WIM System Field Calibration and Validation Summary Report - Revised

Minnesota SPS-5
SHRP ID – 270500

Validation Date: April 26, 2011
Submitted: May 16, 2011

Table of Contents

List of Figures

List of Tables

1 Executive Summary

A WIM validation was performed on April 26, 2011 at the Minnesota SPS-5 site located on route US-2 at milepost 91.8, 3.3 miles west of SR 2.

This site was installed on October 06, 2006. The in-road sensors are installed in the westbound lane. The site is equipped with quartz WIM sensors and IRD iSINC 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 November 12, 2008 and this validation visit, it appears that no changes have been made to the equipment during this time.

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 indicated bouncing at a location 450 feet prior to the WIM scales. The dynamics appeared to diminish prior to the trucks crossing the WIM scales and did not appear to 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 –Validation Results – 26-Apr-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-1.2 ± 6.2%	Pass
Tandem Axles	±15 percent	-0.4 ± 4.0%	Pass
GVW	±10 percent	-0.5 ± 2.7%	Pass
Vehicle Length	±3.0 percent (2.2 ft)	-0.4 ± 1.0 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.0 ft	Pass

Truck speeds were manually collected for each test run by a radar gun and compared with the speed reported by the WIM equipment. For this site, the error in speed measurement was 0.1 ± 0.9 mph, which is within the ±1.0 mph tolerance established by the LTPP Field Operations Guide for SPS WIM Sites. In addition, 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. The overall misclassification rate of 14.3% from the 43 truck sample (Class 4 – 13) was due to the 7 cross-classifications of Class 3, 4, 5, and 8 vehicles.

There were two test trucks used for the 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 binned wood chips.

- The *Secondary* truck was a Class 9 vehicle with air suspension on the tractor tandem, walking beam suspension on the trailer tandem, standard tandem spacing on the tractor and standard tandem on the trailer. The Secondary truck was loaded with binned wood chips.

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	12.0	15.7	15.7	16.9	16.9	17.5	4.3	35.3	4.1	61.2	75.0
2	62.8	11.5	14.4	14.4	11.3	11.3	17.2	4.4	33.0	4.1	58.7	70.0

The posted speed limit at the site is 65 mph. During the testing, the speed of the test trucks ranged from to 53 to 67 mph, a variance of 14 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 44.1 to 65.9 degrees Fahrenheit, a range of 21.8 degrees Fahrenheit. The cloudy weather conditions prevented attaining the desired 30 degree range in pavement surface temperature.

A review of the LTPP Standard Release Database 24 shows that there are 33 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 March 14, 2011 (Data) to the most recent Comparison Data Set (CDS) from November 10, 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 2 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	54	2
2007	351	12
2008	351	12
2009	198	7

As shown in the table, this site requires three additional years of data to meet the minimum of five years of research quality data. The 2007 and 2008 data does not meet the 210-day minimum requirement for a calendar year.

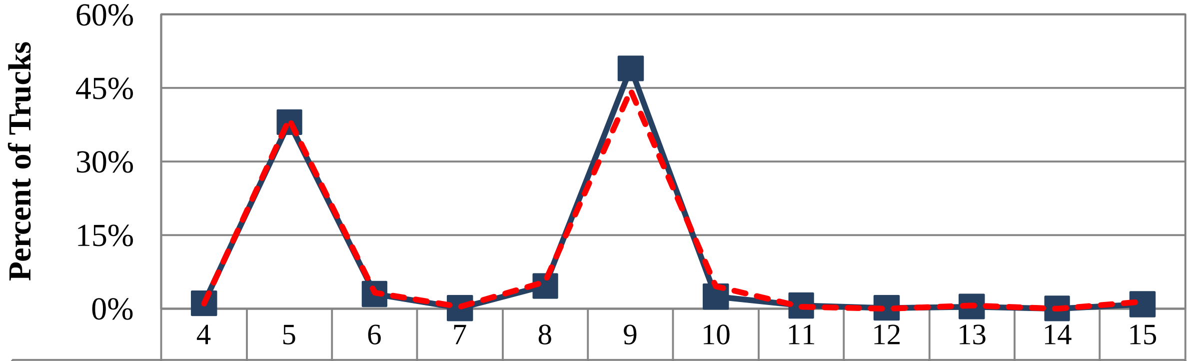
Table 2-2 provides a monthly breakdown of the available data for years 2006 through 2009.

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											25	29	2
2007	27	28	29	29	30	29	27	31	29	31	30	31	12
2008	31	29	31	29	30	30	18	31	30	31	30	31	12
2009	31	28	29	30	31	30	19						7

2.2 Classification Data Analysis

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



	4	5	6	7	8	9	10	11	12	13	14	15
Data	1.1%	38.0%	3.0%	0.1%	4.6%	49.0%	2.4%	0.6%	0.1%	0.4%	0.0%	0.8%
CDS	1.0%	38.6%	3.2%	0.4%	5.5%	44.4%	4.6%	0.4%	0.0%	0.6%	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 (49.0%) and Class 5 (38.0%). 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 0.8 percent of the vehicles at this site are unclassified.

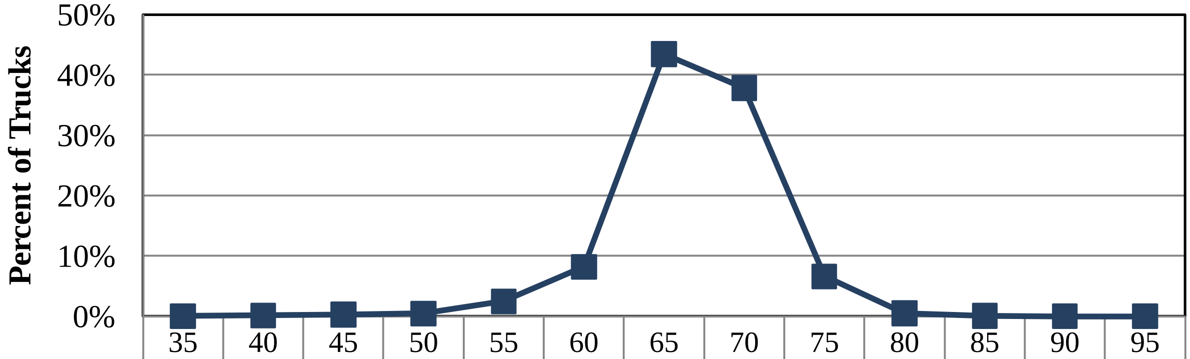
Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	11/10/2008		3/14/2011		
4	41	1.0%	28	1.1%	0.0%
5	1526	38.6%	1010	38.0%	-0.6%
6	128	3.2%	79	3.0%	-0.3%
7	15	0.4%	2	0.1%	-0.3%
8	216	5.5%	122	4.6%	-0.9%
9	1756	44.4%	1303	49.0%	4.6%
10	180	4.6%	65	2.4%	-2.1%
11	14	0.4%	15	0.6%	0.2%
12	0	0.0%	3	0.1%	0.1%
13	23	0.6%	10	0.4%	-0.2%
14	0	0.0%	0	0.0%	0.0%
15	53	1.3%	22	0.8%	-0.5%

From the table it can be seen that the number of Class 9 vehicles has increased by 4.6 percent from November 2008 and March 2011. However, the total percentage of heavy trucks (vehicle Classes 8 to 15) increased by only 1.7%. Changes in the distribution of heavy trucks may be attributed to seasonal and natural variations in truck volumes. During the same time period, the percentage of Class 5 trucks decreased by 0.6 percent. These differences may be attributed to small sample size used to develop vehicle class distributions, changes in the use of the roadway for local deliveries, cross-classifications of type 3 and 5 vehicles, as well as natural variations in truck volumes.

2.3 Speed Data Analysis

The traffic data received from the Phase II Contractor was analyzed to determine the expected truck speed distributions. This will provide a basis for 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%	0.1%	0.3%	0.4%	2.5%	8.2%	43.4%	37.8%	6.6%	0.5%	0.1%	0.0%	0.0%

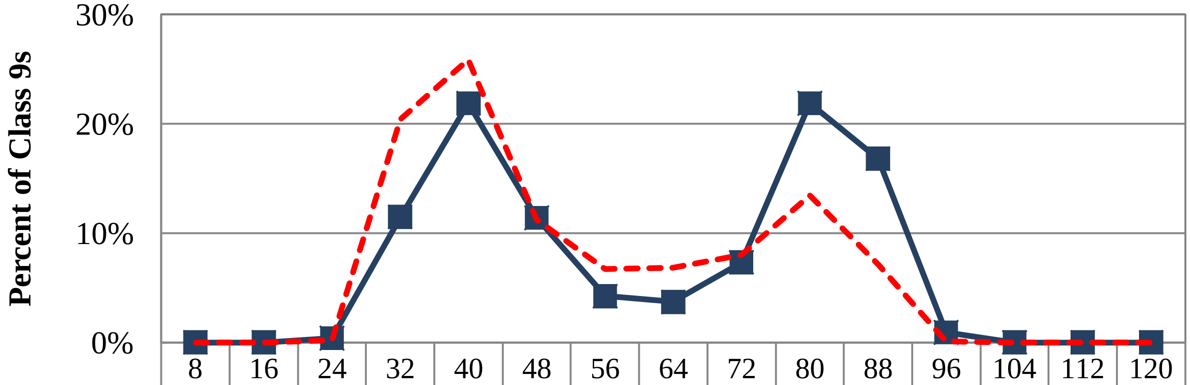
Figure 2-2 – Truck Speed Distribution – 21-Mar-11

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 65 and 70 mph. The posted speed limit at this site is 65 and the 85^{th} percentile speed for trucks at this site is 69 mph. The range of truck speeds for the validation is expected to be 55 to 65 mph.

2.4 GVW Data Analysis

The traffic data received from the Regional Support Contractor was analyzed to determine the expected Class 9 GVW distributions. Figure 2-3 shows a comparison between GVW plots generated using a two-week W-card sample from March 2011 and the Comparison Data Set from November 2008.

As shown in Figure 2-3, while there was a notable reduction in the percentage of unloaded trucks, there was an increase in partially loaded tucks and notable increase in fully loaded trucks recorded between the November 2008 Comparison Data Set (CDS) and the March 2011 two-week sample W-card dataset (Data).



	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
Data	0.0%	0.0%	0.4%	11.5	21.9	11.4	4.2%	3.7%	7.3%	21.9	16.8	0.9%	0.0%	0.0%	0.0%
CDS	0.0%	0.0%	0.2%	20.4	25.9	11.2	6.7%	6.8%	8.0%	13.4	7.1%	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

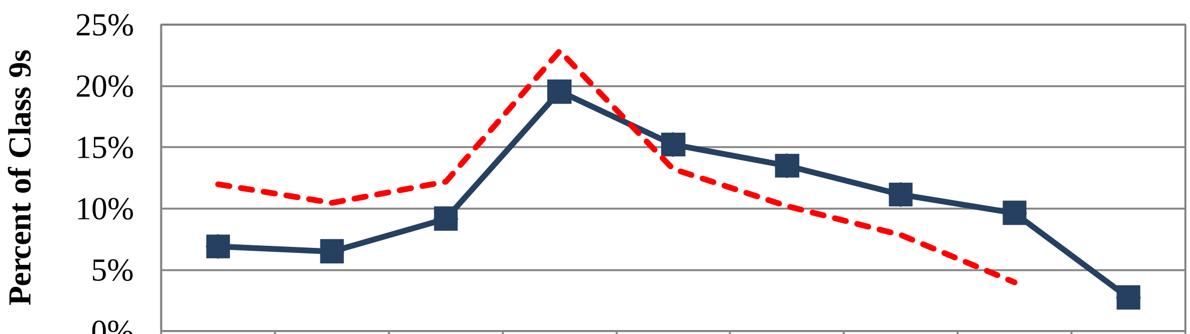
GVW weight bins (kips)	CDS		Data		Change
	Date				
	11/10/2008		3/14/2011		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	4	0.2%	5	0.4%	0.2%
32	352	20.4%	149	11.5%	-8.9%
40	446	25.9%	284	21.9%	-4.0%
48	194	11.2%	148	11.4%	0.2%
56	116	6.7%	55	4.2%	-2.5%
64	118	6.8%	48	3.7%	-3.1%
72	138	8.0%	95	7.3%	-0.7%
80	232	13.4%	284	21.9%	8.4%
88	123	7.1%	218	16.8%	9.7%
96	2	0.1%	12	0.9%	0.8%
104	0	0.0%	0	0.0%	0.0%
112	0	0.0%	0	0.0%	0.0%
120	0	0.0%	0	0.0%	0.0%
Average =	49.3 kips		57.0 kips		7.7 kips

As shown in the table, the percentage of unloaded Class 9 trucks in the 32 to 40 kips range decreased by 4.0 percent while the percentage of loaded Class 9 trucks in the 72 to 80 kips range increased by 8.4 percent. During this time period the percentage of overweight trucks increased by 10.5 percent. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site increased by 7.7 kips, or 15.6 percent, from 49.3 kips to 57.0 kips kips.

2.5 Class 9 Front Axle Weight Data Analysis

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

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



	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0
Data	6.9%	6.5%	9.2%	19.5%	15.2%	13.5%	11.1%	9.7%	2.7%
CDS	12.0%	10.4%	12.2%	22.9%	13.3%	10.2%	7.9%	4.0%	

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

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

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

F/A weight bins (kips)	CDS		Data		Change
	Date				
	11/10/2008		3/14/2011		
9.0	101	5.9%	71	5.6%	-0.3%
9.5	205	12.0%	88	6.9%	-5.1%
10.0	179	10.4%	83	6.5%	-3.9%
10.5	209	12.2%	117	9.2%	-3.0%
11.0	392	22.9%	249	19.5%	-3.3%
11.5	227	13.3%	194	15.2%	2.0%
12.0	175	10.2%	172	13.5%	3.3%
12.5	135	7.9%	142	11.1%	3.3%
13.0	68	4.0%	123	9.7%	5.7%
13.5	22	1.3%	35	2.7%	1.5%
Average =	10.7 kips		11.1 kips		0.4 kips

The table shows that the average front axle weight for Class 9 trucks has increased by 0.4 kips, or 3.7 percent. According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 11.1 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.

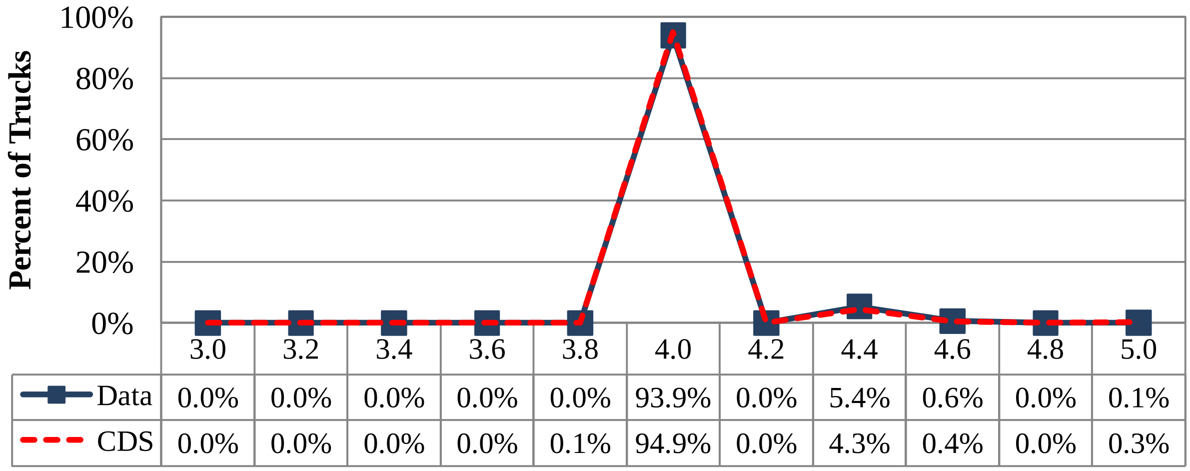


Figure 2-5 – Comparison of Class 9 Tractor Tandem Spacing

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

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

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

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	11/10/2008		3/14/2011		
3.0	0	0.0%	0	0.0%	0.0%
3.2	0	0.0%	0	0.0%	0.0%
3.4	0	0.0%	0	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	1	0.1%	0	0.0%	-0.1%
4.0	1637	94.9%	1219	93.9%	-1.0%
4.2	0	0.0%	0	0.0%	0.0%
4.4	75	4.3%	70	5.4%	1.0%
4.6	7	0.4%	8	0.6%	0.2%
4.8	0	0.0%	0	0.0%	0.0%
5.0	5	0.3%	1	0.1%	-0.2%
Average =	4.0 feet		4.0 feet		0.0 feet

From the table it can be seen that the greatest percentage 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 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 2008) based on the last calibration with the most recent two-week WIM data sample from the site (March 2011). Comparison of vehicle class distribution data indicates a 4.6 percent increase in the number of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have increased by 0.4 kips and average Class 9 GVW has increased by 15.6 percent for the March 2011 data. The data indicates that the average truck tandem spacing remained unchanged at 4.0 feet.

3 WIM Equipment Discussion

From a comparison between the report of the most recent validation of this equipment on November 12, 2008 and this validation visit, it appears that no changes to the equipment have occurred during this time.

3.1 Description

This site was installed on October 06, 2006 by International Road Dynamics. It is instrumented with quartz 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 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 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 August 06, 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 125 in/mi and is located approximately 448 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 102 in/mi and is located approximately 349 feet prior to the WIM scale. These areas of the pavement were closely investigated during the validation visit, and truck dynamics in this area were closely observed. A dip on the right side of the lane approximately 450 feet prior to the scales was noted. Although trucks were observed to be bouncing in this area, the dynamics appeared to diminish prior to the trucks crossing over the WIM scale area.

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

4.3 LTPP Pavement Profile Data Analysis

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

Table 4-1 – Recommended WIM Smoothness Index Thresholds

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

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

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

Table 4-2 – WIM Index Values

Profiler Passes			**Pass 1**	**Pass 2**	**Pass 3**	**Pass 4**	**Pass 5**	**Avg**
Left	LWP	LRI (m/km)	0.563	0.539	0.537			0.546
		SRI (m/km)	*0.290*	*0.339*	*0.303*			*0.311*
		Peak LRI (m/km)	0.707	0.637	0.638			0.661
		Peak SRI (m/km)	*0.383*	*0.396*	*0.369*			*0.383*
	RWP	LRI (m/km)	*0.446*	*0.486*	0.542			*0.491*
		SRI (m/km)	*0.274*	*0.354*	*0.331*			*0.320*
		Peak LRI (m/km)	0.564	0.589	0.619			0.591
		Peak SRI (m/km)	*0.350*	*0.449*	*0.451*			*0.417*
Center	LWP	LRI (m/km)	0.639	*0.482*	*0.467*	*0.437*	*0.420*	0.506
		SRI (m/km)	*0.497*	*0.358*	*0.432*	*0.156*	*0.302*	*0.361*
		Peak LRI (m/km)	0.646	0.561	0.556	0.533	0.531	0.574
		Peak SRI (m/km)	1.162	*0.526*	*0.485*	*0.341*	*0.420*	*0.629*
	RWP	LRI (m/km)	0.656	0.640	0.633	0.592	0.635	0.630
		SRI (m/km)	*0.400*	0.529	0.511	*0.492*	*0.486*	*0.483*
		Peak LRI (m/km)	0.664	0.652	0.666	0.633	0.662	0.654
		Peak SRI (m/km)	*0.632*	*0.727*	0.757	*0.657*	0.775	*0.693*
Right	LWP	LRI (m/km)	0.676	0.667	0.648			0.664
		SRI (m/km)	*0.414*	*0.487*	0.546			*0.482*
		Peak LRI (m/km)	0.676	0.675	0.707			0.686
		Peak SRI (m/km)	**0.828**	***0.748***	***0.674***			**0.750**
	RWP	LRI (m/km)	0.590	0.563	0.581			0.578
		SRI (m/km)	0.519	*0.452*	0.634			0.535
		Peak LRI (m/km)	0.658	0.631	0.647			0.645
		Peak SRI (m/km)	0.800	*0.742*	*0.659*			*0.734*

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 right 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 Validation 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 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 validation test truck runs were conducted on April 26, 2011, beginning at approximately 7:32 AM and continuing until 2:20 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with binned wood chips, 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 binned wood chips, and equipped with air suspension on the tractor, walking beam 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 Validation and were re-weighed at the conclusion of the Validation. The average test truck weights and measurements are provided in Table 5-1.

Table 5-1 – 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	77.2	12.0	15.7	15.7	16.9	16.9	17.5	4.3	35.3	4.1	61.2	75.0
2	62.8	11.5	14.4	14.4	11.3	11.3	17.2	4.4	33.0	4.1	58.7	70.0

Test truck speeds varied by 14 mph, from 53 to 67 mph. The measured Validation pavement temperatures varied 21.8 degrees Fahrenheit, from 44.1 to 65.9. The cloudy weather conditions prevented attaining the desired 30 degree temperature range. Table 5-2 provides a summary of the Validation results.

Table 5-2 – Validation Overall Results – 26-Apr-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-1.2 ± 6.2%	Pass
Tandem Axles	±15 percent	-0.4 ± 4.0%	Pass
GVW	±10 percent	-0.5 ± 2.7%	Pass
Vehicle Length	±3.0 percent (2.2 ft)	-0.4 ± 1.0 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.0 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 0.1 ± 0.9 mph, which is within the ±1.0 mph tolerance established by the LTPP Field Guide. In addition, 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.

5.1.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relationship exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 65 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-3.

Table 5-3 – Validation Results by Speed – 26-Apr-11

Parameter	95% Confidence Limit of Error	Low 53.0 to 57.7 mph	Medium 57.8 to 62.4 mph	High 62.5 to 67.0 mph
Steering Axles	±20 percent	-1.4 ± 4.6%	-1.5 ± 7.9%	-0.8 ± 7.0%
Tandem Axles	±15 percent	-1.7 ± 2.7%	1.2 ± 3.8%	-0.7 ± 3.3%
GVW	±10 percent	-1.6 ± 2.2%	0.7 ± 2.3%	-0.7 ± 1.9%
Vehicle Length	±3.0 percent (2.2 ft)	-0.3 ± 1.0 ft	-0.5 ± 1.1 ft	-0.3 ± 1.0 ft
Vehicle Speed	± 1.0 mph	0.1 ± 1.1 mph	0.1 ± 1.2 mph	0.1 ± 0.6 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.0 ft	0.0 ± 0.1 ft	0.0 ± 0.0 ft

From the table, it can be seen that, on average, the WIM equipment estimates all weights with similar accuracy. For GVW and tandem axle weights, the range of errors is consistent at all speeds. For steering axle weights, the range in error is greater at the medium and high speeds when compared with the low speeds. Consequently, 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 the low speeds and estimated GVW without apparent bias at the medium and high speeds. The range in error was similar throughout the entire speed range. There does not appear to be a correlation between speed and GVW estimates at this site.

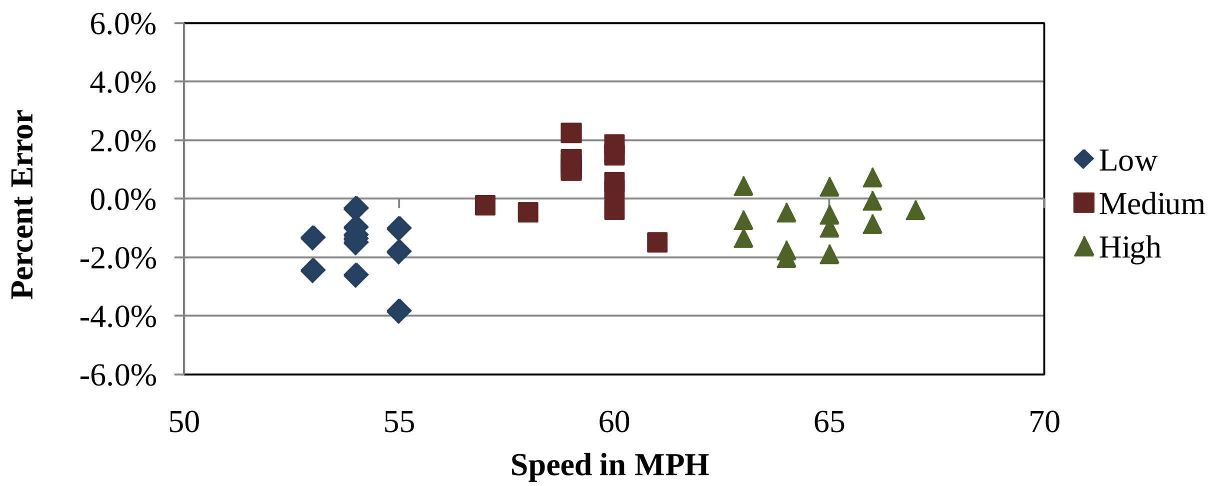


Figure 5-1 – Validation GVW Error by Speed – 26-Apr-11

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment estimates steering axle weights with similar accuracy at all speeds. The range in error appears to be greater at the medium and high speeds when compared with lower speeds.

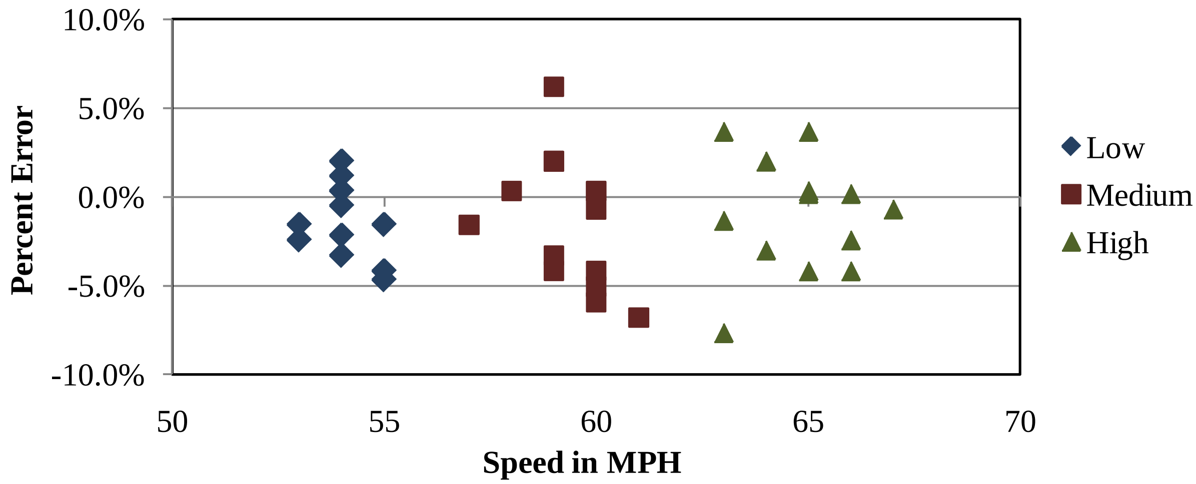


Figure 5-2 – Validation Steering Axle Weight Errors by Speed – 26-Apr-11

5.1.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-3, the equipment underestimates tandem axle weights at low speeds and estimates them without apparent bias at the medium and high speeds. The range in error is similar throughout the entire speed range.

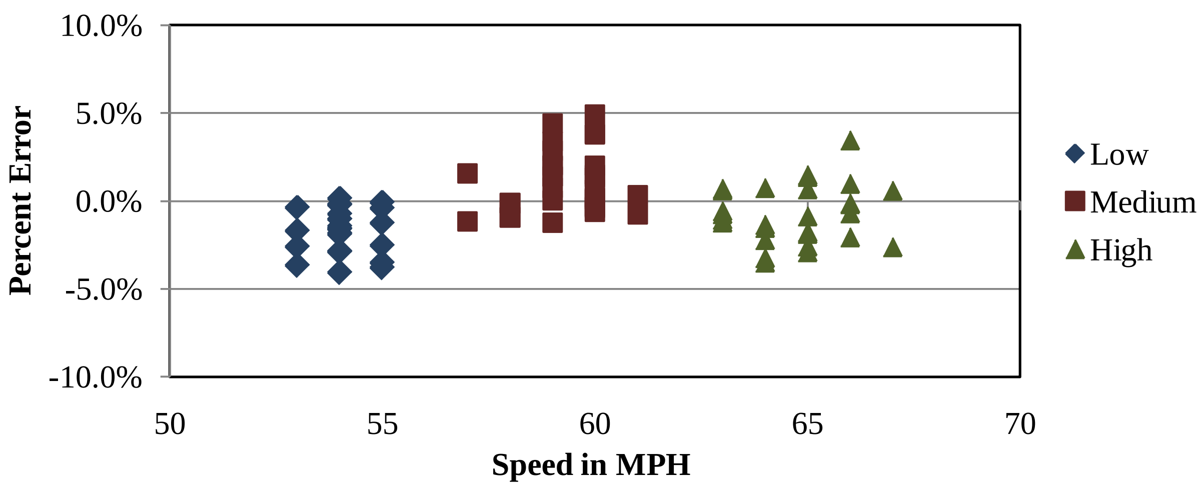


Figure 5-3 – Validation Tandem Axle Weight Errors by Speed – 26-Apr-11

5.1.1.4 GVW Errors by Speed and Truck Type

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

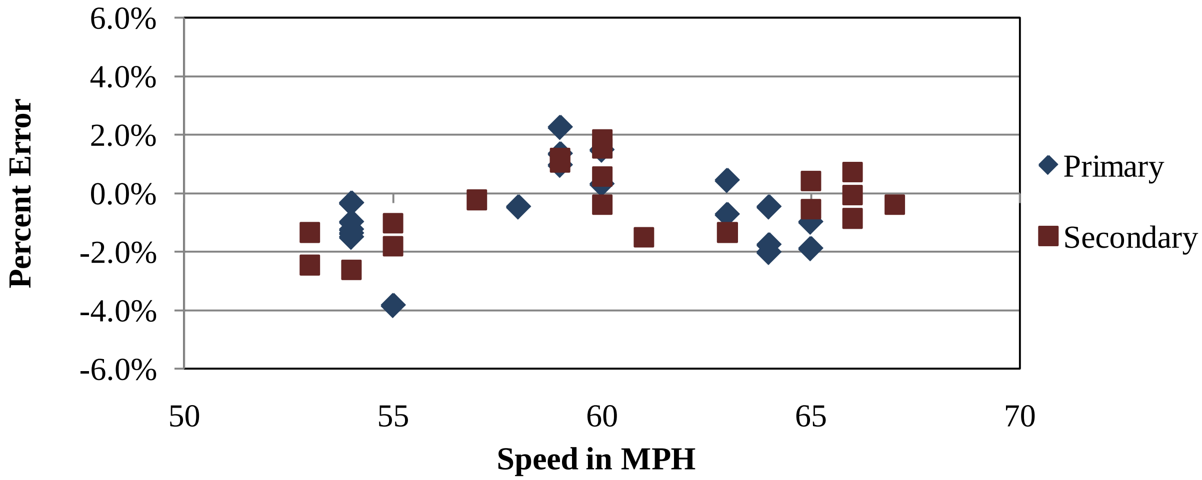


Figure 5-4 – Validation GVW Errors by Truck and Speed – 26-Apr-11

5.1.1.5 Axle Length Errors by Speed

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

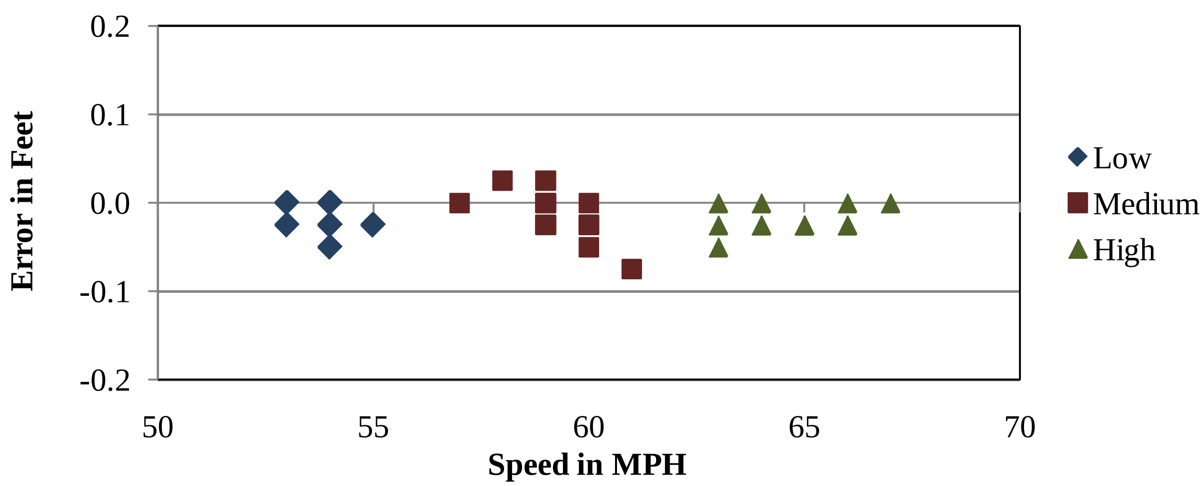


Figure 5-5 – Validation Axle Length Errors by Speed – 26-Apr-11

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 0.0 to -1.0 feet. Distribution of errors is shown graphically in Figure 5-6.

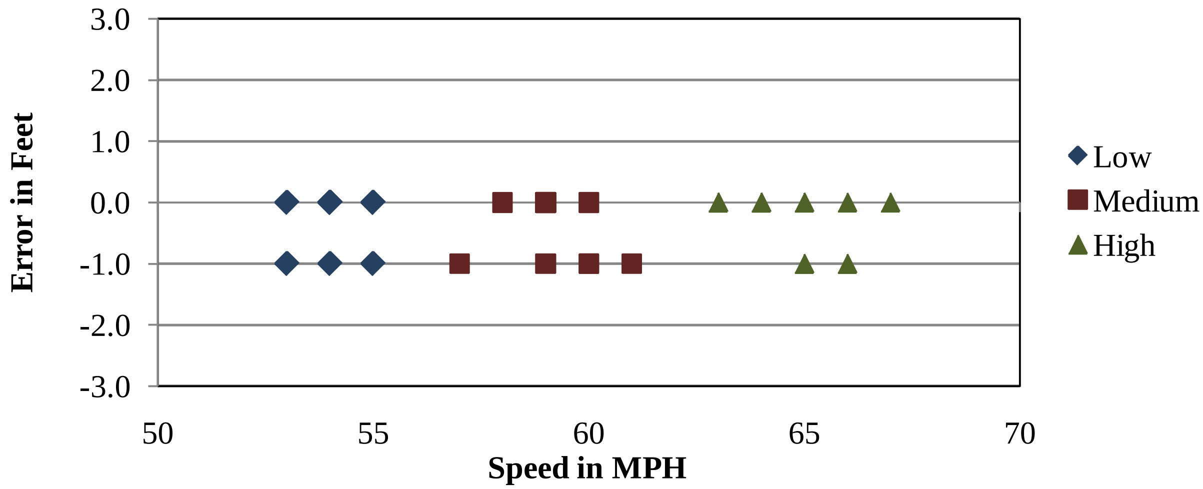


Figure 5-6 – Validation Overall Length Error by Speed – 26-Apr-11

5.1.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy. Although the range of pavement temperatures varied by only 21.8 degrees, from 44.1 to 65.9 degrees Fahrenheit, the validation test runs are being reported under three temperature groups – low, medium and high, as shown in Table 5-4.

Table 5-4 – Validation Results by Temperature – 26-Apr-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		44.1 to 52 degF	**52.1 to 62.0 degF**	**62.1 to 65.9 degF**
Steering Axles	±20 percent	-1.1 ± 5.9%	-0.1 ± 6.1%	-2.6 ± 7.3%
Tandem Axles	±15 percent	0.2 ± 4.9%	-0.6 ± 3.5%	-0.7 ± 4.2%
GVW	±10 percent	0.0 ± 2.9%	-0.5 ± 2.3%	-1.0 ± 3.3%
Vehicle Length	±3.0 percent (2.2 ft)	-0.4 ± 1.1 ft	-0.4 ± 1.1 ft	-0.3 ± 1.0 ft
Vehicle Speed	± 1.0 mph	0.1 ± 1.2 mph	0.0 ± 0.8 mph	0.2 ± 0.9 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.0 ft	0.0 ± 0.0 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 appears to estimate GVW without apparent bias at the low temperatures and slightly underestimate GVW at the medium and higher temperatures. There appears to be a slight correlation between temperature and GVW estimates at this site. The range in error is similar for the three temperature groups.

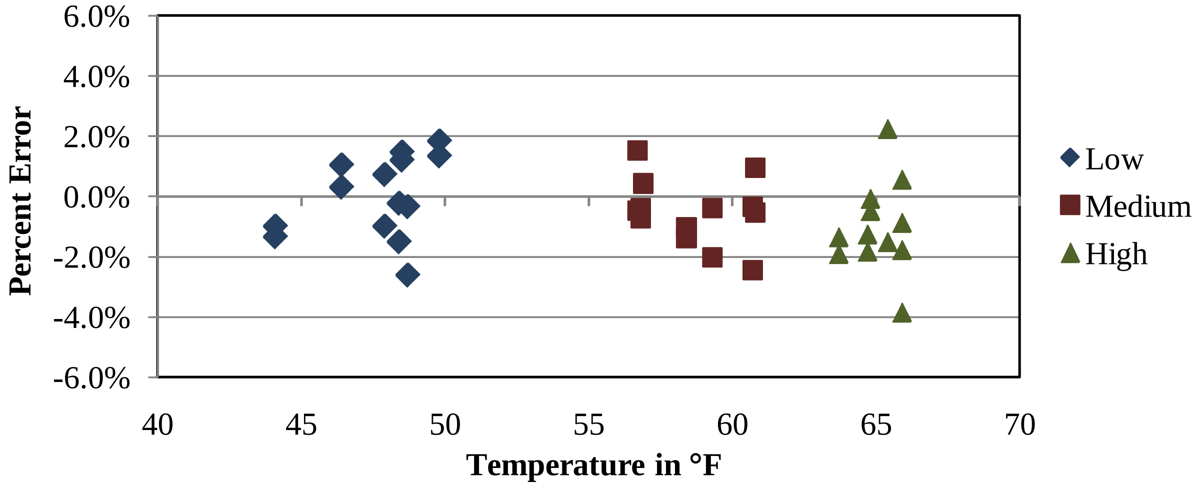


Figure 5-7 – Validation GVW Errors by Temperature – 26-Apr-11

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 illustrates that for steering axles, the WIM equipment appears to weight with similar accuracy at the low and medium temperatures, and underestimate at the higher temperatures, presenting a relationship between steering axle weight estimation and temperature.

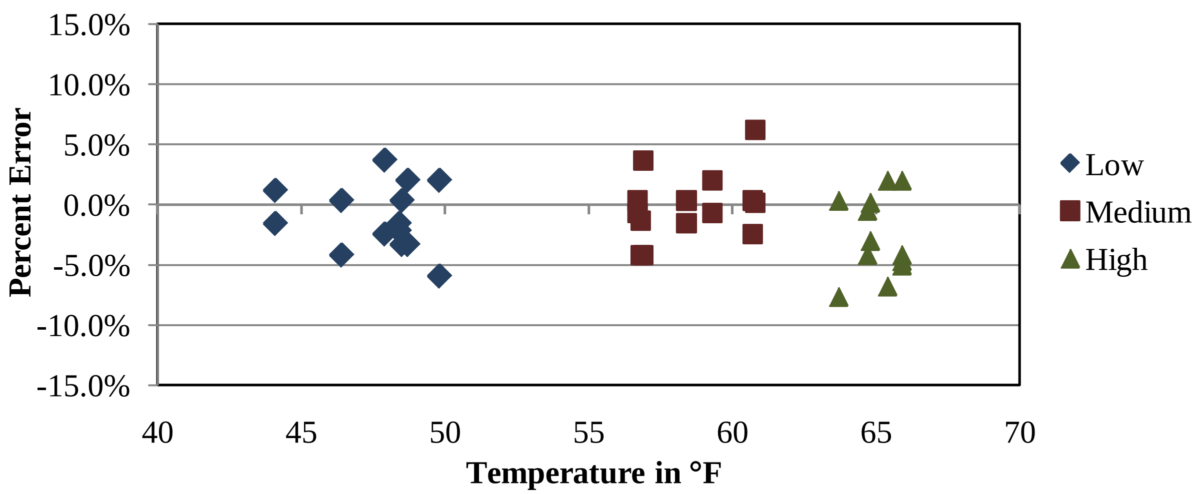


Figure 5-8 – Validation Steering Axle Weight Errors by Temperature – 26-Apr-11

5.1.2.3 Tandem Axle Weight Errors by Temperature

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

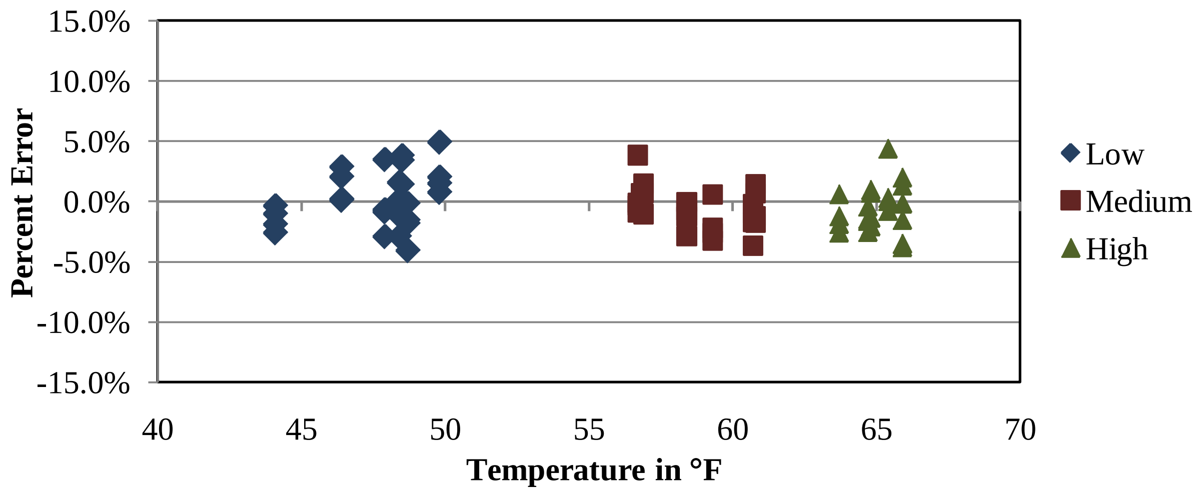


Figure 5-9 – Validation Tandem Axle Weight Errors by Temperature – 26-Apr-11

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 where error estimates for GVW for both trucks are similar at all temperatures. For both trucks, the range of errors and bias are consistent over the range of temperatures. Distribution of errors is shown graphically in Figure 5-10.

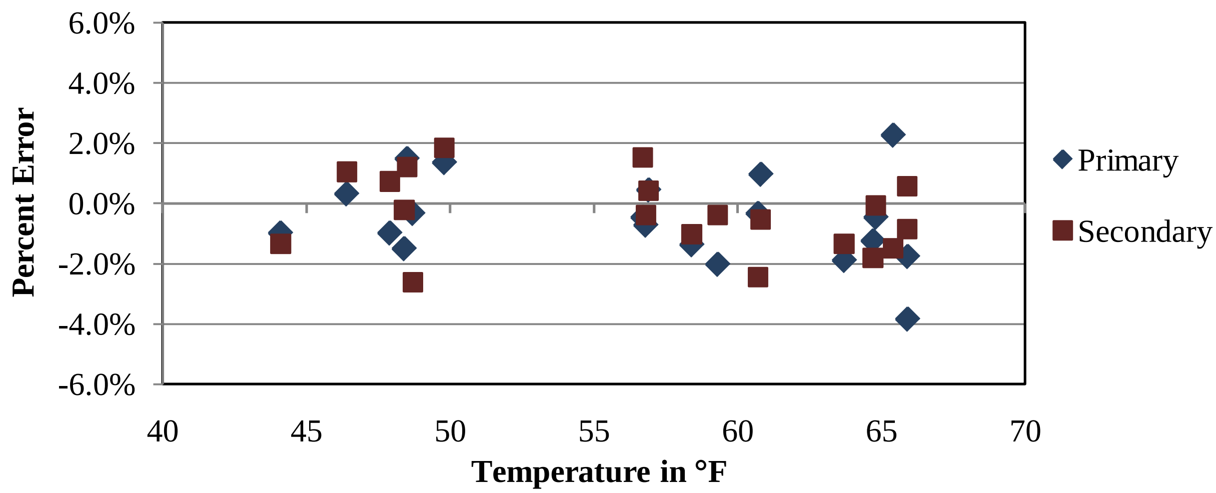


Figure 5-10 – Validation GVW Error by Truck and Temperature – 26-Apr-11

5.1.3 GVW and Steering Axle Trends

Figure 5-11 is provided to illustrate the predicted GVW error with respect to the post-validation errors by speed.

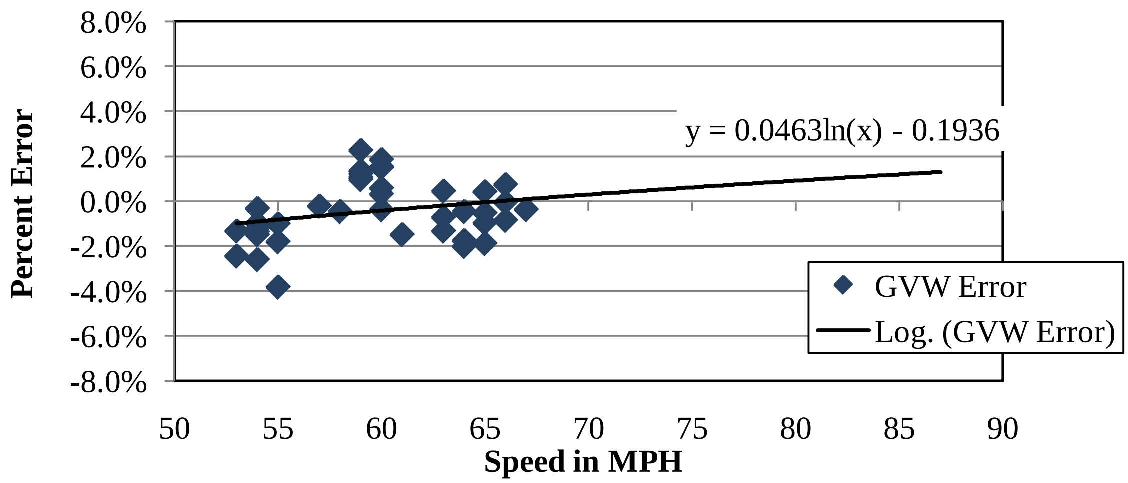


Figure 5-11 – GVW Error Trend by Speed

Figure 5-12 is provided to illustrate the predicted Steering Axle error with respect to the post-validation errors by speed.

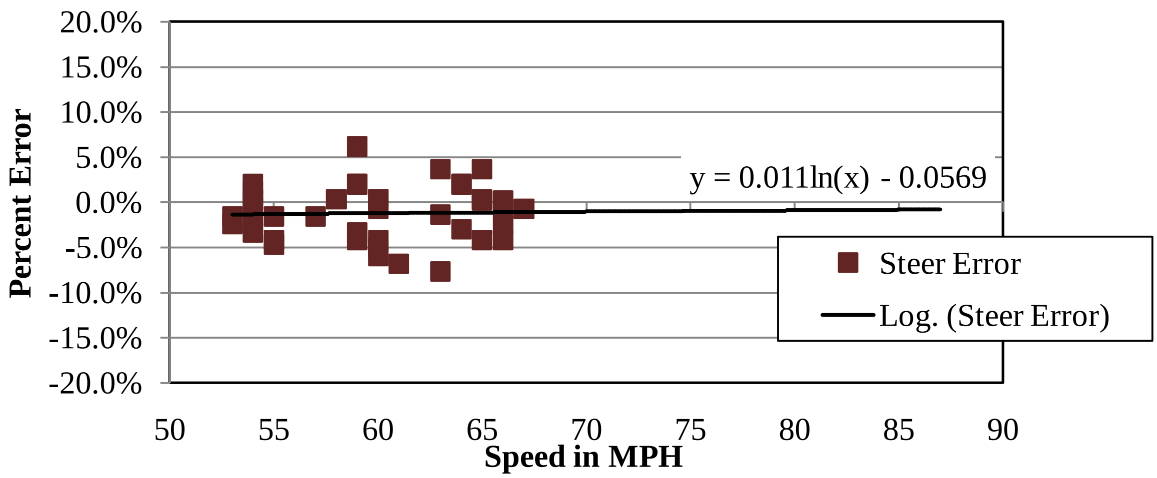


Figure 5-12 – Steering Axle Trend by Speed

5.1.4 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.

5.1.4.1 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 53 to 67 mph.
- Pavement temperature. Pavement temperature ranged from 44.1 to 65.9 degrees Fahrenheit.
- Interaction between the factors such as the interaction between speed and pavement temperature.

5.1.4.2 Results

For analysis of GVW weights, the value of regression coefficients and their statistical properties are summarized in Table 5-5. 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 5-5 are for the null hypothesis that assumes that the coefficients are equal to zero. The effects of speed and temperature were found to be statistically significant. For example, the probability that the effect of speed on the observed GVW errors occurred by chance alone was 4 percent.

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

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value
Intercept	-2.7254	2.8468	-0.9574	0.3448
Speed	0.1008	0.0473	2.1311	0.0400
Temp	-0.0668	0.0284	-2.3573	0.0240
Truck	0.0884	0.4008	0.2204	0.8268

The relationship between speed and measurement errors is shown in Figure 5-13. The figure includes a trend line for the predicted percent error. Besides the visual assessment of the relationship, Figure 5-13 provides quantification and statistical assessment of the relationship.

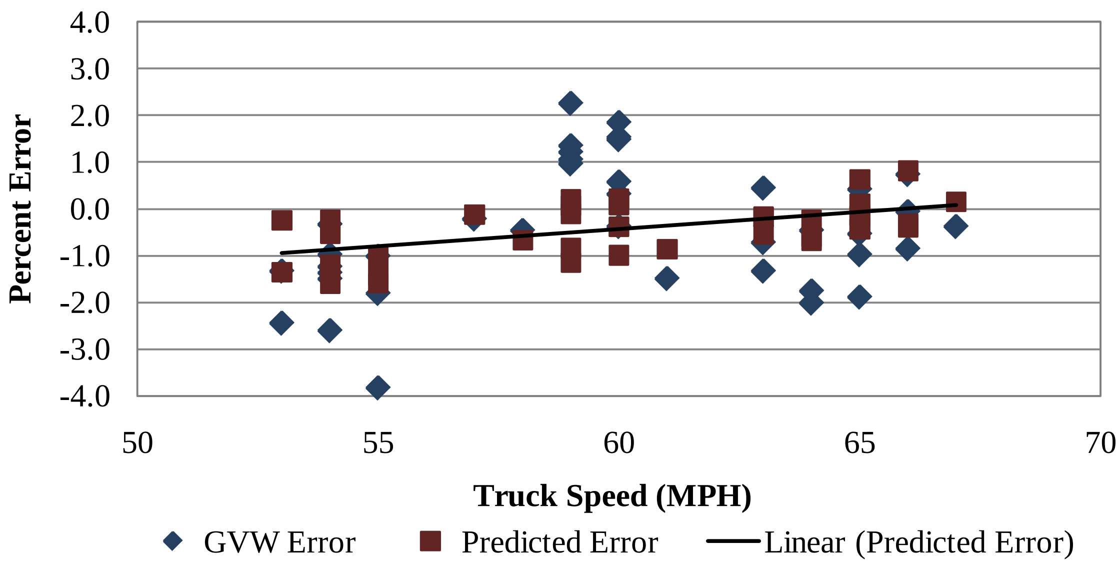


Figure 5-13 – Influence of Truck Speed on the Measurement Error of GVW

The quantification is provided by the value of the regression coefficient, in this case 0.1008 (in Table 5-5). This means, for example, that for a 10 mph increase in speed, the % error was increased by about 1 % (0.1008 x 10). The statistical assessment of the relationship is provided by the probability value of the regression coefficient. The effect of truck type on GVW was not statistically significant. The probability that the regression coefficient for truck type (-0.0884 in Table 5-5) is different from zero was 0.8268. In other words, there is about 83 percent chance that the value of the regression coefficient is due to the chance alone.

5.1.4.3 Summary Results

Table 5-6 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 5-6 indicates that the relationship was not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 5-6 – Summary of Regression Analysis

Factor	**Factor**					
	Speed		**Temperature**		**Truck type**	
	Regression coefficient	Probability value	Regression coefficient	Probability value	Regression coefficient	Probability value
GVW	0.1008	0.0400	-0.0668	0.0240	-	-
Steering axle	-	-	-0.0734	0.1674	-4.0521	0.0000
Tandem axle tractor	0.2045	0.0019	-0.0663	0.0790	1.3171	0.0155
Tandem axle trailer	-	-	-0.0709	0.1248	-	-

5.1.4.4 Conclusions

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

2. Temperature had statistically significant effect on the measurement errors of all factors.

3. Truck type had statistically significant effect on measurement errors of steering axle weights, and the tandem trailer axle weights. The regression coefficient for truck type in Table 5-6, 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 steering axle weights for the Secondary truck was about 4 % lower than the mean error for the Primary truck.

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

5.1.5 Classification and Speed Evaluation

The 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.

Due to the low volume of truck traffic, a manual sample of only 49 vehicles including 43 trucks (Class 4 through 13) was collected for the Validation classification study at this site. 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 5-7 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 5-8, five Class 3 vehicles were identified by the equipment as Class 5 vehicles, a Class 3 vehicle was identified as a Class 8 truck and a Class 4 vehicle (bus) was identified as a Class 5 vehicle. There was one Class 9 truck reported as unclassified by the equipment. The combined results presented an overcount of six Class 5 vehicles and one Class 8 vehicle and an undercount of six Class 3 vehicles, one Class 4 and one Class 9 vehicle, as shown in Table 5-7.

Table 5-7 – Validation Classification Study Results – 26-Apr-11

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	6	1	6	6	3	2	25	0	0	0	0
WIM Count	0	0	12	6	3	3	24	0	0	0	0
Observed Percent	12%	2%	12%	12%	6%	4%	51%	0%	0%	0%	0%
WIM Percent	0%	0%	24%	12%	6%	6%	49%	0%	0%	0%	0%
Misclassified Count	6	1	0	0	0	0	0	0	0	0	0
Misclassified Percent	100%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Unclassified Count	0	0	0	0	0	0	1	0	0	0	0
Unclassified Percent	0%	0%	0%	0%	0%	0%	4%	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 5-8.

Table 5-8 – Validation Misclassifications by Pair – 26-Apr-11

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

As shown in the table, a total of seven vehicles, including 0 heavy trucks (6 – 13) were misclassified by the equipment. Based on the vehicles observed during the 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 14.3%.

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 5-9.

Table 5-9 – Validation Unclassified Trucks by Pair – 26-Apr-11

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

Based on the manually collected sample of the 43 trucks, 2.3% of the vehicles at this site were reported as unclassified during the study. Although based on a small sample due to the low volume of truck traffic, 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 0.3 mph; the range of errors was 0.8 mph.

5.2 Calibration

The Validation study demonstrated that the site is currently providing high-quality research type traffic loading data. The mean measurement error for GVW of the two test trucks was 0.5 %. Consequently, no calibration of the equipment compensation factors was required. The operating system weight compensation parameters that were in place prior to the Validation and left in place at the conclusion are shown in Table 5-10.

Table 5-10 – Initial and Final System Parameters – 26-Apr-11

Speed Point	MPH	Left		Right	
		1	3	2	4
64	40	3650	3650	3282	3282
80	50	3786	3786	3404	3404
96	60	3942	3942	3544	3544
112	70	3868	3868	3478	3478
125	78	3506	3506	3153	3153
Axle Distance (cm)		365			
Dynamic Comp (%)		100			
Loop Width (cm)		183			

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	
13-Dec-06	0	0	0	N/A	N/A	0	0	N/A	N/A	N/A	0
13-Dec-06	0	0	0	N/A	N/A	0	0	N/A	N/A	N/A	0
28-Aug-07	100	0	0	0	50	0	0	N/A	N/A	N/A	0
29-Aug-07	N/A	0	0	0	0	0	0	N/A	N/A	N/A	0
11-Nov-08	100	25	25	N/A	100	0	N/A	N/A	N/A	N/A	0
12-Nov-08	0	0	0	N/A	0	0	0	N/A	N/A	N/A	0
26-Apr-11	100	0	0	0	0	0	0	0	0	0	2

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, and single axle and tandem axle weights 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
13-Dec-06	-0.6 ± 3.1	-5.2 ± 3.6	1.6 ± 5.4
13-Dec-06	3.0 ± 1.5	-1.6 ± 3.3	4.6 ± 1.8
28-Aug-07	-4.2 ± 2.9	-4.8 ± 4.0	-3.5 ± 4.6
29-Aug-07	-2.6 ± 2.7	-2.4 ± 4.6	-2.3 ± 4.5
11-Nov-08	-6.2 ± 2.3	-6.6 ± 3.4	-6.2 ± 2.6
12-Nov-08	-0.2 ± 2.3	-0.4 ± 3.9	-0.2 ± 2.7
26-Apr-11	-0.5 ± 1.3	-1.2 ± 3.0	-0.4 ± 2.0

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 does not demonstrate any trend or drift to underestimate or overestimate 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)			
		13-Dec-06	29-Aug-07	12-Nov-08	26-Apr-11
Steering Axles	±20 percent	-1.6 ± 6.8	-2.4 ± 9.2	-0.4 ± 7.9	-1.2 ± 6.2
Tandem Axles	±15 percent	4.6 ± 3.7	-2.3 ± 9.0	-0.2 ± 5.4	-0.4 ± 4.0
GVW	±10 percent	3.0 ± 3.1	-2.6 ± 5.4	-0.2 ± 4.6	-0.5 ± 2.7

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.

A review of the LTPP Standard Release Database 24 shows that there are two years of level “E” WIM data for this site. This site requires three 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
- Validation Sheet 16 – Site Calibration Summary
- 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

Minnesota, SPS-5
SHRP ID: 270500

Validation Date: April 26, 2011

APPLIED RESEARCH ASSOCIATES, INC.

Photo 1 – Cabinet Exterior

Photo 2 – Cabinet Interior (Front)

Photo 3 – Leading Loop

Photo 4 – Leading WIM Sensor

Photo 5 – Trailing WIM Sensor

Photo 6 – Trailing Loop Sensor

Photo 7 – Power Service Box

Photo 8 – Telephone Service Box

Photo 9 – Downstream

Photo 10 – Upstream

Photo 11 – Truck 1

Photo 12 – Truck 1 Tractor

Photo 13 – Truck 1 Trailer and Load

Photo 14 – Truck 1 Suspension 1

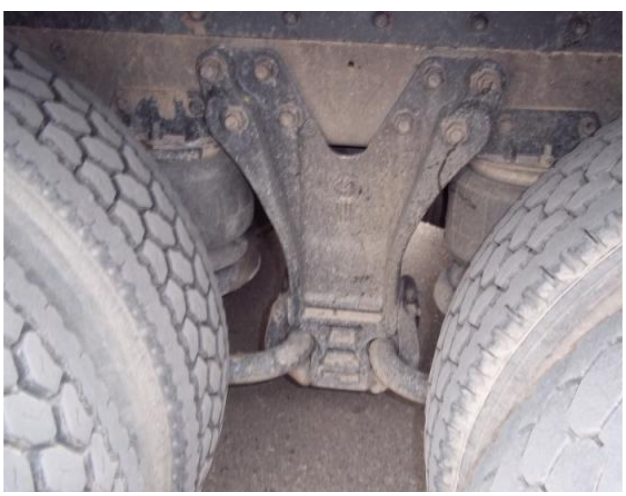


Photo 15 – Truck 1 Suspension 2

Photo 16 – Truck 1 Suspension 3

Photo 17 – Truck 1 Suspension 4

Photo 18 – Truck 1 Suspension 5

Photo 19 – Truck 2

Photo 20 – Truck 2 Tractor

Photo 21 – Truck 2 Trailer and Load

Photo 22 – Truck 2 Suspension 1

Photo 23 – Truck 2 Suspension 2

Photo 24 – Truck 2 Suspension 3

Photo 25 – Truck 2 Suspension 4

Photo 26 – Truck 2 Suspension 5

Traffic Sheet 16	STATE CODE:	27
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	270500
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	4/26/2011

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 4/26/11

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

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

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

5. **EQUIPMENT MANUFACTURER:** IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

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

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

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

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

Mean Difference Between -

	Mean		Standard Deviation
Dynamic and Static GVW:	-0.5%	Standard Deviation:	1.3%
Dynamic and Static Single Axle:	-1.2%	Standard Deviation:	3.0%
Dynamic and Static Double Axles:	-0.4%	Standard Deviation:	2.0%

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

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

		Low		High	Runs
a.	Low	53.0	to	55.0	12
b.	Medium	55.1	to	61.0	14
c.	High	61.1	to	67.0	14
d.			to		
e.			to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 27 SPS WIM ID: 270500 DATE (mm/dd/yyyy) 4/26/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3937 | 3539

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: Time

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: 717-512-6638

E-mail: dwolf@ara.com

Traffic Sheet 20 **LTPP MONITORED TRAFFIC DATA** **SPEED AND CLASSIFICATION STUDIES**	STATE CODE: 27 SPS WIM ID: 270500 DATE (mm/dd/yyyy) 4/26/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
52	6	5028	51	6	65	9	350	64	9
59	6	5544	59	6	55	7	385	55	7
65	9	5554	65	9	53	8	392	53	8
68	9	5560	68	9	56	6	401	56	6
59	8	5563	60	8	64	9	419	63	9
55	5	5626	55	5	67	9	422	67	9
61	9	5650	61	9	66	9	436	65	9
66	**8**	**5653**	**65**	**3**	68	9	437	68	9
65	9	5659	63	9	66	9	494	64	9
59	**5**	**5672**	**59**	**3**	67	9	521	67	9
65	9	5697	65	9	60	6	529	62	6
62	**5**	**5703**	**62**	**3**	64	9	577	64	9
60	6	5708	60	6	64	9	613	63	9
60	5	5709	60	5	64	9	620	63	9
68	9	5729	68	9	63	9	634	64	9
66	5	5855	65	5	61	5	660	61	5
67	9	5961	67	9	68	5	662	67	5
61	**5**	**5990**	**61**	**3**	68	9	673	68	9
67	**15**	**6051**	**65**	**9**	62	9	688	62	9
64	9	6097	63	9	65	5	703	65	5
66	6	6117	66	6	**58**	**5**	**704**	**58**	**4**
66	**5**	**6217**	**66**	**3**	**65**	**5**	**706**	**63**	**3**
64	9	258	64	9	63	9	707	63	9
65	9	282	65	9	58	7	719	58	7
64	7	302	65	7					

Sheet 1 - 0 to 50 Start: 9:37:00 Stop: 14:20:00

Recorded By: djw Verified By: ar

Validation Test Truck Run Set - Pre