	65	9	8037	64	9
56	9	7761	56	9	55	9	8040	55	9

Sheet 2 - 51 to 100 Start: 13:12:08 Stop: 14:00:29

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Post