WIM System Field Calibration and Validation Summary Report

Colorado SPS-2
SHRP ID – 080200

Validation Date: March 17, 2011
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1 Executive Summary

A WIM validation was performed on March 16 and 17, 2011 at the Colorado SPS-2 site located on route I-76 at milepost 39.7, 0.75 miles east of the Market Street interchange.

This site was installed on April 27, 2006. The in-road sensors are installed in the eastbound 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 April 30, 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.

Table 1-1 – Post-Validation Results – 17-Mar-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-1.1 ± 5.7%	Pass
Tandem Axles	±15 percent	0.1 ± 4.6%	Pass
GVW	±10 percent	0.0 ± 3.0%	Pass
Vehicle Length	±3.0 percent (1.7 ft)	0.4 ± 1.1 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 0.6 ± 2.6 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 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.

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 stone.

- 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 on the trailer. The Secondary truck was loaded with stone.

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	77.1	10.3	16.6	16.6	16.8	16.8	18.0	4.3	25.2	4.0	51.5	56.0
2	67.3	9.7	14.0	14.0	14.8	14.8	17.8	4.3	25.0	3.9	51.0	56.3

The posted speed limit at the site is 75 mph. During the testing, the speed of the test trucks ranged from to 62 to 74 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 35.0 to 78.9 degrees Fahrenheit, a range of 43.9 degrees Fahrenheit. The sunny 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 2 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 October 11, 2010 (Data) to the most recent Comparison Data Set (CDS) from May 05, 2008. The assessments performed prior to the site visits are used to develop reasonable expectations for the validation. The results of further investigations performed as a result of the analyses are provided in Section 5 of this report.

2.1 LTPP WIM Data Availability

A review of the LTPP Standard Release Database 24 shows that there are 3 years of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2006 to 2009.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2006	191	7
2007	347	12
2008	361	12
2009	242	8

As shown in the table, this site requires 2 additional years of data to meet the minimum of five years of research quality data. The 2006 data does not meet the 210-day minimum requirement for a calendar year.

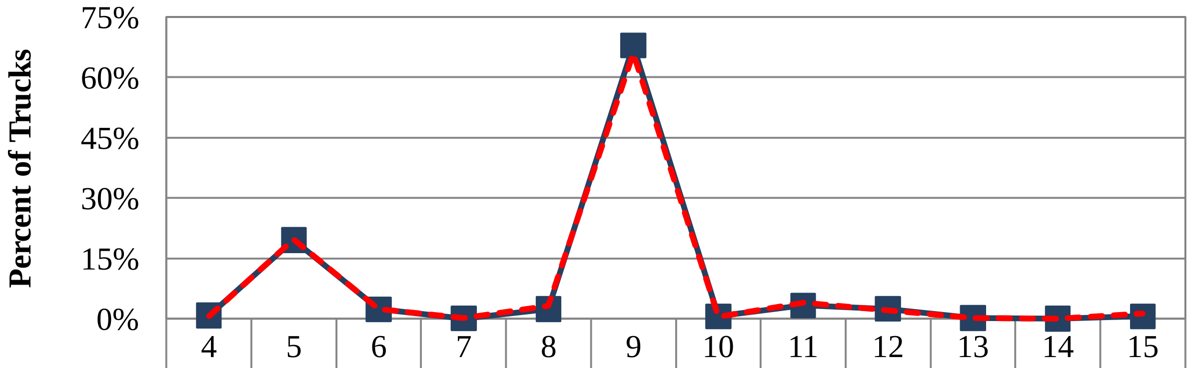
Table 2-2 provides a monthly breakdown of the available data for years 2006 through 2009.

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	30	30	10		29	30	31	7
2007	31	28	31	30	31	30	31	31	30	29	30	15	12
2008	31	29	27	30	31	30	31	30	30	31	30	31	12
2009	31	28	31	30	31	30	31	30					8

2.2 Classification Data Analysis

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



	4	5	6	7	8	9	10	11	12	13	14	15
Data	0.8%	19.5%	2.3%	0.1%	2.4%	67.9%	0.6%	3.3%	2.4%	0.2%	0.0%	0.6%
CDS	0.6%	19.8%	2.4%	0.2%	3.2%	65.9%	0.5%	3.9%	2.1%	0.1%	0.0%	1.3%

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 (67.9%) and Class 5 (19.5%). 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 0.6 percent of the vehicles at this site are unclassified.

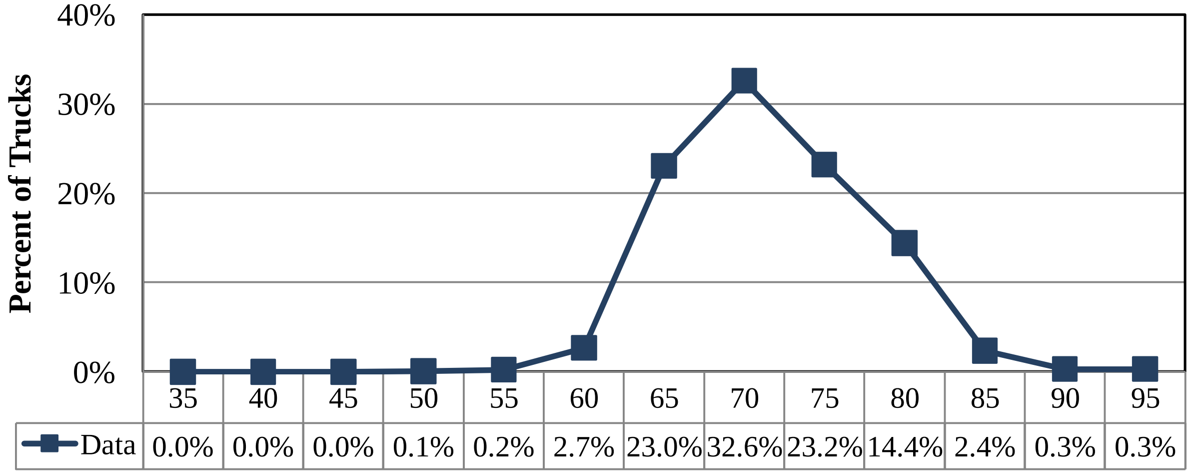
Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	5/5/2008		10/11/2010		
4	107	0.6%	135	0.8%	0.2%
5	3449	19.8%	3417	19.5%	-0.2%
6	412	2.4%	405	2.3%	0.0%
7	27	0.2%	9	0.1%	-0.1%
8	566	3.2%	419	2.4%	-0.8%
9	11499	65.9%	11874	67.9%	2.0%
10	83	0.5%	98	0.6%	0.1%
11	689	3.9%	572	3.3%	-0.7%
12	362	2.1%	427	2.4%	0.4%
13	25	0.1%	27	0.2%	0.0%
14	0	0.0%	0	0.0%	0.0%
15	227	1.3%	97	0.6%	-0.7%

From the table it can be seen that the number of Class 9 vehicles has increased by 2.0 percent from May 2008 and October 2010. Changes in the number of heavier trucks may be attributed to seasonal variations in truck distributions. During the same time period, the number of Class 5 trucks decreased by 0.2 percent. These differences may be attributed to natural variations in truck volumes.

2.3 Speed Data Analysis

The traffic data received from the Phase II Contractor was analyzed to determine the expected truck speed distributions. This will provide a basis for 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%	0.0%	0.1%	0.2%	2.7%	23.0%	32.6%	23.2%	14.4%	2.4%	0.3%	0.3%

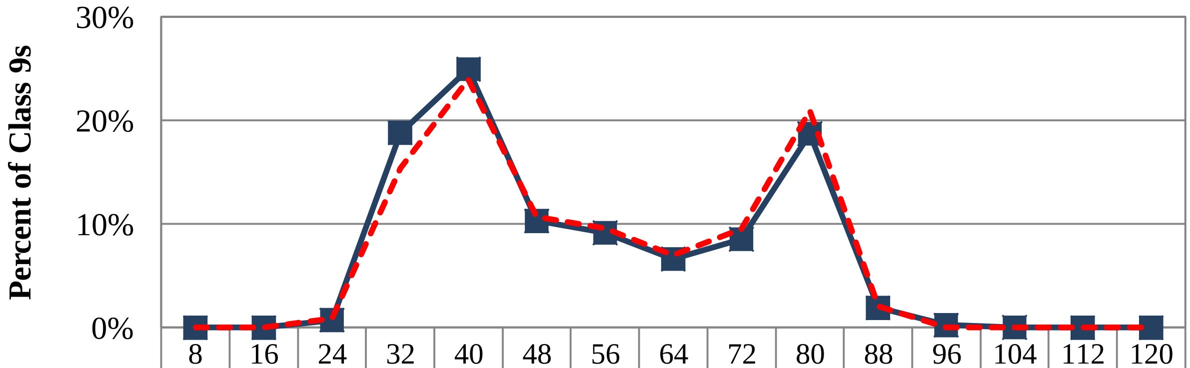
Figure 2-2 – Truck Speed Distribution – 11-Feb-11

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 75 mph and the 85th percentile speed for trucks at this site is 76 mph. The range of truck speeds for the validation will be 65 to 75 mph.

2.4 GVW Data Analysis

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

As shown in Figure 2-3, there is a small decrease in the percentage of loaded trucks and an increase in unloaded trucks between the May 2008 Comparison Data Set (CDS) and the October 2010 two-week sample W-card dataset (Data).



	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
Data	0.0%	0.0%	0.7%	18.8	24.9	10.3	9.1%	6.6%	8.6%	18.7	1.9%	0.2%	0.0%	0.0%	0.0%
CDS	0.0%	0.0%	0.9%	15.4	23.9	10.7	9.6%	7.0%	9.5%	20.9	2.0%	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

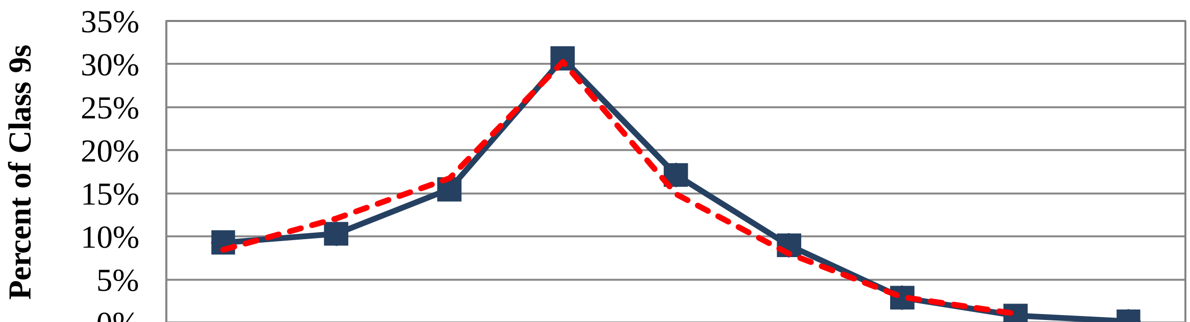
GVW weight bins (kips)	CDS		Data		Change
	Date				
	5/5/2008		10/11/2010		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	103	0.9%	86	0.7%	-0.2%
32	1755	15.4%	2226	18.8%	3.4%
40	2734	23.9%	2953	24.9%	1.0%
48	1220	10.7%	1219	10.3%	-0.4%
56	1095	9.6%	1082	9.1%	-0.4%
64	799	7.0%	783	6.6%	-0.4%
72	1089	9.5%	1012	8.6%	-1.0%
80	2389	20.9%	2216	18.7%	-2.2%
88	234	2.0%	226	1.9%	-0.1%
96	6	0.1%	29	0.2%	0.2%
104	0	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 =	50.9 kips		49.3 kips		-1.6 kips

As shown in the table, the number of unloaded class 9 trucks in the 32 to 40 kips range increased by 1.0 percent while the number of loaded class 9 trucks in the 72 to 80 kips range decreased by 2.2 percent. The number of overweight trucks increased during this time period by 0.1 percent. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site decreased by 1.6 kips, or 3.1 percent, from 50.9 to 49.3 kips.

2.5 Class 9 Front Axle Weight Data Analysis

The CDS data received from the Regional Support Contractor was analyzed to determine the expected average front axle weight. This will provide a basis for the evaluation of the quality of the data by comparing the average front axle weight from the 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 October 2010 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	9.3%	10.3%	15.5%	30.7%	17.1%	9.0%	2.9%	0.8%	0.2%
CDS	8.5%	12.1%	16.8%	30.3%	14.9%	8.0%	3.0%	1.0%	

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 increased between the May 2008 Comparison Data Set (CDS) and the October 2010 dataset (Data).

Table 2-5 provides the Class 9 front axle weight distribution data for the May 2008 Comparison Data Set (CDS) and the October 2010 dataset (Data).

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

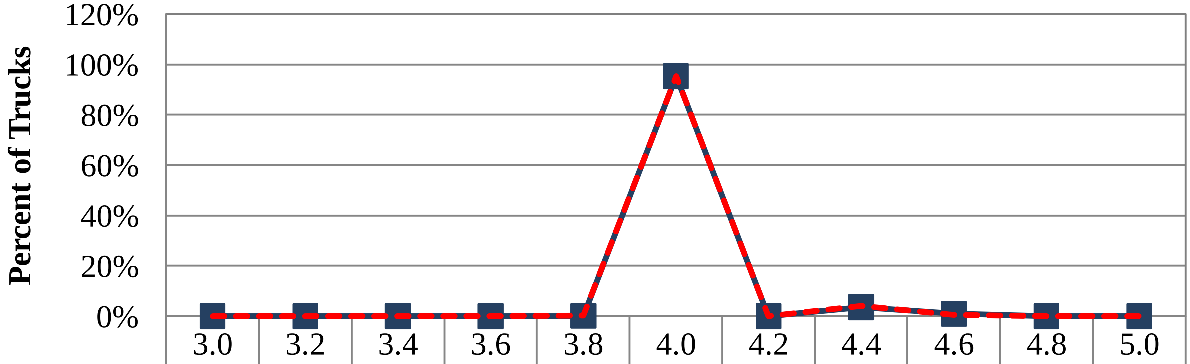
F/A weight bins (kips)	CDS		Data		Change
	Date				
	5/5/2008		10/11/2010		
9.0	611	5.4%	509	4.3%	-1.1%
9.5	967	8.5%	1099	9.3%	0.8%
10.0	1380	12.1%	1216	10.3%	-1.8%
10.5	1911	16.8%	1829	15.5%	-1.3%
11.0	3452	30.3%	3622	30.7%	0.4%
11.5	1699	14.9%	2024	17.1%	2.2%
12.0	916	8.0%	1062	9.0%	1.0%
12.5	340	3.0%	343	2.9%	-0.1%
13.0	115	1.0%	93	0.8%	-0.2%
13.5	12	0.1%	19	0.2%	0.1%
Average =	10.5 kips		10.6 kips		0.1 kips

The table shows that the average front axle weight for Class 9 trucks has increased by 0.1 kips, or 1.0 percent. According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 10.6 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%	95.4%	0.0%	3.6%	0.9%	0.0%	0.0%
CDS	0.0%	0.0%	0.1%	0.0%	0.1%	95.2%	0.0%	4.1%	0.4%	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 October 2010 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				
	5/5/2008		10/11/2010		
3.0	0	0.0%	0	0.0%	0.0%
3.2	3	0.0%	1	0.0%	0.0%
3.4	8	0.1%	1	0.0%	-0.1%
3.6	0	0.0%	0	0.0%	0.0%
3.8	14	0.1%	12	0.1%	0.0%
4.0	10881	95.2%	11292	95.4%	0.2%
4.2	0	0.0%	0	0.0%	0.0%
4.4	467	4.1%	421	3.6%	-0.5%
4.6	50	0.4%	107	0.9%	0.5%
4.8	0	0.0%	0	0.0%	0.0%
5.0	1	0.0%	2	0.0%	0.0%
Average =	4.0 feet		4.0 feet		0.0 feet

From the table it can be seen that the majority of drive tandem spacings for 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, which is identical to the expected average of 4.0 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 (October 2010). Comparison of vehicle class distribution data indicates a 2.0 percent increase in the number of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have increased by 1.0 percent and average Class 9 GVW has decreased by 3.1 percent for the October 2010 data. The data indicates an average truck tandem spacing of 4.0 feet, which is identical 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 April 30, 2008 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

3.1 Description

This site was installed on April 27, 2006 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 October 15, 2010 by the Western Regional Support Contractor using a high-speed profiler, where the operator measures the pavement profile over the entire one-thousand foot long WIM Section, 900 feet prior to WIM scales and 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, 10 profile passes were made, 4 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 195 in/mi and is located approximately 450 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 140 in/mi and is located approximately 400 feet prior to the WIM scale. This area of pavement was closely investigated during the validation visit, and truck dynamics in this area were closely observed. There were no distresses observed that would influence truck dynamics in the WIM scale area.

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

4.3 LTPP Pavement Profile Data Analysis

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

Table 4-1 – Recommended WIM Smoothness Index Thresholds

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

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

The profile analysis was based on four different indices: Long Range Index (LRI), which represents the pavement roughness starting 25.8 m prior to the scale and ending 3.2 m after the scale in the direction of travel; Short Range Index (SRI), which represents the pavement roughness beginning 2.74 m prior to the WIM scale and ending 0.46 m after the scale; Peak LRI – the highest value of LRI within 30 m prior to the scale; and Peak SRI – the highest value of SRI between 2.45 m prior to the scale and 1.5 m after the scale. The results from the analysis for each of the indices for the right wheel path (RWP) and left wheel path (LWP) values for the 3 left, 3 right and 4 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**	**Pass5**	**Avg**
Left	LWP	LRI (m/km)	0.885	1.079	0.967			0.977
		SRI (m/km)	0.999	1.515	1.114			1.209
		Peak LRI (m/km)	1.106	1.112	1.306			1.175
		Peak SRI (m/km)	**1.008**	**1.809**	**1.205**			**1.341**
	RWP	LRI (m/km)	0.657	0.571	0.695			0.641
		SRI (m/km)	0.801	0.737	0.748			0.762
		Peak LRI (m/km)	0.805	0.757	0.854			0.805
		Peak SRI (m/km)	0.880	0.763	0.776			0.806
Center	LWP	LRI (m/km)	0.667	0.654	0.608	0.681		0.653
		SRI (m/km)	0.820	0.888	0.671	1.076		0.864
		Peak LRI (m/km)	0.855	0.936	0.917	0.837		0.886
		Peak SRI (m/km)	0.921	0.982	*0.729*	1.168		0.950
	RWP	LRI (m/km)	0.689	0.929	0.684	0.744		0.762
		SRI (m/km)	1.214	1.395	0.720	0.861		1.048
		Peak LRI (m/km)	0.699	0.935	0.827	0.903		0.841
		Peak SRI (m/km)	1.391	1.664	0.939	0.967		1.240
Right	LWP	LRI (m/km)	0.589	0.670	0.591			0.617
		SRI (m/km)	0.710	0.671	0.653			0.678
		Peak LRI (m/km)	0.705	0.813	0.757			0.758
		Peak SRI (m/km)	0.813	0.751	0.774			0.779
	RWP	LRI (m/km)	0.602	0.546	0.588			0.579
		SRI (m/km)	0.885	0.868	0.826			0.860
		Peak LRI (m/km)	0.737	0.673	0.677			0.696
		Peak SRI (m/km)	1.135	0.934	0.901			0.990

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 for the left shift passes (shown in bold).

4.4 Recommended Pavement Remediation

No pavement remediation is recommended.

5 Statistical Reliability of the WIM Equipment

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

5.1 Pre-Validation

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

The 40 pre-validation test truck runs were conducted on March 16, 2011, beginning at approximately 7:21 AM and continuing until 4:09 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with stone, 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 stone, 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	77.1	10.3	16.6	16.6	16.8	16.8	18.0	4.3	25.2	4.0	51.5	56.0
2	67.3	9.7	14.0	14.0	14.8	14.8	17.8	4.3	25.0	3.9	51.0	56.3

Test truck speeds varied by 12 mph, from 62 to 74 mph. The measured pre-validation pavement temperatures varied 41.7 degrees Fahrenheit, from 32.6 to 74.3. The sunny weather conditions provided the desired 30 degree temperature range. Table 5-2 provides a summary of the pre-validation results.

Table 5-2 – Pre-Validation Overall Results – 16-Mar-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-7.1 ± 5.5%	Pass
Tandem Axles	±15 percent	-2.4 ± 4.6%	Pass
GVW	±10 percent	-3.0 ± 2.9%	Pass
Vehicle Length	±3.0 percent (1.7 ft)	2.4 ± 1.1 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 -0.7 ± 2.5 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 75 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 – 16-Mar-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		62.0 to 66.0 mph	66.1 to 70.1 mph	70.2 to 74.0 mph
Steering Axles	±20 percent	-4.3 ± 7.3%	-7.5 ± 3.7%	-9.0 ± 3.4%
Tandem Axles	±15 percent	-3.4 ± 4.8%	-1.5 ± 3.7%	-3.0 ± 4.4%
GVW	±10 percent	-3.4 ± 4.0%	-2.3 ± 2.3%	-3.8 ± 2.6%
Vehicle Length	±3.0 percent (1.7 ft)	2.4 ± 1.4 ft	2.5 ± 1.0 ft	2.2 ± 1.2 ft
Vehicle Speed	± 1.0 mph	-0.8 ± 1.8 mph	-0.9 ± 2.9 mph	-0.3 ± 2.8 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, on average, the WIM equipment underestimates all weights at all speeds. For steering axles, the error increases and the range in error decreases as speed increased. For GVW and tandem axle weights, the error and range of errors is reasonably consistent at all speeds. There does appear to be a relationship between steering axle 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 underestimated GVW 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.

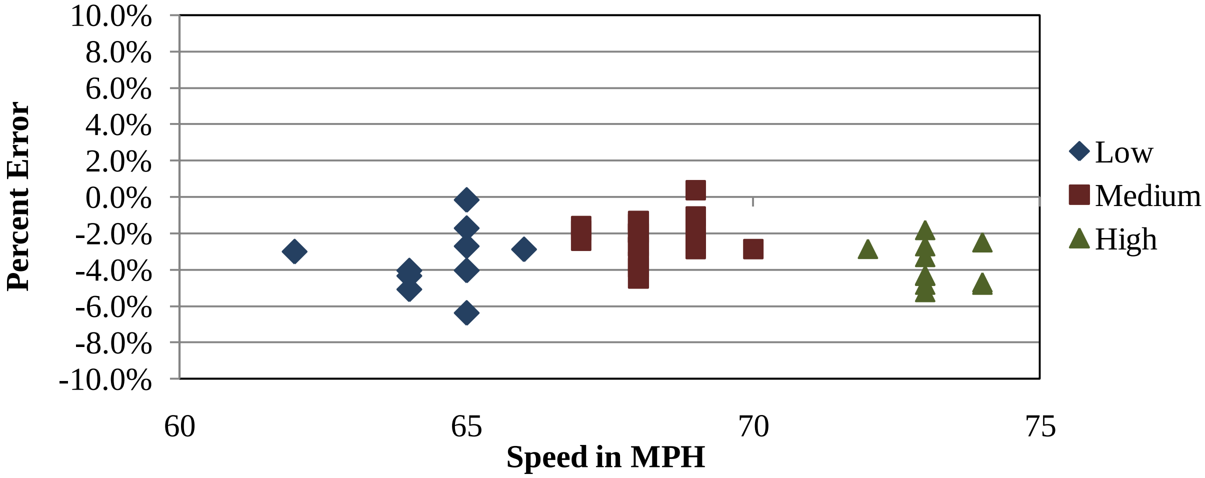


Figure 5-1 – Pre-Validation GVW Error by Speed – 16-Mar-11

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment increasingly underestimated steering axle weights as speed increased. The range of error is reasonably consistent throughout the range in speeds.

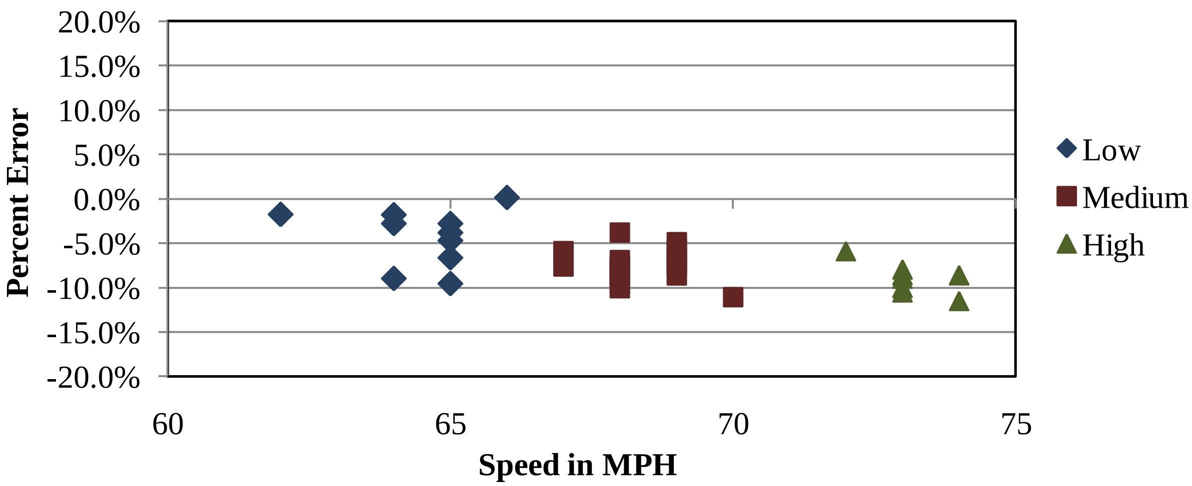


Figure 5-2 – Pre-Validation Steering Axle Weight Errors by Speed – 16-Mar-11

5.1.1.3 Tandem Axle Weight Errors by Speed

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

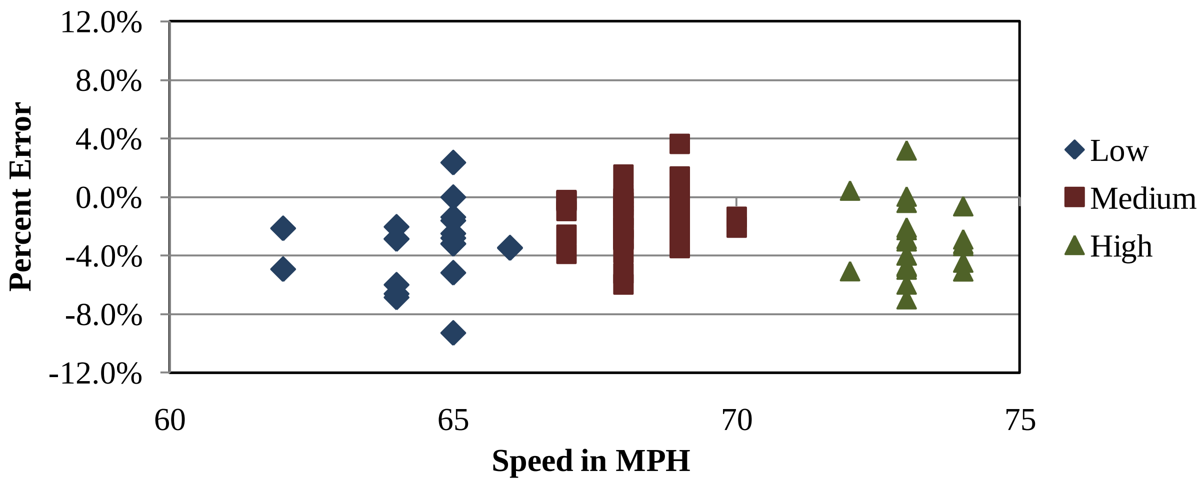


Figure 5-3 – Pre-Validation Tandem Axle Weight Errors by Speed – 16-Mar-11

5.1.1.4 GVW Errors by Speed and Truck Type

As shown graphically in Figure 5-4, when the GVW error for each truck is analyzed as a function of speed, it can be seen that the WIM equipment underestimates GVW for both the partially loaded (Secondary) truck and the heavily loaded (Primary) truck with similar error and range of errors.

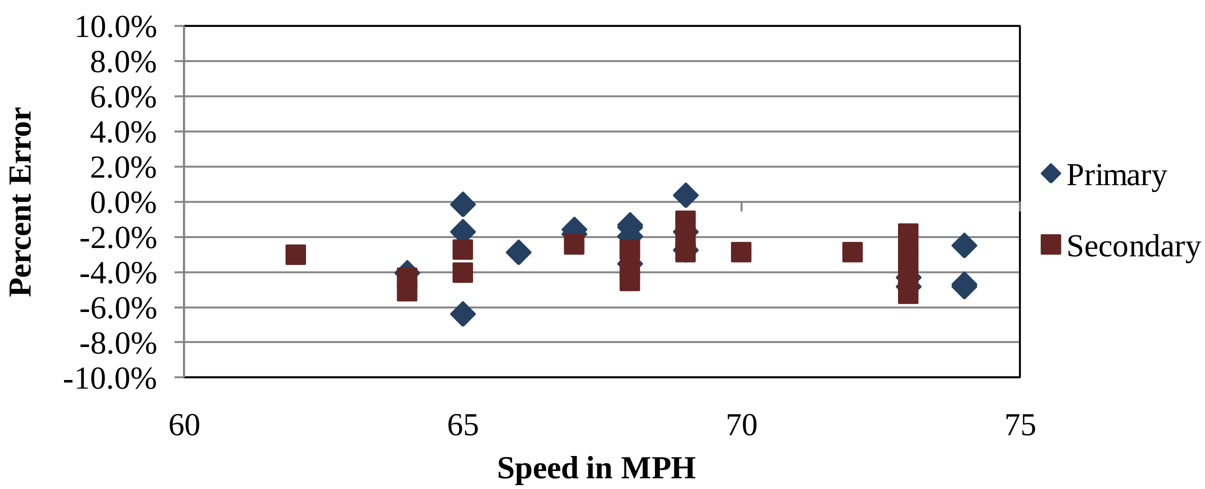


Figure 5-4 – Pre-Validation GVW Errors by Truck and Speed – 16-Mar-11

5.1.1.5 Axle Length Errors by Speed

For this site, the error in axle length measurement was consistent at all speeds. Measurement error ranged from -0.1 feet to 0.0 feet. Distribution of errors is shown graphically in Figure 5-5.

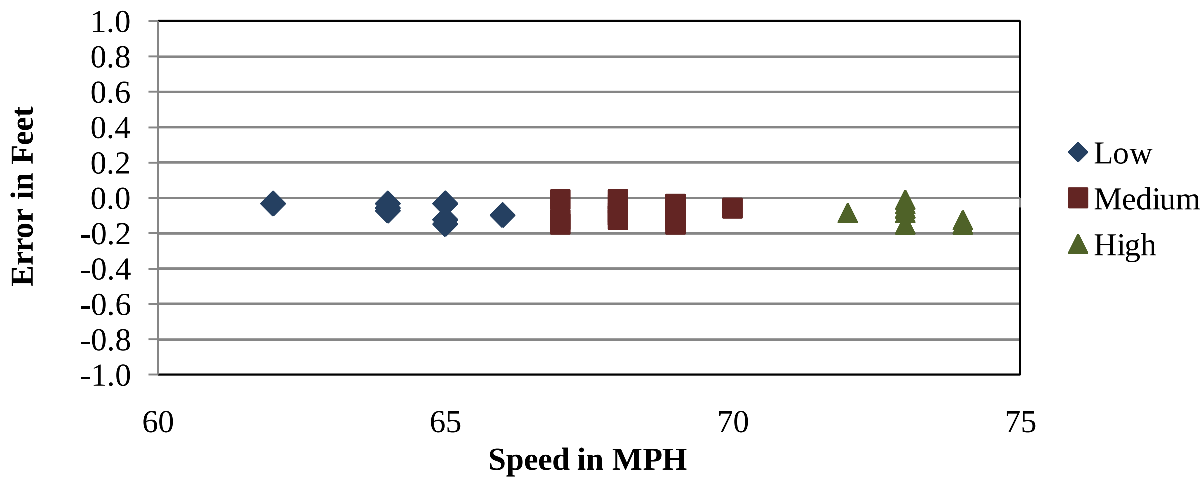


Figure 5-5 – Pre-Validation Axle Length Errors by Speed – 16-Mar-11

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 1.8 to 3.0 feet. Distribution of errors is shown graphically in Figure 5-6.

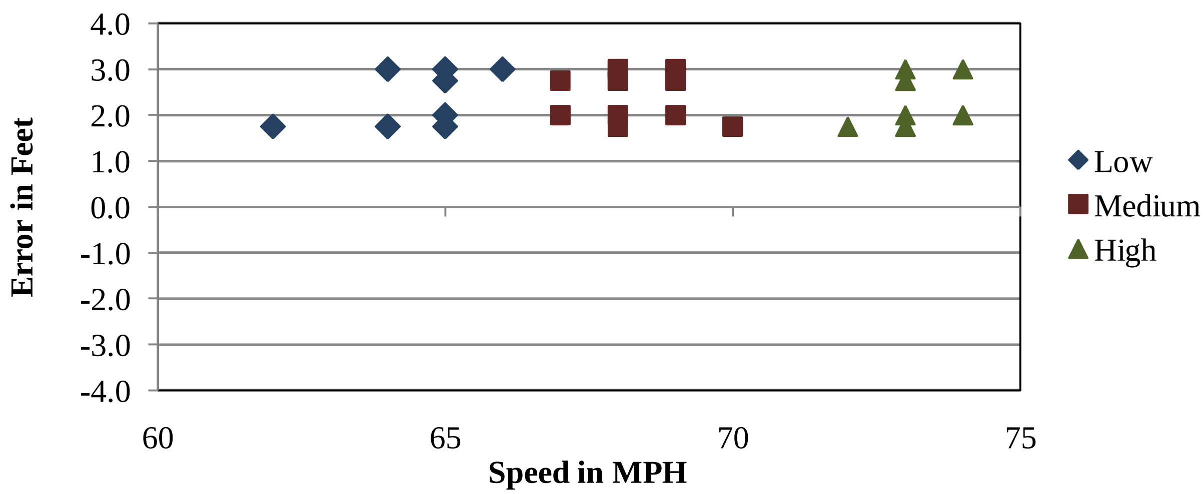


Figure 5-6 – Pre-Validation Overall Length Error by Speed – 16-Mar-11

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 41.7 degrees, from 32.6 to 74.3 degrees Fahrenheit. The pre-validation test runs are being reported under three temperature groups – low, medium and high temperature, as shown in Table 5-4.

Table 5-4 – Pre-Validation Results by Temperature – 16-Mar-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		32.6 to 46.5 degF	46.6 to 60.5 degF	60.6 to 74.3 degF
Steering Axles	±20 percent	-5.5 ± 7.8%	-6.5 ± 4.9%	-8.7 ± 3.9%
Tandem Axles	±15 percent	-3.0 ± 4.6%	-2.3 ± 4.9%	-2.2 ± 5.0%
GVW	±10 percent	-3.2 ± 2.3%	-2.7 ± 3.3%	-3.0 ± 3.5%
Vehicle Length	±3.0 percent (1.7 ft)	2.6 ± 1.2 ft	2.4 ± 1.1 ft	2.3 ± 1.2 ft
Vehicle Speed	± 1.0 mph	-0.9 ± 3.1 mph	-0.2 ± 3.2 mph	-1.0 ± 1.6 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, and axle group weights.

5.1.2.1 GVW Errors by Temperature

From Figure 5-7, it can be seen that the equipment underestimated GVW across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and GVW estimates at this site.

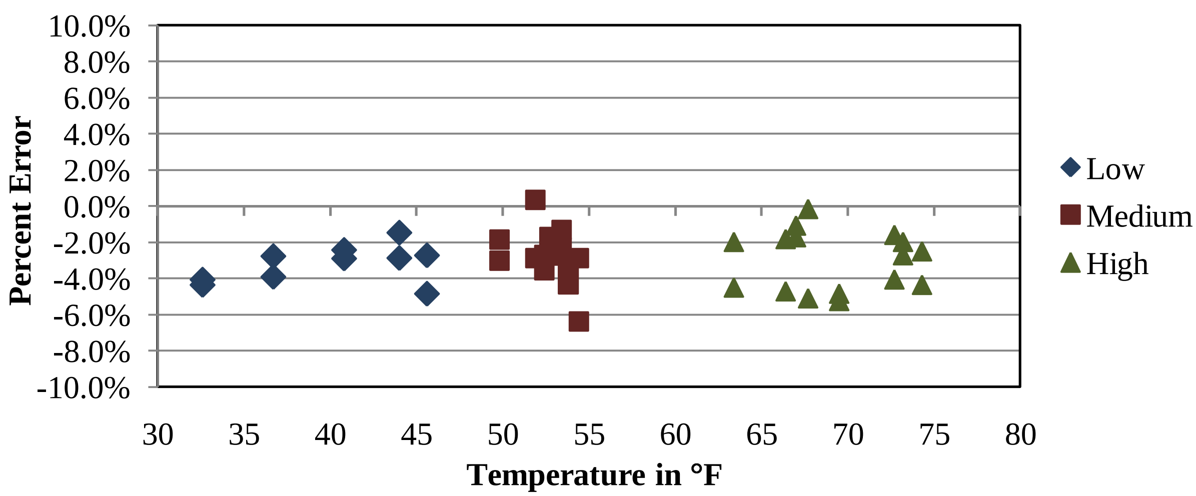


Figure 5-7 – Pre-Validation GVW Errors by Temperature – 16-Mar-11

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 illustrates that the WIM equipment underestimated steering axle weights across the range of temperatures observed in the field. The range in error is similar for the three temperature groups.

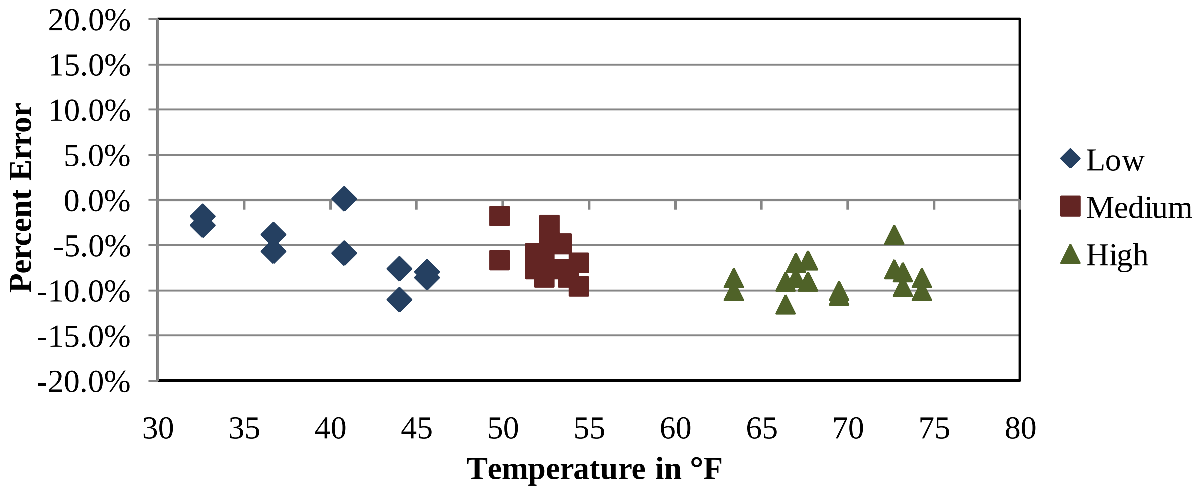


Figure 5-8 – Pre-Validation Steering Axle Weight Errors by Temperature – 16-Mar-11

5.1.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-9, the WIM equipment generally underestimated tandem axle weights across the range of temperatures observed in the field. The range in tandem axle errors is consistent for the three temperature groups.

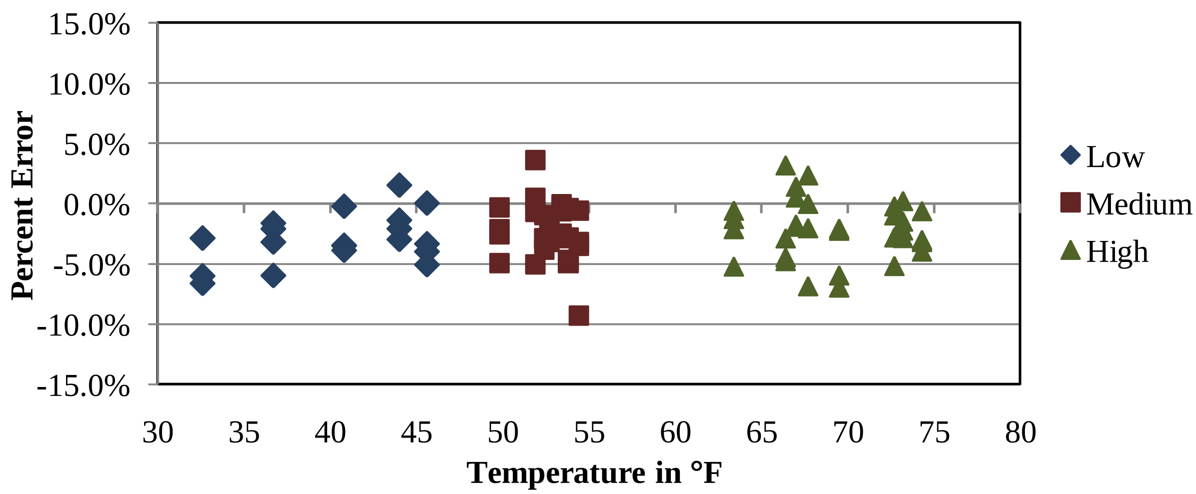


Figure 5-9 – Pre-Validation Tandem Axle Weight Errors by Temperature – 16-Mar-11

5.1.2.4 GVW Errors by Temperature and Truck Type

As shown graphically in Figure 5-10, when analyzed for each test truck, it can be seen that the WIM equipment underestimated GVW for the both trucks with similar bias. The range of errors appears to be greater for the heavily loaded (Primary) Primary truck than the partially loaded (Secondary) truck at the lower temperatures.

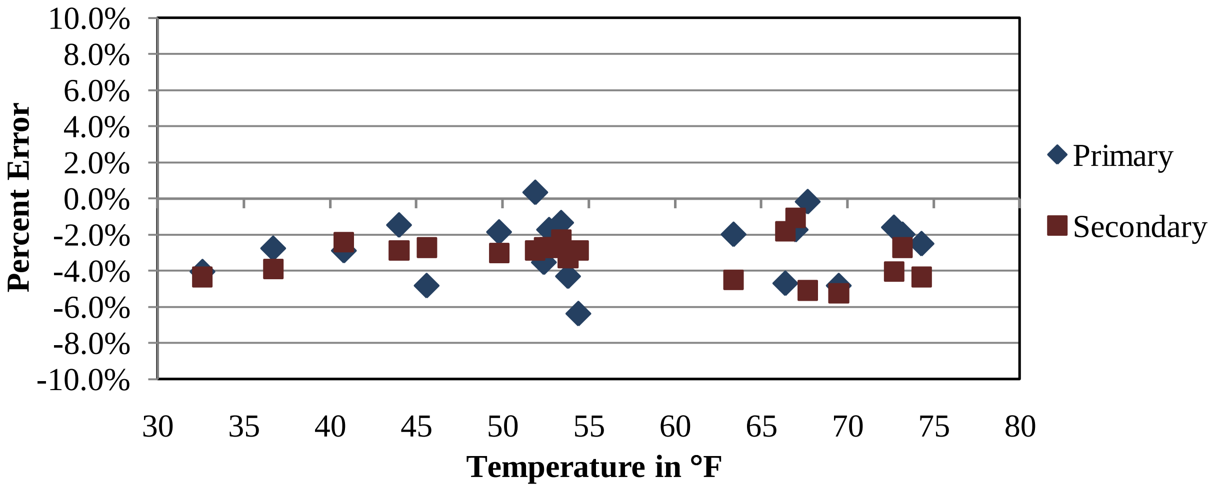


Figure 5-10 – Pre-Validation GVW Error by Truck and Temperature – 16-Mar-11

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 104 vehicles including 102 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 type of vehicle. As shown in Table 5-6, two Class 5 vehicles were identified as Class 4 vehicles by the equipment. Additionally, two passenger cars were identified as Class 5 vehicles (not shown in the table). The combined results of the misclassifications resulted in an over-count of two Class 4 vehicles. The cause of the misclassifications was not investigated in the field. There were no unclassified vehicles reported by the equipment.

Table 5-5 – Pre-Validation Classification Study Results – 16-Mar-11

Class	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Observed Count	0	15	6	0	1	77	1	0	2	0
WIM Count	2	15	6	0	1	77	1	0	2	0
Observed Percent	0.0	14.4	5.8	0.0	1.0	74.0	1.0	0.0	1.9	0.0
WIM Percent	1.9	14.4	5.8	0.0	1.0	74.0	1.0	0.0	1.9	0.0
Misclassified Count	0	4	0	0	0	0	0	0	0	0
Misclassified Percent	0.0	26.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unclassified Count	0	0	0	0	0	0	0	0	0	0
Unclassified Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The misclassified percentage in Table 5-5 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 – 16-Mar-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
5/2	2	6/9	0	10/9	0
5/4	2	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	0	8/5	0	13/10	0
5/9	0	8/9	0		

Based on the vehicles observed during the pre-validation study, the misclassification percentage is 0.0% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 3.8%.

As shown in the table, a total of 4 vehicles, including 0 heavy trucks (6 – 13) were misclassified by the equipment. The misclassifications were four Class 5 trucks – two identified as Class 2 and two identified as Class 4 by the WIM equipment.

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 – 16-Mar-11

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

Based on the manually collected sample of the 102 trucks, 0.0% 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 0.1 mph; the range of errors was 1.4 mph.

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 – 17-Mar-11

Speed Point	MPH	Left	Right
		1	2
88	55	3466	3502
96	60	3482	3517
104	65	3447	3480
112	70	3446	3480
120	75	3386	3419
Axle Distance (cm)		370	
Dynamic Comp (%)		100	
Loop Width (cm)		200	

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 -3.0% and errors of -3.4%, -2.3%, and -3.8% at the 65, 70 and 75 mph speed points respectively. The error for the 65 mph speed point was extrapolated to derive new compensation factors for the 55 mph and 60 mph speed points. To compensate for these errors, the changes in Table 5-9 were made to the compensation factors. Note that the errors given in Table 5-9 reflect adjustments that were made to the front axle correction factor, and consequently do not exactly match the errors reported above.

Table 5-9 – Calibration 1 Equipment Factor Changes – 17-Mar-11

Speed Points	Old Factors		Error	New Factors	
	Left	Right		Left	Right
	1	2		1	2
88	3466	3502	-2.46%	3489	3658
96	3482	3517	-2.46%	3505	3674
104	3447	3480	-2.46%	3470	3635
112	3446	3480	-1.72%	3443	3608
120	3386	3419	-3.22%	3435	3599
Axle Distance (cm)	370		0.6%	372	
Dynamic Comp (%)	100		-7.2%	105	
Loop Width (cm)	200		2.4 ft	273	

5.2.1.2 Calibration 1 Results

The results of the 10 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 – 17-Mar-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-2.2 ± 5.3%	Pass
Tandem Axles	±15 percent	-0.7 ± 6.4%	Pass
GVW	±10 percent	-0.9 ± 4.6%	Pass
Vehicle Length	±3.0 percent (1.7 ft)	0.3 ± 1.2 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.

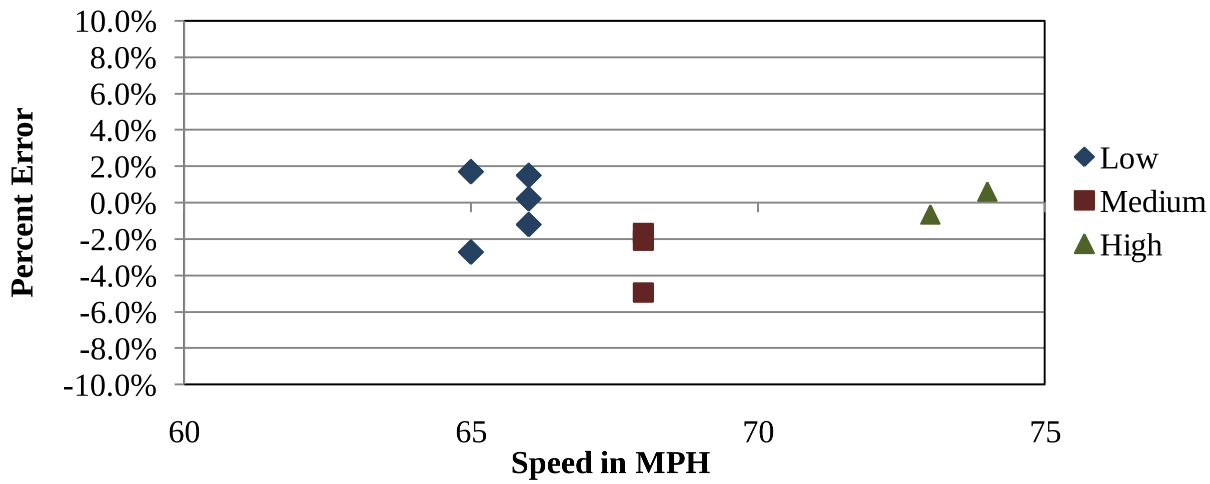


Figure 5-11 – Calibration 1 GVW Error by Speed – 17-Mar-11

Based on the results of the first calibration, where GVW estimate bias decreased to -0.9 percent, a second calibration was not considered to be necessary. The 10 calibration runs were combined with 30 additional post-validation runs to complete the WIM system validation.

5.3 Post-Validation

The 40 post-validation test truck runs were conducted on March 17, 2011, beginning at approximately 7:47 AM and continuing until 2:57 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with stone, 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 stone, 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	77.1	10.3	16.6	16.6	16.8	16.8	18.0	4.3	25.2	4.0	51.5	56.0
2	67.3	9.7	14.0	14.0	14.8	14.8	17.8	4.3	25.0	3.9	51.0	56.3

Test truck speeds varied by 12 mph, from 62 to 74 mph. The measured post-validation pavement temperatures varied 43.9 degrees Fahrenheit, from 35.0 to 78.9. 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 – 17-Mar-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-1.1 ± 5.7%	Pass
Tandem Axles	±15 percent	0.1 ± 4.6%	Pass
GVW	±10 percent	0.0 ± 3.0%	Pass
Vehicle Length	±3.0 percent (1.7 ft)	0.4 ± 1.1 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 0.6 ± 2.6 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 0.0, 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 75 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 – 17-Mar-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		62.0 to 66.0 mph	66.1 to 70.1 mph	70.2 to 74.0 mph
Steering Axles	±20 percent	0.5 ± 6.8%	-2.3 ± 4.5%	-1.6 ± 5.3%
Tandem Axles	±15 percent	0.6 ± 5.5%	-0.8 ± 4.3%	0.5 ± 3.6%
GVW	±10 percent	0.6 ± 3.4%	-1.0 ± 2.9%	0.3 ± 2.3%
Vehicle Length	±3.0 percent (1.7 ft)	0.4 ± 1.2 ft	0.5 ± 0.9 ft	0.3 ± 1.2 ft
Vehicle Speed	± 1.0 mph	0.6 ± 2.8 mph	1.0 ± 3.1 mph	0.1 ± 2.3 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 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 is similar throughout the entire speed range.

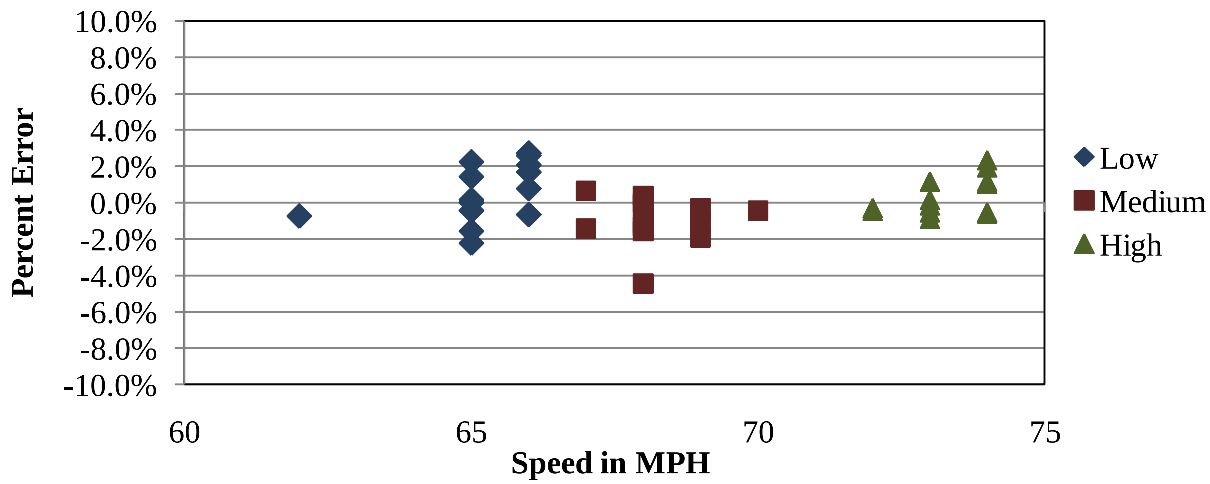


Figure 5-12 – Post-Validation GVW Errors by Speed – 17-Mar-11

5.3.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-13, the equipment estimated steering axle weights with similar accuracy at all speeds. The range in error is similar throughout the entire speed range. There does not appear to be a correlation between speed and steering axle weight estimates at this site.

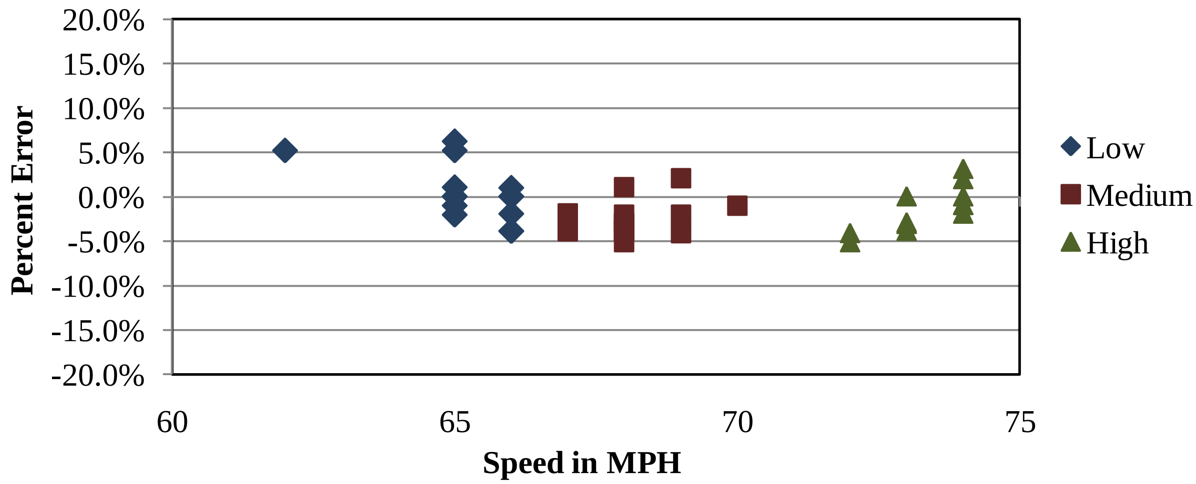


Figure 5-13 – Post-Validation Steering Axle Weight Errors by Speed – 17-Mar-11

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 appears to decrease as speed increases.

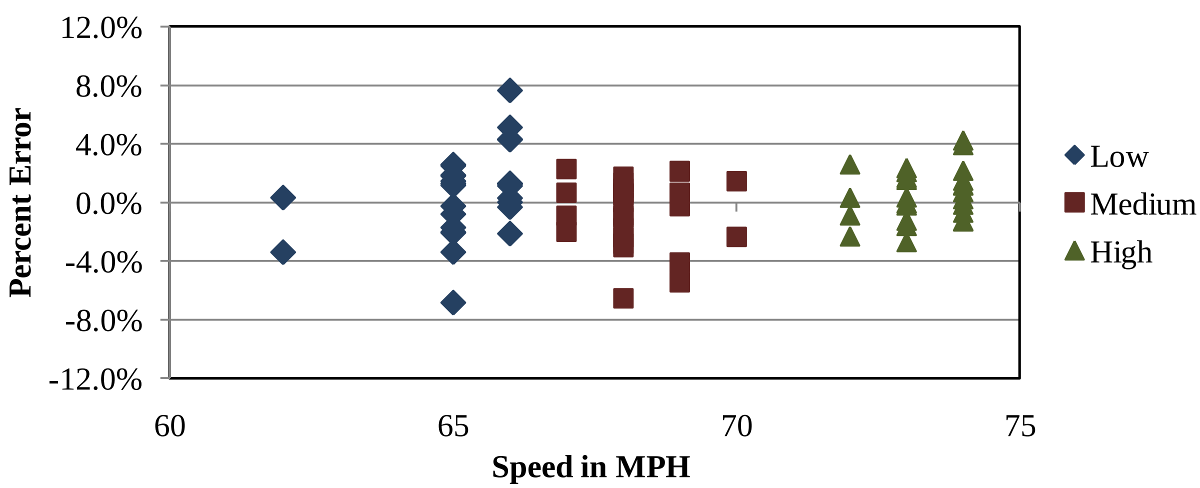


Figure 5-14 – Post-Validation Tandem Axle Weight Errors by Speed – 17-Mar-11

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.

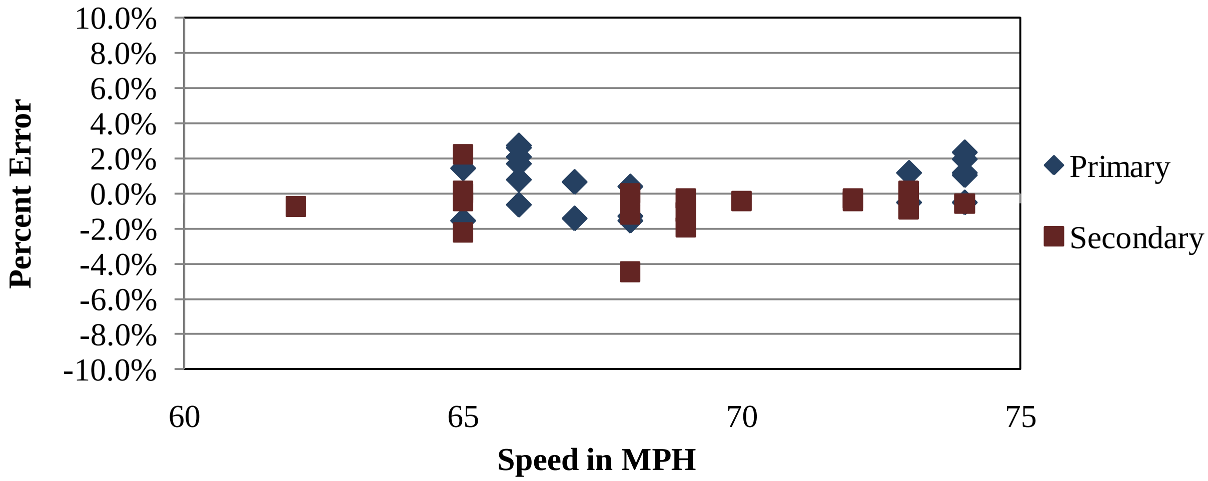


Figure 5-15 – Post-Validation GVW Error by Truck and Speed – 17-Mar-11

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.

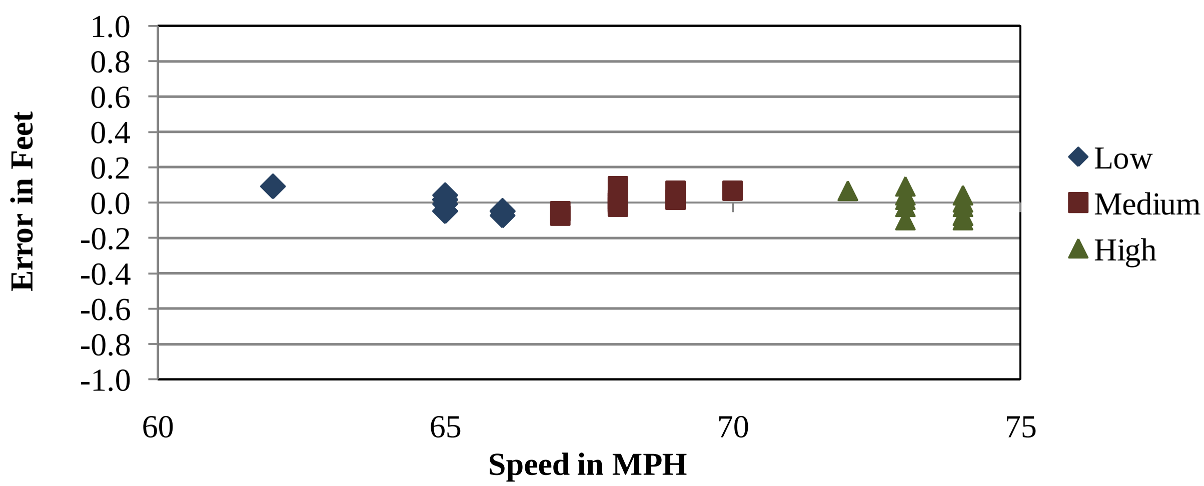


Figure 5-16 – Post-Validation Axle Length Error by Speed – 17-Mar-11

5.3.1.6 Overall Length Errors by Speed

For this system, the WIM equipment measures overall length consistently over the entire range of speeds, with errors ranging from -0.3 to 1.0 feet. Distribution of errors is shown graphically in Figure 5-17.

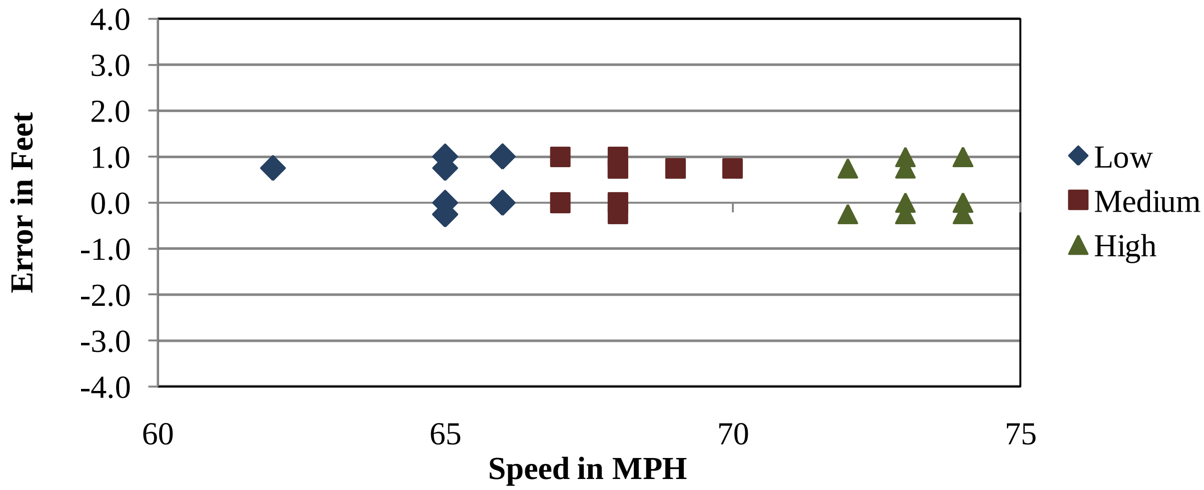


Figure 5-17 – Post-Validation Overall Length Error by Speed – 17-Mar-11

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 43.9 degrees, from 35.0 to 78.9 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 – 17-Mar-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		35.0 to 49.6 degF	49.7 to 69.0 degF	69.1 to 78.9 degF
Steering Axles	±20 percent	-0.5 ± 5.3%	-0.8 ± 7.8%	-1.7 ± 5.4%
Tandem Axles	±15 percent	-0.4 ± 6.4%	-0.3 ± 4.4%	0.7 ± 4.3%
GVW	±10 percent	-0.4 ± 4.7%	-0.3 ± 2.7%	0.4 ± 2.6%
Vehicle Length	±3.0 percent (1.7 ft)	0.3 ± 1.2 ft	0.3 ± 1.2 ft	0.6 ± 1.0 ft
Vehicle Speed	± 1.0 mph	0.6 ± 3.1 mph	0.6 ± 3.0 mph	0.6 ± 2.6 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 acceptable accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and GVW estimates at this site.

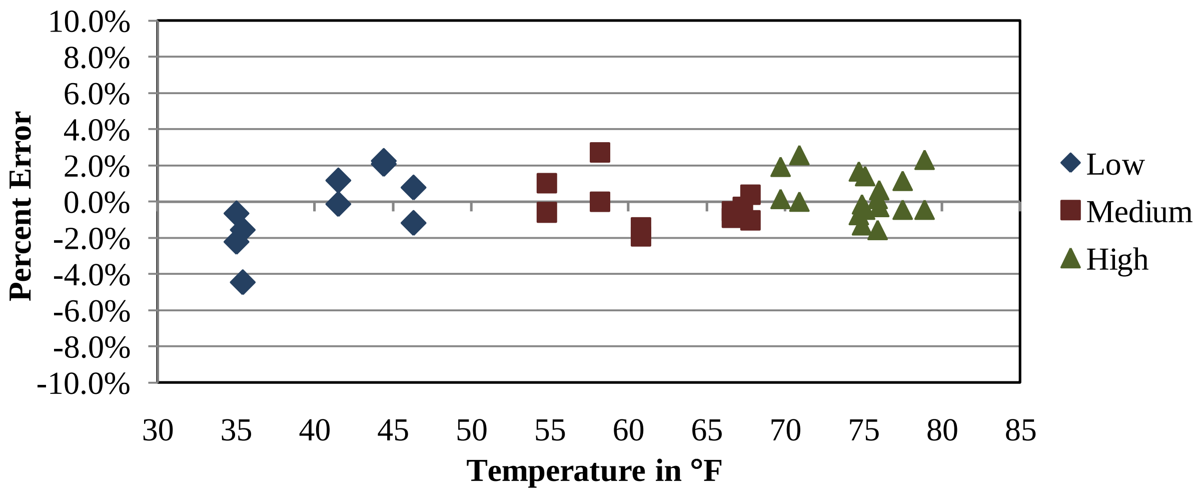


Figure 5-18 – Post-Validation GVW Errors by Temperature – 17-Mar-11

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-19 demonstrates that for steering axles, the WIM equipment appears to estimate weights with similar accuracy across the range of temperatures observed in the field. The range in error is similar for different temperature groups.

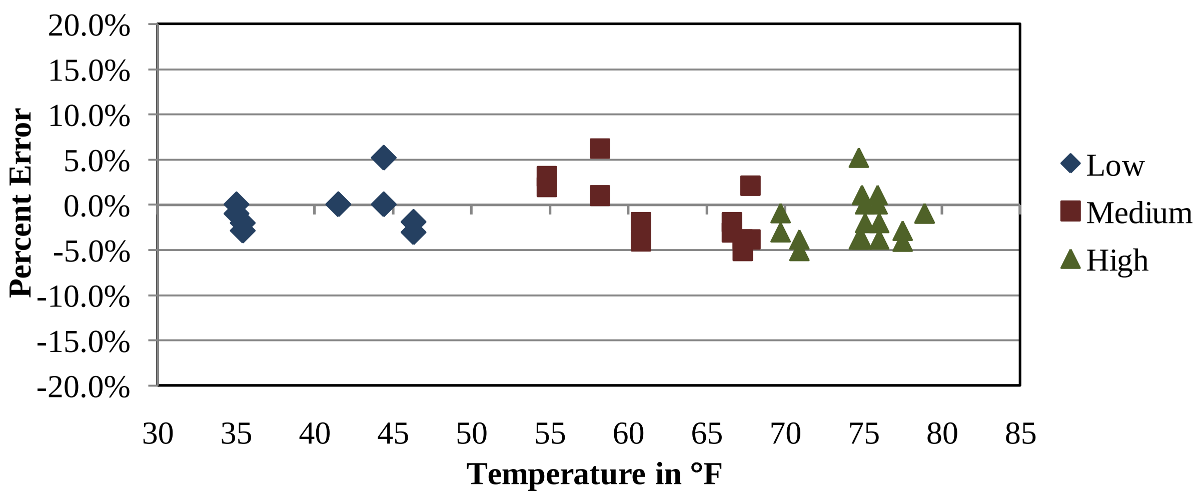


Figure 5-19 – Post-Validation Steering Axle Weight Errors by Temperature – 17-Mar-11

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 acceptable similar accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and tandem axle weight estimates at this site. The range in tandem axle errors is consistent for the three temperature groups.

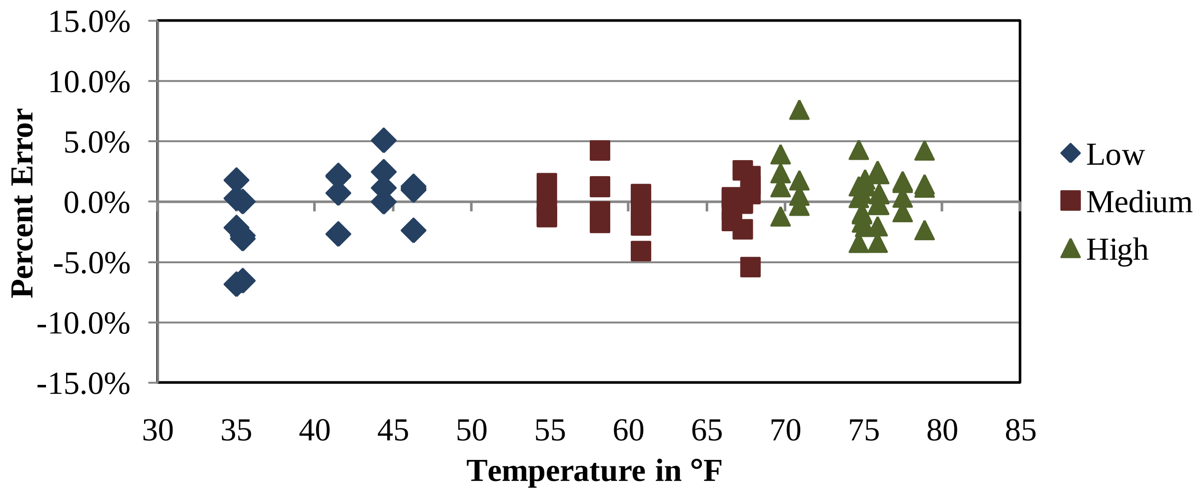


Figure 5-20 – Post-Validation Tandem Axle Weight Errors by Temperature – 17-Mar-11

5.3.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-21, when analyzed by truck type, the average GVW measurement error for both trucks is similar at all temperatures. For both trucks, the range of errors and bias are reasonably consistent over the range of temperatures.

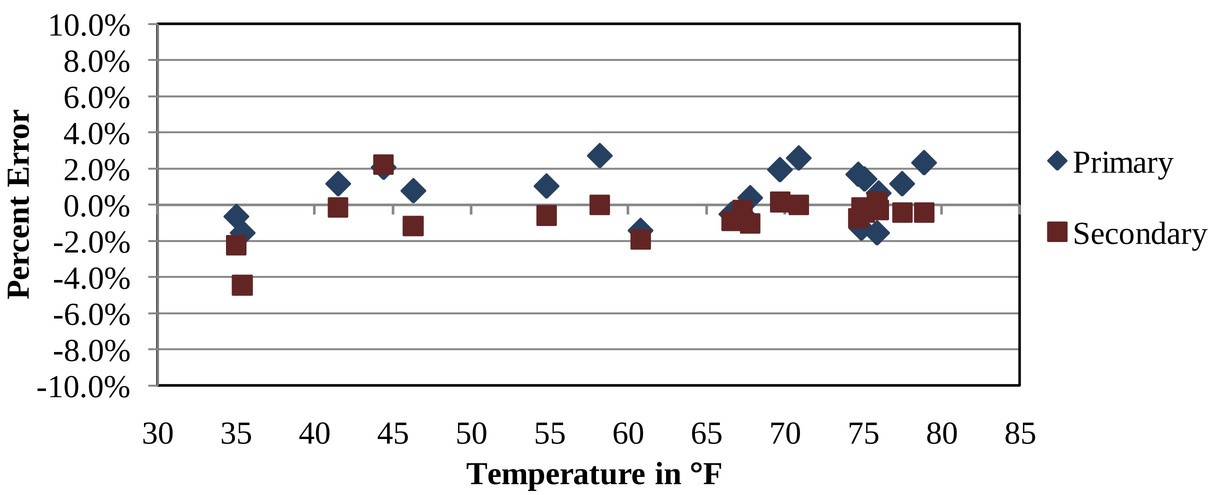


Figure 5-21 – Post-Validation GVW Error by Truck and Temperature – 17-Mar-11

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.

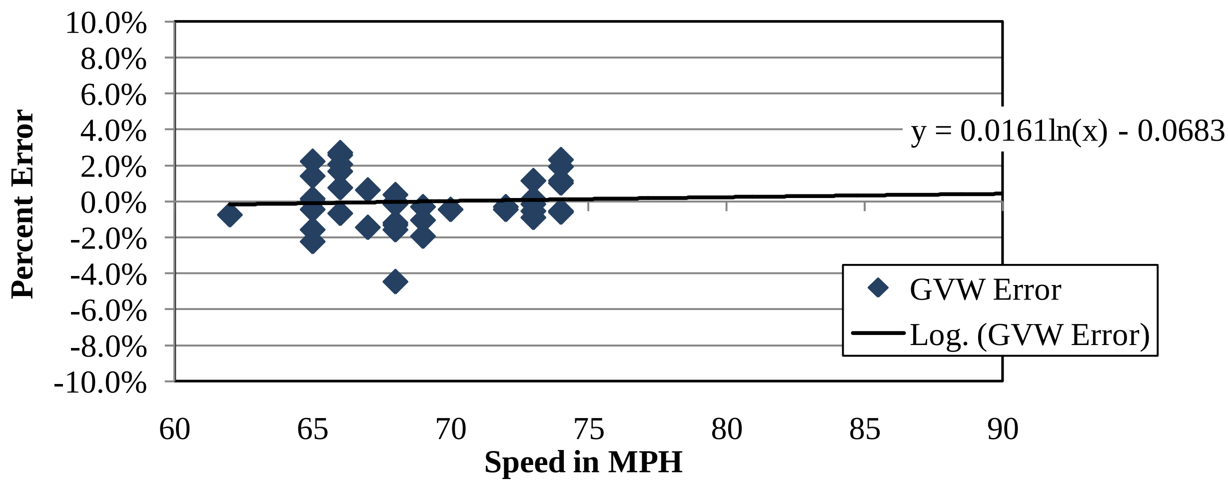


Figure 5-22 – GVW Error Trend by Speed

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

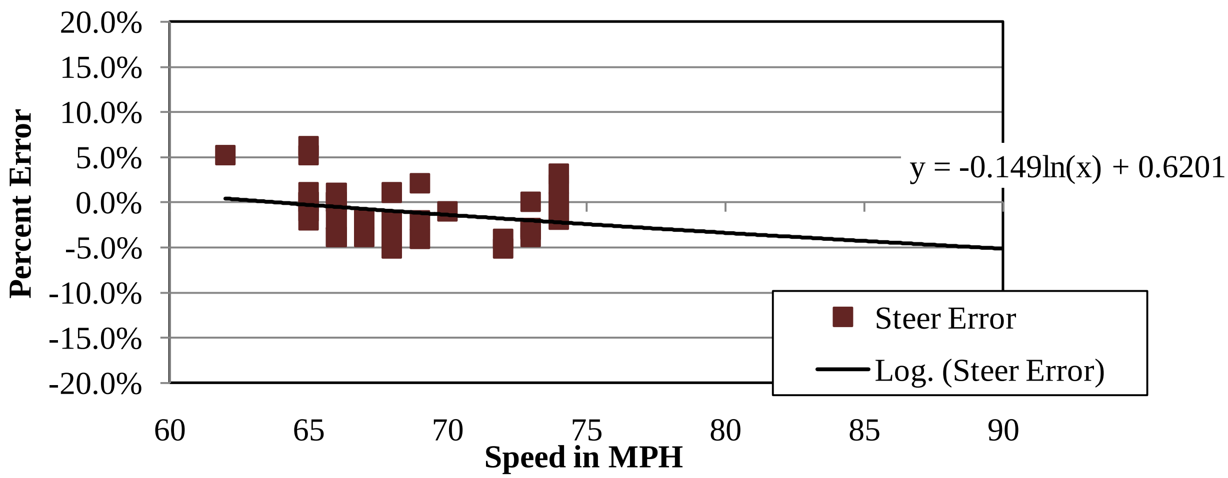


Figure 5-23 – Steering Axle Trend by Speed

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 62 to 74 mph.
- Pavement temperature. Pavement temperature ranged from 35.0 to 78.9 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. Only the effect of truck type was found to be statistically significant. The probability that the effect of truck type 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	-3.3914	4.6387	-0.7311	0.4694
Speed	0.0428	0.0664	0.6443	0.5235
Temp	0.0169	0.0160	1.0554	0.2983
Truck	-1.4332	0.4580	-3.1292	0.0035

As an example, 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.

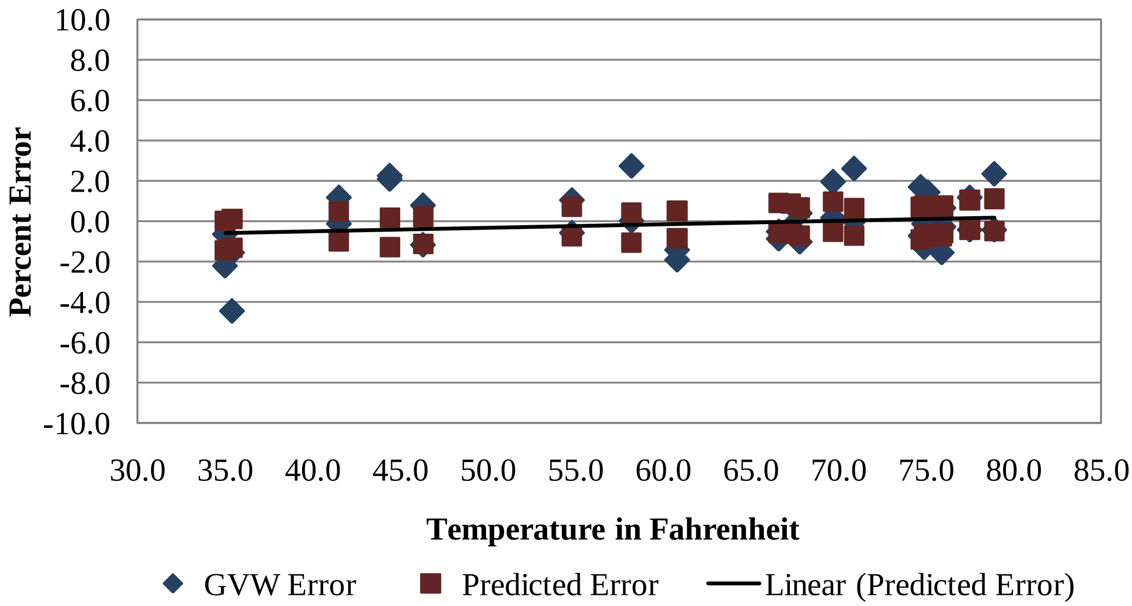


Figure 5-24 – Influence of Temperature on the Measurement Error of GVW

The quantification is provided by the value of the regression coefficient, in this case 0.0169 (in Table 5-15). This means, for example, that for a 20 degree increase in temperature, the % error is increased by about 0.34 % (0.0169 x 20). The statistical assessment of the relationship is provided by the probability value of the regression coefficient. The effect of temperature on GVW was not statistically significant. The probability that the regression coefficient for temperature (-0.0169) is not different from zero was 0.2983. In other words, there is about 30 percent chance that the value of the regression coefficient is due to the chance alone.

The regression coefficient for the truck type represents the difference between the mean errors for the primary and secondary trucks. (Truck type is an indicator variable with values of 0 or 1.).

The mean error in GVW for the primary truck was about 1.4 % larger than the error for the secondary truck.

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.

5.3.4.3 Summary Results

Table 5-16 lists regression coefficients and their probability values for all combinations of factors and % errors evaluated. Not listed in the table are factor interactions because the interactions were not statistically significant. Entries in the table are provided only if the probability value was smaller than 0.20. The dash in Table 5-16 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	-	-	-	-	-1.4332	0.0035
Steering axle	-0.1891	0.1397	-	-	-	-
Tandem axle tractor	-0.0971	0.1288	-	-	-	-
Tandem axle trailer	-	-	0.0526	0.0936	-2.7897	0.0029

5.3.4.4 Conclusions

1. Speed had no statistically significant effect on measurement errors.

2. Temperature had no statistically significant effect on measurement errors with possible exception of tandem axles on trailers. The probability value of 0.0936 for tandem axles on trailers represents marginal statistical significance.

3. Truck type had statistically significant effect on measurement errors for GVW, and tandem axle trailer weights.

4. Even though temperature and truck type had statistically significant effect on measurement errors for 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. For this site, no vehicles were misclassified and no vehicles were unclassified by the equipment.

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

Class	4	5	6	7	8	9	10	11	12	13
Observed Count	0	14	6	0	3	75	1	1	0	0
WIM Count	0	14	6	0	3	75	1	1	0	0
Observed Percent	0.0	14.0	6.0	0.0	3.0	75.0	1.0	1.0	0.0	0.0
WIM Percent	0.0	14.0	6.0	0.0	3.0	75.0	1.0	1.0	0.0	0.0
Misclassified Count	0	0	0	0	0	0	0	0	0	0
Misclassified Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unclassified Count	0	0	0	0	0	0	0	0	0	0
Unclassified Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. 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 0.0%.

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. Based on the manually collected sample of the 100 trucks, 0.0% 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 0.2 mph; the range of errors was 1.5 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 three 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-Jun-06	0	30	0	N/A	0	0	N/A	0	0	N/A	0
28-Jun-06	N/A	38	0	N/A	0	0	0	0	N/A	N/A	1
16-Oct-07	N/A	0	0	N/A	0	0	N/A	0	N/A	N/A	0
17-Oct-07	100	11	N/A	N/A	0	0	N/A	0	0	N/A	0
29-Apr-08	100	29	25	N/A	75	3	N/A	0	N/A	0	0
30-Apr-08	N/A	22	0	100	100	4	0	0	0	N/A	5
16-Mar-11	0	13	0	0	0	0	0	0	0	0	0
17-Mar-11	0	0	0	0	0	0	0	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	Single Axles	Tandem
27-Jun-06	3.3 ± 2.4	3.1 ± 2.8	3.3 ± 3.2
28-Jun-06	-0.6 ± 1.8	-1.2 ± 3.2	-0.5 ± 3.1
16-Oct-07	-3.5 ± 3.3	-7.5 ± 4.7	-2.8 ± 4.5
17-Oct-07	0.9 ± 2.6	-2.3 ± 4.5	1.5 ± 3.9
29-Apr-08	3.5 ± 1.7	-0.1 ± 1.6	4.2 ± 2.4
30-Apr-08	-0.9 ± 1.6	-5.0 ± 2.9	-0.1 ± 2.0
16-Mar-11	-3.0 ± 1.4	-7.2 ± 2.5	-2.7 ± 3.9
17-Mar-11	-0.1 ± 1.6	-1.1 ± 2.8	0.1 ± 2.3

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 and axle weights 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)			
		28-Jun-06	17-Oct-07	30-Apr-08	17-Mar-11
Steering Axles	±20 percent	-1.2 ± 6.6	-2.3 ± 9.2	-5.0 ± 5.8	-1.1 ± 5.7
Tandem Axles	±15 percent	-0.5 ± 6.2	1.5 ± 7.8	-0.1 ± 4	0.1 ± 4.6
GVW	±10 percent	-0.6 ± 3.6	0.9 ± 5.2	-0.9 ± 3.3	-0.1 ± 3.2

From Table 6-3, it appears that the mean error and the 95% confidence interval have remained reasonably consistent for all weights since the equipment was installed, with the exception of the July 24, 2007 validation, where some of the 95% confidence intervals were slightly increased.

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**
88	55	3489	3658
96	60	3505	3674
104	65	3470	3635
112	70	3443	3608
120	75	3435	3599
Axle Distance (cm)	372		
Dynamic Comp (%)	105		
Loop Width (cm)	273		

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 2 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

Colorado, SPS-2
SHRP ID: 080200

Validation Date: March 17, 2010

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 Meter

Photo 9 – Telephone Pedestal

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: 08 SPS WIM ID: 080200 DATE (mm/dd/yyyy) 3/16/2011

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 3/16/11

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: 20

	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 -

	Mean		Standard Deviation
Dynamic and Static GVW:	-3.0%	Standard Deviation:	1.4%
Dynamic and Static Single Axle:	-7.2%	Standard Deviation:	2.5%
Dynamic and Static Double Axles:	-2.7%	Standard Deviation:	3.9%

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

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

			Low		High	Runs
a.	Low	-	62.0	to	66.0	10
b.	Medium	-	66.1	to	70.1	19
c.	High	-	70.2	to	74.0	11
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 08 SPS WIM ID: 080200 DATE (mm/dd/yyyy) 3/16/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3435 | 3599

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	-	0.0
FHWA Class 8:	0.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Pre

Person Leading Calibration Effort: **Kevin Trousdale**

Contact Information: Phone: 717-975-3550

E-mail: ktrousdale@ara.com

Traffic Sheet 16	STATE CODE:	08
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	080200
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	3/17/2011

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 3/17/11

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: 20

	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:	-0.1%	Standard Deviation:	1.6%
Dynamic and Static Single Axle:	-1.1%	Standard Deviation:	2.8%
Dynamic and Static Double Axles:	0.1%	Standard Deviation:	2.3%

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

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	62.0	to	66.0	14
b.	Medium	-	66.1	to	70.1	13
c.	High	-	70.2	to	74.0	13
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: SPS WIM ID: DATE (mm/dd/yyyy)	08 080200 3/17/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3414 | 3577

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	-	0.0
FHWA Class 8:	0.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Post

Person Leading Calibration Effort: **Kevin Trousdale**

Contact Information: Phone: 717-975-3550

E-mail: ktrousdale@ara.com

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 08 SPS WIM ID: 080200 DATE (mm/dd/yyyy) 3/16/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
69	9	614	69	9	72	9	672	71	9
65	9	615	64	9	72	9	674	69	9
73	9	616	75	9	62	9	675	63	9
67	9	618	66	9	68	9	676	67	9
75	9	620	75	9	65	9	680	65	9
72	9	621	72	9	69	9	696	66	9
62	9	623	64	9	70	9	697	70	9
67	9	624	66	9	71	9	706	71	9
67	9	629	67	9	69	9	707	69	9
65	9	635	64	9	74	9	711	74	9
73	9	637	74	9	69	9	712	69	9
77	9	639	77	9	65	9	714	65	9
66	12	646	65	12	67	9	715	66	9
72	6	651	71	6	70	9	718	67	9
71	9	654	72	9	62	8	722	68	8
75	5	655	74	5	67	9	723	66	9
77	5	656	80	5	76	6	729	74	6
72	**5**	**658**	**73**	**2**	67	9	730	70	9
58	9	659	58	9	69	6	733	66	6
78	9	660	80	9	67	9	737	69	9
80	5	661	80	5	74	9	738	74	9
62	6	662	60	6	73	9	743	74	9
68	5	666	67	5	80	5	754	79	5
73	9	667	74	9	70	5	765	69	5
64	9	668	65	9	**81**	**5**	**766**	**79**	**2**

Sheet 1 - 0 to 50 Start: 14:50:00 Stop: 15:27:13

Recorded By: ar Verified By: dw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 08 SPS WIM ID: 080200 DATE (mm/dd/yyyy) 3/16/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
72	6	772	70	6	65	9	916	65	9
70	6	774	69	6	64	9	924	64	9
70	9	782	72	9	68	9	927	69	9
70	9	788	69	9	65	9	928	65	9
62	9	789	63	9	73	9	931	73	9
62	9	797	63	9	65	9	935	65	9
64	9	803	64	9	74	5	936	74	5
68	9	811	67	9	67	9	937	68	9
72	5	814	71	5	65	9	941	65	9
66	9	832	64	9	65	9	942	64	9
65	9	834	64	9	71	9	952	72	9
71	5	855	71	5	67	9	959	66	9
68	**4**	**861**	**70**	**5**	70	12	960	70	12
67	9	862	68	9	68	9	963	67	9
73	10	863	73	10	65	9	967	66	9
69	9	867	69	9	61	5	969	63	5
64	9	869	63	9	65	5	971	65	5
75	9	873	75	9	70	9	973	70	9
68	9	878	68	9	70	9	987	71	9
69	9	895	67	9	69	9	988	69	9
63	9	900	62	9	71	9	989	69	9
62	9	901	61	9	70	9	990	71	9
75	5	905	75	5	68	5	992	68	5
73	9	911	72	9	**62**	**4**	**998**	**62**	**5**
68	9	912	67	9	64	9	1002	64	9

Sheet 2 - 51 to 100 Start: 15:28:56 Stop: 16:26:43

Recorded By: ar Verified By: dw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 **LTPP MONITORED TRAFFIC DATA** **SPEED AND CLASSIFICATION STUDIES**	STATE CODE: 08 SPS WIM ID: 080200 DATE (mm/dd/yyyy) 3/17/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
73	6	5970	73	6	62	9	6057	62	9
61	9	5971	62	9	68	5	6058	73	5
73	5	5974	72	5	62	9	6059	62	9
64	9	5981	65	9	68	9	6063	67	9
76	9	5983	75	9	69	9	6070	68	9
73	9	5987	73	9	64	9	6073	63	9
71	9	5988	71	9	77	9	6080	78	9
65	9	5989	65	9	64	6	6086	62	6
64	9	5993	65	9	65	5	6087	62	5
65	9	6001	64	9	74	10	6115	74	10
68	9	6007	68	9	69	9	6116	69	9
65	9	6019	66	9	68	9	6117	68	9
75	5	6021	73	5	67	9	6119	67	9
70	9	6027	72	9	65	11	6120	65	11
70	9	6028	69	9	75	5	6128	73	5
68	8	6029	67	8	65	9	6130	65	9
63	9	6034	63	9	67	9	6131	67	9
65	9	6041	65	9	64	9	6132	64	9
72	9	6043	72	9	75	6	6135	75	6
75	9	6044	74	9	64	9	6141	64	9
65	9	6047	68	9	61	6	6147	59	6
67	9	6048	66	9	72	9	6149	72	9
69	9	6049	68	9	65	9	6154	64	9
75	9	6052	74	9	64	5	6161	63	5
67	9	6053	67	9	69	9	6165	69	9

Sheet 1 - 0 to 50 Start: 9:29:00 Stop: 10:12:25

Recorded By: ar Verified By: dw

Validation Test Truck Run Set - Post

Traffic Sheet 20	STATE CODE:	08
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	080200
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	3/17/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
70	9	6166	71	9	66	9	6317	65	9
64	9	6167	64	9	75	9	6319	75	9
68	9	6204	67	9	62	9	6326	61	9
70	5	6205	69	5	70	9	6330	70	9
73	5	6206	72	5	72	9	6332	71	9
64	9	6207	62	9	66	9	6337	66	9
75	9	6208	74	9	67	9	6348	66	9
75	9	6209	72	9	67	9	6352	68	9
65	9	6223	65	9	61	9	6353	61	9
65	8	6224	63	8	65	9	6385	64	9
53	6	6226	51	6	65	8	6386	64	8
81	5	6228	81	5	64	9	6391	64	9
74	5	6229	78	5	65	9	6395	66	9
57	6	6230	56	6	74	9	6398	73	9
74	9	6234	74	9	76	9	6399	74	9
74	9	6236	73	9	68	9	6401	68	9
78	9	6243	81	9	71	9	6404	76	9
70	5	6248	69	5	70	5	6411	70	5
73	9	6249	71	9	65	9	6412	65	9
74	9	6307	74	9	65	9	6413	64	9
59	5	6308	57	5	70	9	6415	72	9
59	9	6312	57	9	66	9	6416	67	9
68	9	6313	69	9	65	9	6425	71	9
66	5	6314	67	5	62	9	6426	62	9
60	9	6315	61	9	73	9	6427	71	9

Sheet 2 - 51 to 100 Start: 10:12:39 Stop: 11:12:53

Recorded By: ar Verified By: dw

Validation Test Truck Run Set - Post