Research Report
KTC-04-15/PL4-03-1F

KENTUCKY TRANSPORTATION CENTER

College of Engineering

ASSESSMENT OF DATA COLLECTION FOR ESAL DETERMINATIONS FOR THE KENTUCKY TRANSPORTATION CABINET, DIVISION OF PLANNING

UNIVERSITY OF KENTUCKY

UNIVERSITY OF KENTUCKY
College of Engineering
Kentucky Transportation Center

Our Mission

We provide services to the transportation community
through research, technology transfer and education.
We create and participate in partnerships to promote
safe and effective transportation systems.

We Value...

Teamwork -- Listening and Communicating, Along with Courtesy and Respect for Others
Honesty and Ethical Behavior
Delivering the Highest Quality Products and Services
Continuous Improvement in All That We Do

For more information or a complete publication list, contact us

KENTUCKY TRANSPORTATION CENTER

176 Raymond Building
University of Kentucky
Lexington, Kentucky 40506-0281

(859) 257-4513
(859) 257-1815 (FAX)
1-800-432-0719
www.ktc.uky.edu
ktc@engr.uky.edu

Research Report
KTC-04-15 / PL4-03-1F

Assessment of Data Collection for ESAL Determinations for the Kentucky Transportation Cabinet, Division of Planning

by

David Q. Hunsucker
Research Engineer

and

R. Clark Graves
Research Engineer

Kentucky Transportation Center
College of Engineering
University of Kentucky

in cooperation with
Kentucky Transportation Cabinet

and

Federal Highway Administration
US Department of Transportation

June 2004

1. Report Number KTC-04-15/PL4-03-1F	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle	5. Report Date
Assessment of Data Collection for ESAL Determinations for the Kentucky Transportation Cabinet, Division of Planning	June 2004
	6. Performing Organization Code
7. Author(s) David Q. Hunsucker and R. Clark Graves	8. Performing Organization Report No. KTC-04-15/PL4-03-1F
9. Performing Organization Name and Address **Kentucky Transportation Center** **College of Engineering** **University of Kentucky** **Lexington, Kentucky 40506-0281**	10. Work Unit No. 11. Contract or Grant No. Division of Planning
12. Sponsoring Agency Name and Address **Kentucky Transportation Cabinet** **State Office Building** **Frankfort, Kentucky 40602**	13. Type of Report and Period Covered Final 14. Sponsoring Agency Code

15. Supplementary Notes

Prepared in cooperation with the Kentucky Transportation Cabinet and the Federal Highway Administration

16. Abstract

The Kentucky Transportation Cabinet Cabinet's Division of Planning collects weight data, traffic volume data, and vehicle classification data. These data are used as inputs to determine ESALs (equivalent single axle loads). ESALs are used in the pavement design process to determine pavement thickness. There have been inconsistencies observed during the computation of the ESALs during the past three or four years. These inconsistencies have resulted in a significant inflation in the estimate of ESALs per year, which if used in the design process would result in significantly thicker pavements. For example, the ESALs per truck axle for rural principal arterials and rural minor arterials, between 1998 and 1999, more than doubled from, 0.275 to 0.555. Although there was only a small increase in this number after 1999, the value remained significantly higher than expected.

The objective of this research study was to evaluate the weight data collection equipment, on-site calibration procedures, and sampling techniques used by the Division of Planning for the different Aggregate Classes of highways in an effort to standardize procedures used by the Division of Planning to collect weight data.

17. Key Words	18. Distribution Statement
Weigh-In-Motion System Traffic volume Vehicle Classification Equivalent Single Axle Load	Unlimited, with approval of the Kentucky Transportation Cabinet

19. Security Classification (report)	20. Security Classification (this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	28	

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The authors wish to express their appreciation and gratitude to Mr. Dan Inabnitt, Chairman of the Study Advisory Committee and Mr. Jeff Young, Kentucky Transportation Cabinet, Division of Planning for their assistance during activities associated with this project. The authors also wish to acknowledge the support of the Study Advisory Committee members; Ms. Annette Coffey, Director, Kentucky Transportation Cabinet, Division of Planning, Mr. Rob Bostrom, Kentucky Transportation Cabinet, Division of Multimodel Programs, and Messrs. David Allen and Jerry Pigman, Kentucky Transportation Center. Also special thanks to the officers of the Kentucky Transportation Cabinet's Department of Motor Vehicles, Division of Kentucky Vehicle Enforcement for weighing the calibration trucks used during this project.

EXECUTIVE SUMMARY

The objectives of this research study were to examine the weight data collection equipment, on-site calibration procedures, and sampling techniques used by the Division of Planning on different functional classes of highways. The functionally classed highways have previously been grouped into aggregate classes for the purpose of processing traffic data and producing annual ESAL estimates.

This effort was an attempt to standardize procedures used by the Division of Planning to collect weight data to ensure that a statistically valid sample would be obtained for each of the Aggregate Classes in order to properly define traffic characteristics, particularly loadings. Data collected during the years from 1998 through 2001 were analyzed to determine if the data could be used to accurately calculate equivalent single axle loads (ESAL). The data collected for all Aggregate Classes were statistically evaluated and recommendations developed to utilize only those data that exhibited a demonstrated confidence.

The Kentucky Transportation Center also reviewed practices currently being used by selected states that collect traffic information used to determine equivalent single axle loads. The review encompassed both equipment type and procedures being used and what, if any, problems these states may have experienced. Calibration procedures most often used a Type 9 truck and adjusting the WIM systems such that the truck was weighed within an acceptable precision, typically within +/- ten percent of the known weight.

A calibration procedure was developed during this project that assists the Kentucky Transportation Cabinet's Division of Planning personnel in calibrating weigh-in-motion (WIM) scales used to collect traffic weight data. The calibrated scale will produce weight records that will fall within +/- ten percent of a vehicle's actual gross weight or axle weight. The calibration worksheet will automatically inform the WIM technicians of the optimum settings for the front-axle weight of the target vehicle.

It was determined that portable collection systems can be calibrated for a target vehicle type and used to collect data that will be within +/- ten percent of the actual weights of the vehicles in the traffic stream. Preliminary data collected from the portable systems to determine their transportability were inconclusive.

Improved maintenance of the collection systems is key to keeping a system that will perform well over a long period of time. Typical items include regular, routine inspections of the WIM system and the surrounding pavement for distresses. Repair often includes re-caulking the loops and piezo strips.

A refined data collection process should be formulated to insure that sufficient traffic data are being collected for each Aggregate Class of highways. It still must be determined, within the scope of the available resources, the amount of data necessary to be collected, the number of sites necessary, and optimal site locations for data collection.

1.0 INTRODUCTION AND BACKGROUND

The Kentucky Transportation Cabinet's Division of Planning collects weight data, traffic volume data, and vehicle classification data. This information is used as inputs in determining ESALs (equivalent single axle loads). ESALs are used in the pavement design process to determine pavement thickness. There have been inconsistencies observed during the computation of the system default ESALs in the past four years. These inconsistencies have resulted in a significant inflation in the estimate of ESALs per year, which if used in the design process would result in significantly thicker pavements. The inconsistent data is most obvious for Aggregate Class II (rural principal arterials and rural minor arterials), Aggregate Class V (urban other freeways and expressways and urban other principal arterials), and Aggregate Class VI (urban minor arterials, urban collectors and urban locals). Pigman, etc. previously defined the aggregation of highway functional classes, in a 1995 research report and these are detailed for the reader in Appendix A.

More specifically, in Aggregate Class II between 1998 and 1999, the average ESALs per truck axle more than doubled from, 0.275 to 0.555. However, there was only a small increase in the average number of ESALs per axle in Aggregate Class II after 1999, but these values remained significantly higher than expected. A substantial increase in the average number of ESALs per truck axle was observed in both Aggregate Class V and Aggregate Class VI between 1999 and 2000, nearly tripling and quadrupling, respectively. The average ESALs per axle determined for the succeeding years in these two aggregate classes did not increase dramatically but again, were extremely higher than preceding year's data would have predicted through use of a trend line.

The objectives of this research study were to examine the weight data collection equipment, on-site calibration procedures, and sampling techniques used by the Division of Planning for the different Aggregate Classes of highways. The effort was an attempt to standardize procedures used by the Division of Planning to collect weight data to ensure that a statistically valid sample would be obtained for each of the Aggregate Classes in order to properly define traffic characteristics. Data collected during the years from 1998 through 2001 were analyzed to determine if the data could be used to accurately calculate equivalent single axle loads. The data collected for all Aggregate Classes were statistically evaluated and recommendations developed to utilize only those data that exhibited a demonstrated confidence. The Kentucky Transportation Center also reviewed practices currently being used by selected states that collect traffic information used to determine equivalent single axle loads. The review encompassed both equipment type and procedures being used and what, if any, problems these states may have experienced.

2.0 PRACTICES IN SELECTED STATES

North Carolina, Ohio, California, Florida and Montana were states identified by the study advisory committee as having superior weigh-in-motion (WIM) data collection programs for planning purposes. Not surprisingly all of the contacts within these states indicated that maintenance was key to keeping a system that performed well over a long period of time.

Typical items included regular, routine inspections of the WIM system and the surrounding pavement for distress. Repair often included re-caulking the loops and piezo strips.

Fine-tuning or calibration takes place throughout the design life of a WIM site. Parameters are adjusted when problems are identified, generally through some type of quality assurance program. It was deemed most important that data analysts be strongly familiar with site and traffic characteristics, truck operating characteristics and the WIM system's vehicle passage processing in order to validate data and fine tune the calibration. Calibration procedures for these states generally consisted of using Type 9 trucks and adjusting parameters such that the calibration truck was weighed within an acceptable precision, typically within ten percent of the known weight.

3.0 DEVELOPMENT OF A CALIBRATION METHOD AND WORKSHEET

The data collection process typically uses a PEEK ADR 2000 and a pair of piezoelectric axle sensors, also known as piezo cables, in each lane data is being collected. For lanes in which truck weights are desired, the process involves setting a value for the front axle of weight of a target vehicle and using the auto-calibration feature of the PEEK ADR to compensate for changes in pavement temperature. The target vehicle is chosen based on characteristics of the traffic stream to ensure sufficient changes are made in the auto-calibration factor to compensate for changes in temperature.

The WIM calibration procedure developed during this project involved varying the value of the front axle weight of the target vehicle in the PEEK controller unit and collecting data from the passage of calibration trucks having a known weight. Typically a loaded Type 9, five-axle, 18-wheel truck is most desirable for this purpose. However, a Type 6, three-axle dump truck was used more often for this effort because of the ready availability to researchers and the safety feasibility (ease and safety of turnaround) of this truck type. The probable value of the front-axle weight of a target vehicle was determined by taking ten data points at three, or four selected values of the target vehicle's front axle weight. For example, when the target vehicle was a Type 2 vehicle, a passenger car, ten data points were collected at three, or four weights around 2,000 pounds, both above and below this value, which is the value that Kentucky's WIM technicians had previously used as an average weight for the front axle of Type 2 vehicles. If the target vehicle for a site was a Type 9, the data were collected at values around 10,000 pounds. This effort produced the desired calibration curve from which the optimum weight of the front axle of the target vehicle is determined. Plotting the results and determining where this line intersects the gross vehicle weight of the calibration vehicle determined the most likely value for the front axle of the target vehicle. A graphical example of this process is presented in Figure 1.

The WIM collection site used for the initial development of the calibration procedure was located in southern Jessamine County on US 27. The target vehicle for this site is a Type 2, or a passenger car. Both a Type 6 and a Type 9 truck were used during in the calibration process. Data were collected while using the PEEK controller unit to vary the target value weight of the target vehicle's front-axle weight at front-axle weight to values of 1,500, 2,000, 2,500 and 3,500 pounds. Data were collected only after allowing the current calibration factor in the PEEK controller to stabilize once the target value was changed.

Figure 1 was produced using the results obtained with the Type 9-calibration truck. The value to be used for the front axle weight of the target vehicle to set the PEEK ADR 2000 controller is determined at the intersection of the calibration curve and the gross-weight line of the calibration truck. A work sheet for data entry was developed that automatically calculates this intersection point and informs the users, through the use of a macro equation, of the value at which the front axle weight of the target vehicle should be set. The work sheet is presented in Appendix B.

For this site, the researchers requested the WIM technician to set the front axle weight for the Type 2 target vehicle at 2,600 pounds for the northbound lane and 2,250 pounds for the southbound lane, and to set the controller to collect all vehicle statistics. This data would be used to assess the impact of the calibration change through subsequent testing. It must be noted that the calibration procedure must be performed on a site-by-site basis. This is due to differing vehicle reactions caused by variations in pavement roughness and grade.

There were ten permanent sites calibrated during this project and those results are included in Table 1 and the calibration curves for the permanent weigh stations are presented in Appendix C. The target weight shown in column four of Table 1 represents the value obtained as a result of the calibration activity and is to be entered into the PEEK ADR 2000 controller after the calibration for the front-axle weight of the target vehicle. For instance the target vehicle at the P65 in Jessamine County was a Type 2 classed vehicle. The target vehicle is used in the PEEK ADR 2000 to auto-calibrate the system to compensate for changes in temperature. After performing the data collection for the WIM calibration, it was determined that the target weight for the front axle of the target vehicle was 2,600 pounds in the northbound lane and 2,250 pounds in the southbound lane.

Researchers also evaluated a similar method to calibrate a portable WIM system to determine if the scale could be calibrated at one site and moved to another site to collect data without re-calibrating the scale. It was important that the same scale and data collection unit be utilized for this purpose so that there were consistencies in the equipment. The ability to move a previously calibrated portable WIM system from one site to another without having to recalibrate the system would allow increased data collection, or a shorter amount of time necessary to collect the same data. However, the site difference (grade, pavement roughness, etc.) from the spot where the portable WIM was originally calibrated to where it has been moved may necessitate the WIM to be recalibrated each time it is moved. Sufficient data were not collected during this study to determine the portability of the WIM scale. The feasibility of using a calibrated portable WIM is being determined in the study currently being conducted related to new WIM technologies.

4.0 RESULTS AFTER CALIBRATION IMPLEMENTATION

Data obtained and analyzed after calibration were used to compare to historical averages of ESALs for Aggregate Class I, II, III and V. Three of the sites calibrated were in the Aggregate Class II category and are shown in Figure 2. The results of the calibration efforts and subsequent average ESAL determinations provided further evidence that re-calibration of the permanent WIM stations offered more reasonable results than were being determined with data obtained prior to the calibration effort and more in line with planner's expectations. Other charts comparing historical average ESALs per vehicle to those determined using limited data obtained after calibration may be found in Appendix D.

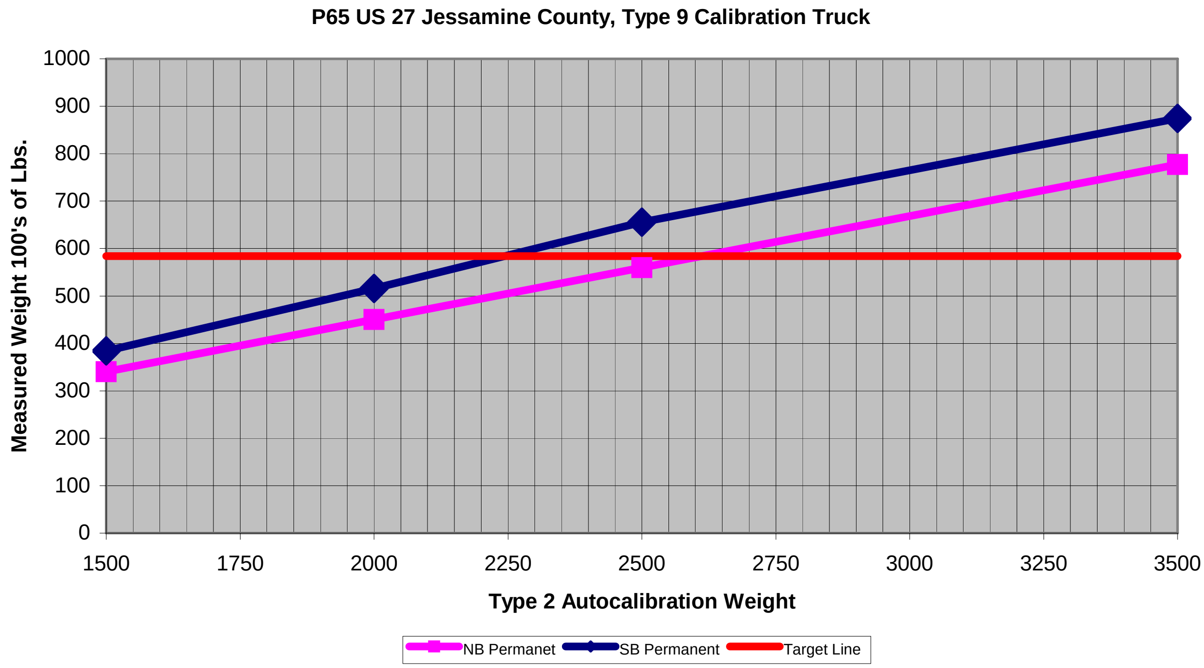
5.0 CONCLUSIONS AND RECOMMENDATIONS

A calibration procedure was developed during this project that, if used properly, was found to produce weight records that fell within +/- ten percent of the calibration vehicle's actual gross weight. Once completed, the calibration worksheet assists the WIM technicians in determining the optimum values to be used to set the front-axle weight of the target vehicle in the PEEK 2000 ADR controller. Portable collection systems can be calibrated for a target vehicle type and used to collect data that will be within +/- ten percent of the actual weights of the calibration vehicles used in the study. Preliminary data collected from the portable systems to determine their portability were inconclusive.

The key to maintaining good WIM systems is to perform system status checks and preventative maintenance on a regular basis. The importance of regular system checks cannot be overstated. For example, during the evaluation of the site on US 127 in Owen County, it was noted that the configuration for the PEEK controller was set for a Type 9, five-axle target vehicle, with a front-axle value of 10,000 pounds and to determine a new auto-calibration factor after 150 of the target vehicles passed over the WIM. The target values for the PEEK ADR 2000 controller were thought to have been set for a Type 2 vehicle having a 2,000-pound front-axle weight and, for auto-calibration purposes, to determine a new calibration factor after the passage of 25 vehicles. It was unknown how long these values had been in use by the data collection system.

A quality assurance program to regularly monitor the WIM data collection systems would detect anomalies such as these. A higher degree of monitoring frequency is needed. A weekly, or bi-weekly monitoring program should be implemented over the long term to ensure continued performance of the permanent WIM stations. Data collected from the permanent WIM sites should be archived and averages of front axle weights should be determined during the status check. Comparing the recent averages to the historical average will indicate if the WIM system is drifting or may indicate an equipment problem or roadway issue. System anomalies can be detected earlier through vigilant monitoring. Routine, regular site visits should continue to be used to perform preventative maintenance activities.

Additional efforts should be directed toward determining how accurate a portable scale is if it is calibrated at one location and moved to another and used to collect data. Preliminary work was performed in this area but the original calibration of the portable scale involved the use of a Type 5 truck, which was unacceptable. The portable system was subsequently recalibrated at the Fayette County P74 site and tested at the Jessamine County P65 site. Results from data collected at the P65 site were promising but additional efforts in this area will be necessary.



Each data point on the chart represents an average of 10 actual data observations.

Figure 1. WIM Calibration Curve for US 27, Jessamine County (P65).

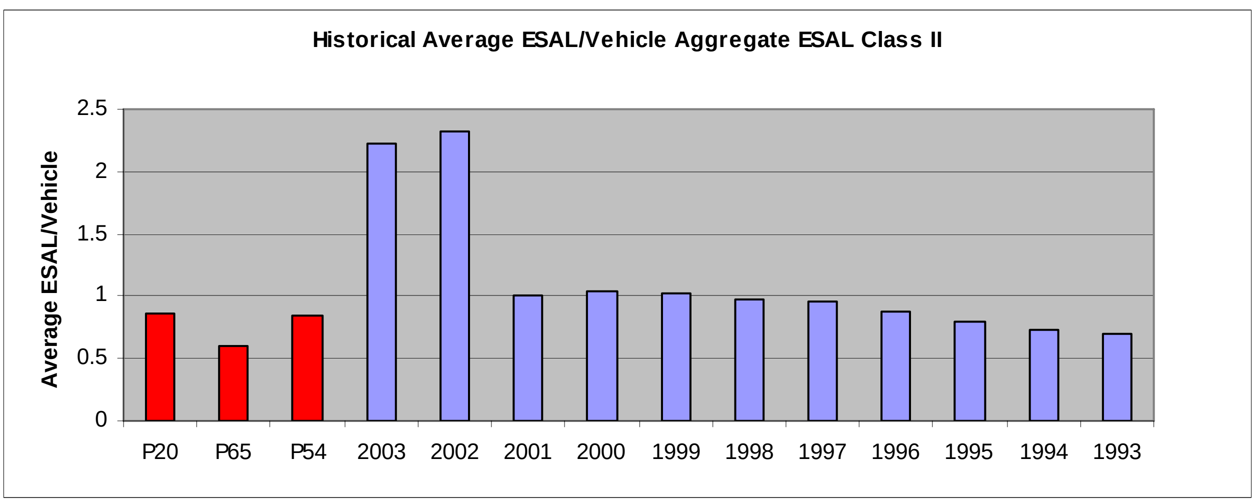


Figure 2. Historical average of average ESAL per vehicle after calibration for sites within Aggregate Class II.

Station	Lane	Target Vehicle	Target Weight
P54, Bluegrass Parkway, Nelson County	EB WB	Type 9	8,450 10,690
P53 Bluegrass Parkway, Woodford County	EB WB	Type 9	10,950 9,690
P65, US 27, Jessamine County	NB SB	Type 2	2,600 2,250
P55, US 127, Owen County Potential Vehicle Classification Problems	NB SB	Type 2	2,100 2,050
P74, I-64, Fayette County Unable to Complete Calibration Initially	EB WB	Type 9	11,750 10,600
P20, Mountain Parkway, Clark County	EB WB	Type 2	2,400 2,250
P80, US 31E, Jefferson County	NB SB	Type 3	2,420 2,690
P73, KY 11 Owsley County	NB SB	Type 2	2,500 2,530
P17, US 60B Davies County Variability in Data, Unable to Determine Calibration Factor			
P58, US 41, Henderson County	NB SB	Type 2	1,750 2,300
P72, I-65 Bullitt County	Center Lane NB SB	Type 9	10,580 10,550
	Outside Lane NB SB	Type 9	11,660 11,150

Table 1. WIM Sites Calibrated

BIBLIOGRAPHY

Jerry G. Pigman, David L. Allen, Jack Harison, Neil Tollner and David H. Cain, Research Report KTC-95-7, Equivalent Single Axeload Computer Program Enhancements, Kentucky Transportation Center, University of Kentucky, May 1995 (Revised December 1995).

David L. Allen and Jerry G. Pigman, Research Report KTC-96-8, A Proposed Method of Calibration and Correlation of Weigh-In-Motion Systems, Kentucky Transportation Center, University of Kentucky, April 1996.

American Society of Testing Materials (ASTM) Standard Specification E1318-02, Standard Specification for Highway Weigh-in-Motion (WIM) Systems with User Requirements and Test Methods.

Section 7-1 7. Weigh-in-Motion Accuracy and Quality Assurance Related to Problems Occurring at the WIM Site, www.ctre.iastate.edu/research/**wim**_pdf/Secti7.pdf

Section 5, Truck Weight Monitoring, Traffic Monitoring Guide, FHWA, May 2001, http://www.fhwa.dot.gov/ohim/tmguide/word/tmg5.doc

Key Findings from LTPP Analysis 1990-1999, Report No. FHWA-RD-00-085, 2000 and Weigh-in-Motion, Report No. FHWA-RD-98-104, 1998, http://www.tfhrc.gov/pavement/ltpp/key.htm

Mark Hallenbeck and Herbert Weinblatt, Equipment for Collecting Traffic Load Data, NCHRP Report 509, National Cooperative Highway Research Program, Transportation Research Board, 2004.

Bonnie L. Walters and Robert K. Whitford, Strategy for Handling the Statistics of Truck Weight Data in Alaska, Presented at the North American Travel Monitoring Exhibition and Conference, Charlotte, North Carolina, May 11-15, 1998.

Mark Hallenbeck and Tu Cheng Kuo, Use of Weigh-In-Motion Data for Pavement Design – a Preliminary Examination of ESAL Calculation Using WIM Data, Third National Conference on Weigh-In-Motion Applications and Future Directions, March 1989.

Sedat Gulen, John Nagle, John Weaver and Victor Gallivan, Determination of Practical ESALS Per Truck Values on Indiana Roads, FHWA/IN/JTRP-2000/23, December 2000.

Tech Brief, WIM Scale Calibration: A Vital Activity for LTPP Sites, Publication No. FHWA-RD-98-104, July 1998.

Henry L. Bishop, et al., The Rhode Island Experience, Presented at the National Traffic data Acquisition Conference, Albuquerque, New Mexico, May 5-9, 1996.

Mark Hallenbeck, Precision of Annual ESAL Loading Estimates Presented at the National Traffic Data Acquisition Conference, Albuquerque, New Mexico, May 5-9, 1996.

APPENDIX A

Aggregation of Functional Classes

Aggregate Class	**Functional Class**
Class I	**Rural Interstates (FC1)**
Class II	**Rural Principal Arterial (FC 2)**
	Rural Minor Arterial (FC 6)
Class III	**Rural Major Collector (FC 7)**
	Rural Minor Collector (FC 8)
	Rural Local (FC 9)
Class IV	**Urban Interstate (FC 11)**
Class V	**Urban Other Freeways and Expressways (FC 12)**
	Urban Other Principal Arterial (FC 14)
Class VI	**Urban Minor Arterial (FC 16)**
	Urban Collector (FC 17)
	Urban Local (FC 19)

APPENDIX B

WIM Calibration Worksheet

I-65 - MP 6.08, Station-P72 08/12/2004

Mile Point	6.08	Date	8/12/2004
County	Bullitt	Time	10:00 AM
Route	I-65	Weather	Cloudy
Station Number	P72	Operator	JY,SS
Number of Scales	2	Data Collector Serial Number	11283-0003
		Type of WIM Sensor	BL Sensor

		Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Total
Truck 1,	Type 6	12,840	18,900	18,900	-	-	50,640

NB Permanent, CL				Type 6 WIM #1					
			Auto	Axle Loads					
Time	Pave Temp	Air Temp	Cal. Target	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Total
			2,000						506
10:22				129	177	199			505
10:35				140	196	196			532
10:48				134	165	166			465
11:01				116	189	189			494
11:22				149	197	189			535
11:30									
			2,500						432
12:34				116	182	145			443
12:46				111	158	168			437
12:58				111	151	155			417
13:10				101	141	140			382
13:22				105	170	155			430
13:34				128	172	185			485
			1,800						641
13:58				164	257	238			659
14:11				166	196	241			603
14:23				172	246	249			667
14:35				173	227	220			620
14:47				188	235	232			655

SB Permanent CL				Type 6 WIM #2					
			Auto	Axle Loads					
Time	Pave Temp	Air Temp	Cal Target	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Total
			10,550						545.5
10:22				142	183	199			524
10:35				139	203	177			519
10:48				160	205	198			563
11:01				148	220	238			606
11:22				136	213	184			533
11:30				140	186	202			528
			9,000						462
12:34				109	154	155			418
12:46				128	185	176			489
12:58				124	171	176			471
13:10				122	157	157			436
13:22				116	174	192			482
13:34				121	171	184			476
			13,000						690
13:58				170	288	268			726
14:11				182	233	233			648
14:23				188	262	246			696
14:35									
14:47									

	Enter Values in this Column
Mile Point	6.08
County	Bullitt
Route	I-65
Station Number	P72
Number of Scales	2

Calibration Truck #1

Scale 1	
Direction of Traffic	NB
RL/CL/LL	CL
Perm/Portable	Permanent
Auto Calibration Factor	**10,467**

Calibrate Scale 1

Scale 2	
Direction of Traffic	SB
RL/CL/LL	CL
Perm/Portable	Permanent
Auto Calibration Factor	**9,811**

Calibrate Scale 2

Scale 3	
Direction of Traffic	NB
RL/CL/LL	RL
Perm/Portable	port
Auto Calibration Factor	**#DIV/0!**

Calibrate Scale 3

Scale 4	
Direction of Traffic	WB
RL/CL/LL	RL
Perm/Portable	Port
Auto Calibration Factor	**#DIV/0!**

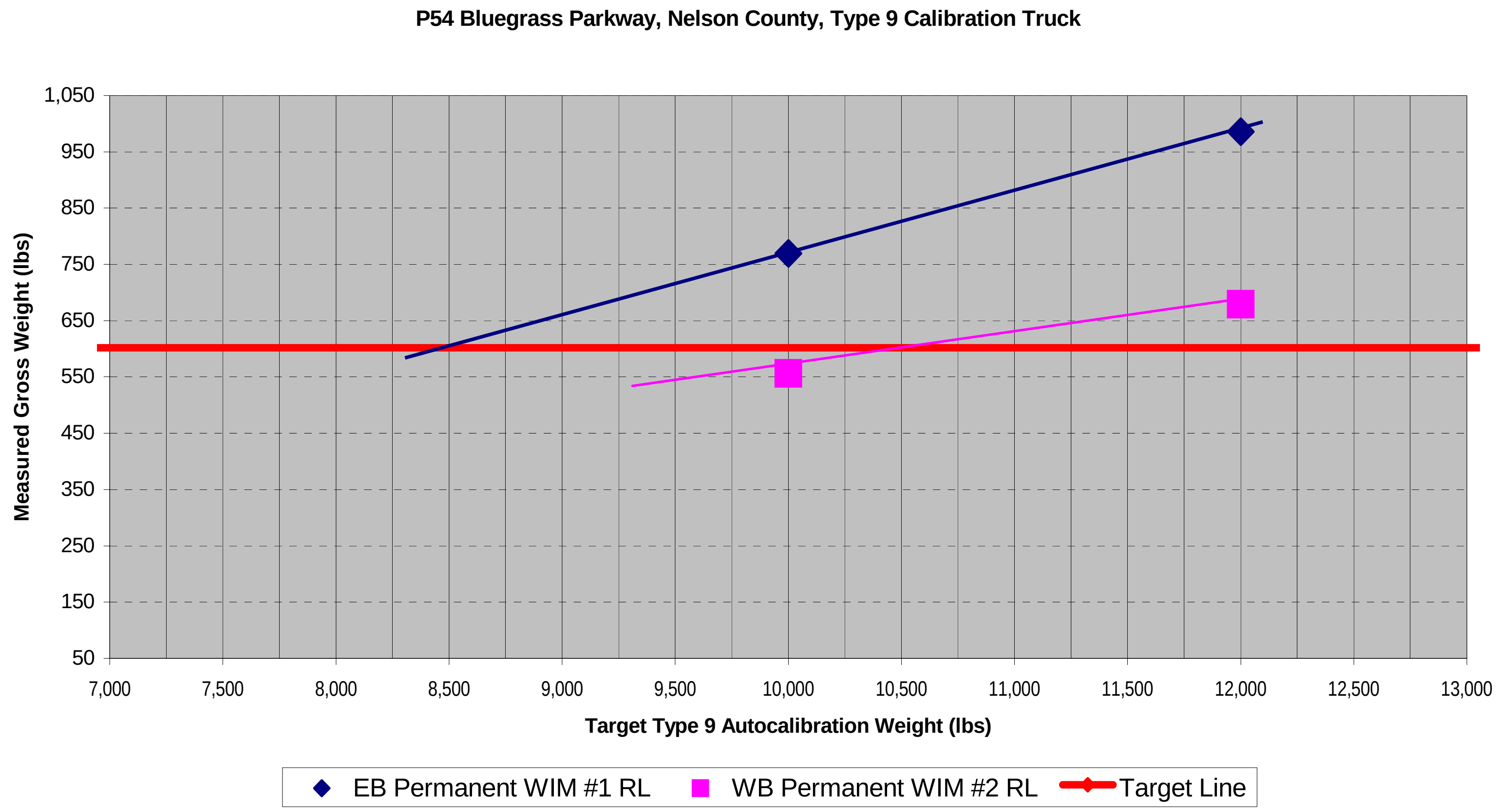
Calibrate Scale 4

Date	8/12/2004
Time	10:00 AM
Weather	Partly Cloudy
Operator	JY,SS
Data Collector Serial Number	11283-0003
Type of WIM Sensor	BL Sensor
Calibration Truck 1 Type	Type 6
Axle 1 Weight	12,840
Axle 2 Weight	18,900
Axle 3 Weight (if applicable)	18,900
Axle 4 Weight (if applicable)	
Axle 5 Weight (if applicable)	

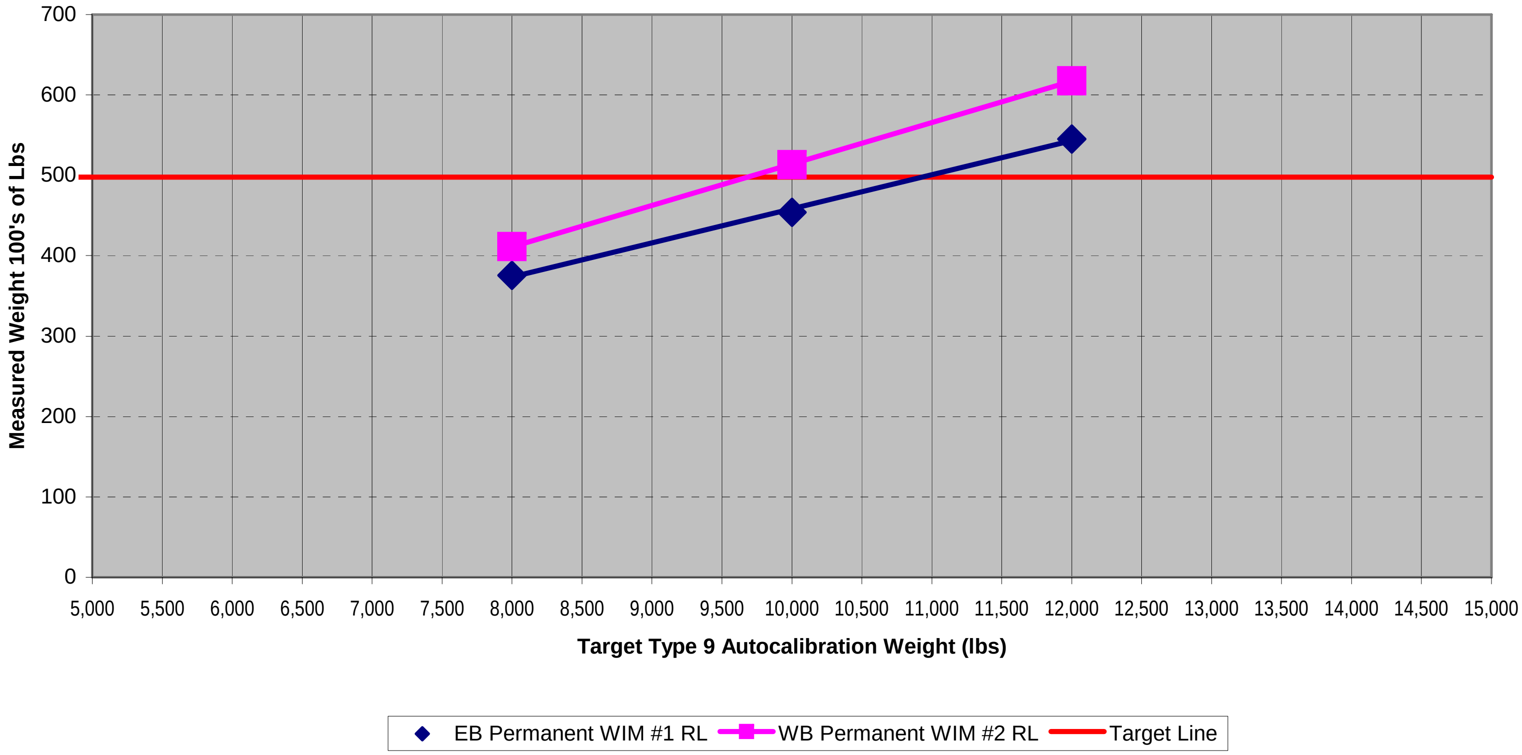
APPENDIX C

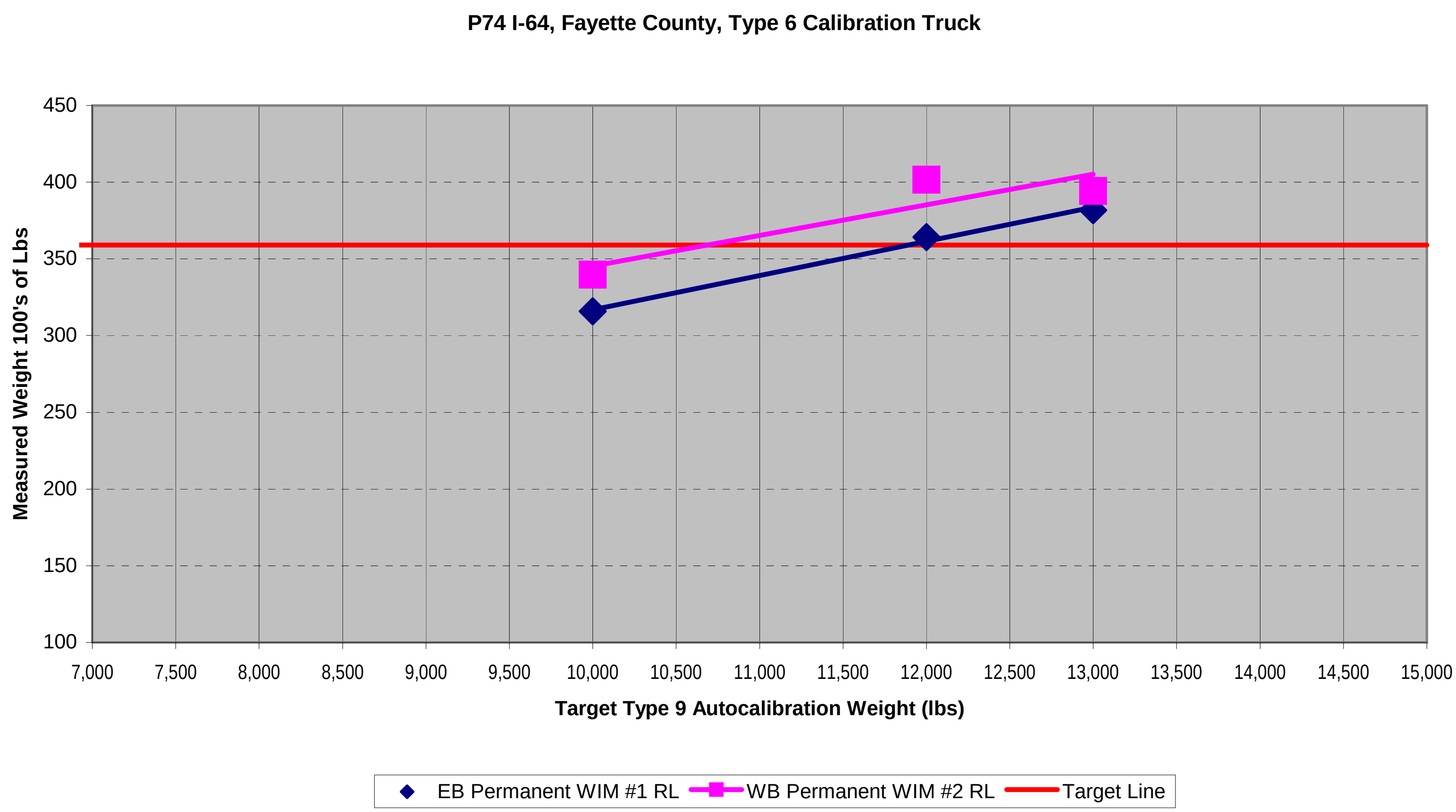
WIM Calibration Curves for Permanent Stations

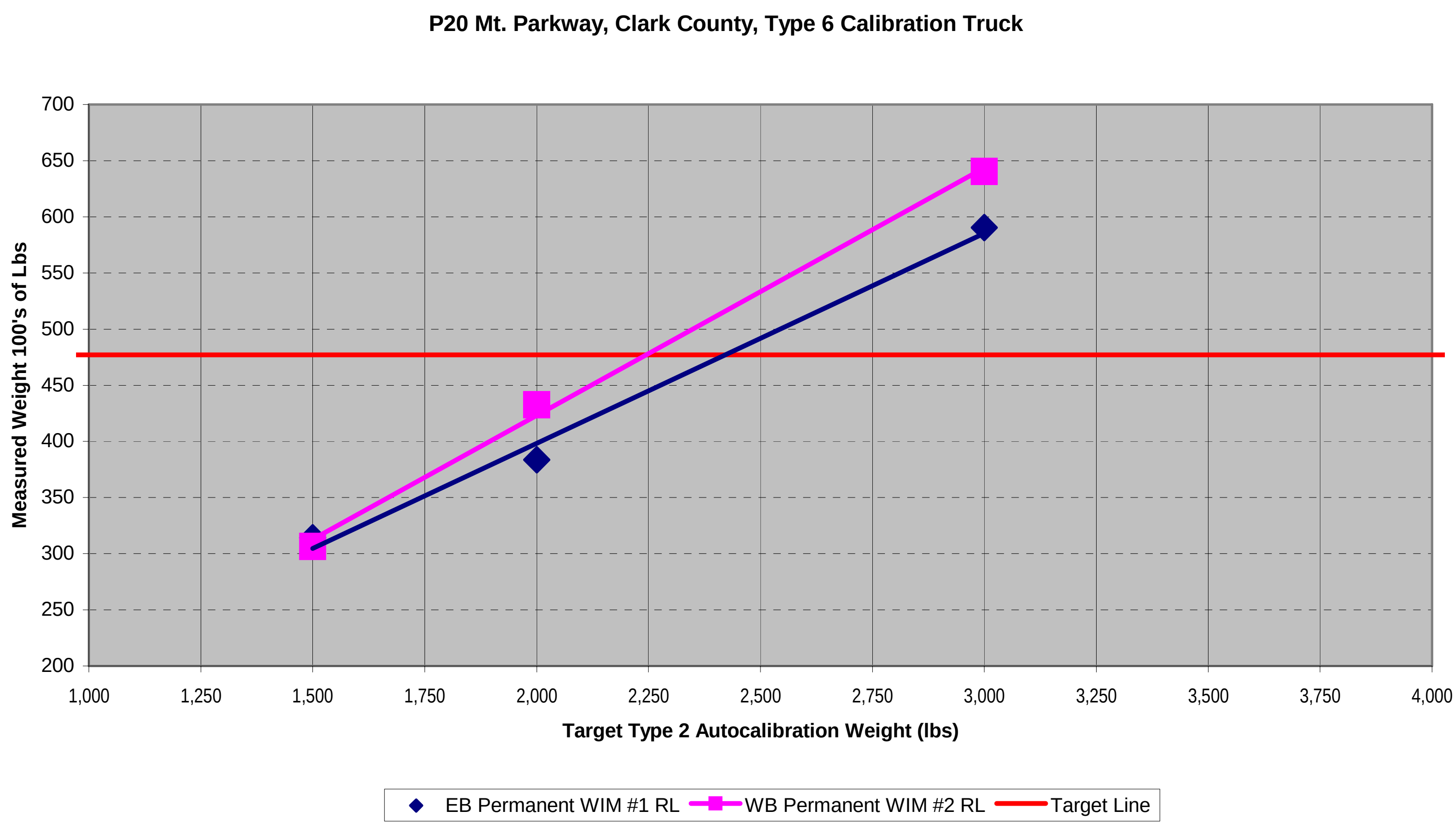
Note: Each data point shown on each of the following calibration curves represents the average of ten data observations.

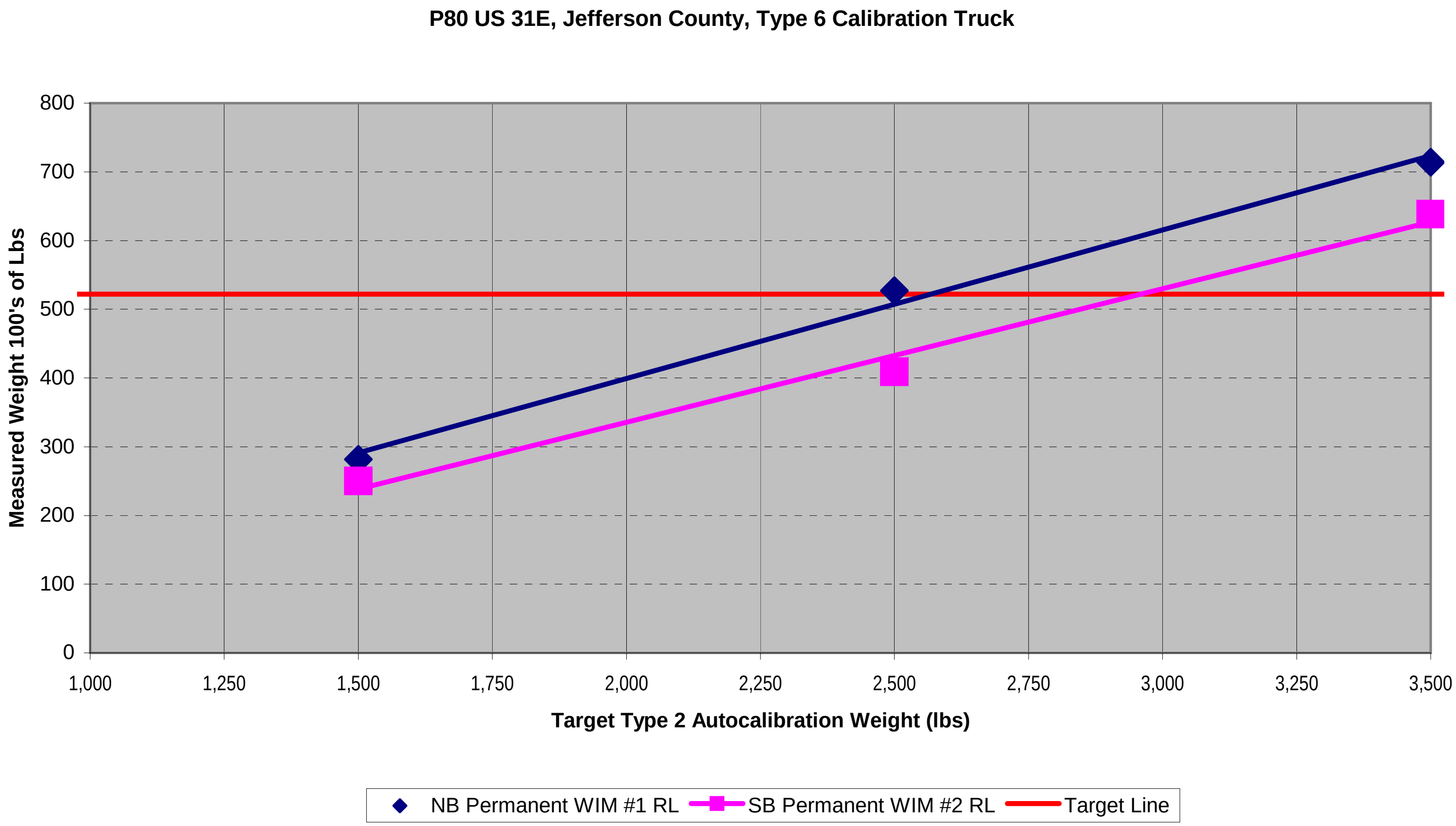

P54 Bluegrass Parkway, Nelson County, Type 9 Calibration Truck
Measured Gross Weight (lbs)
1,050
950
850
750
650
550
450
350
250
150
50
7,000
7,500
8,000
8,500
9,000
9,500
10,000
10,500
11,000
11,500
12,000
12,500
13,000
Target Type 9 Autocalibration Weight (lbs)
EB Permanent WIM #1 RL
WB Permanent WIM #2 RL
Target Line

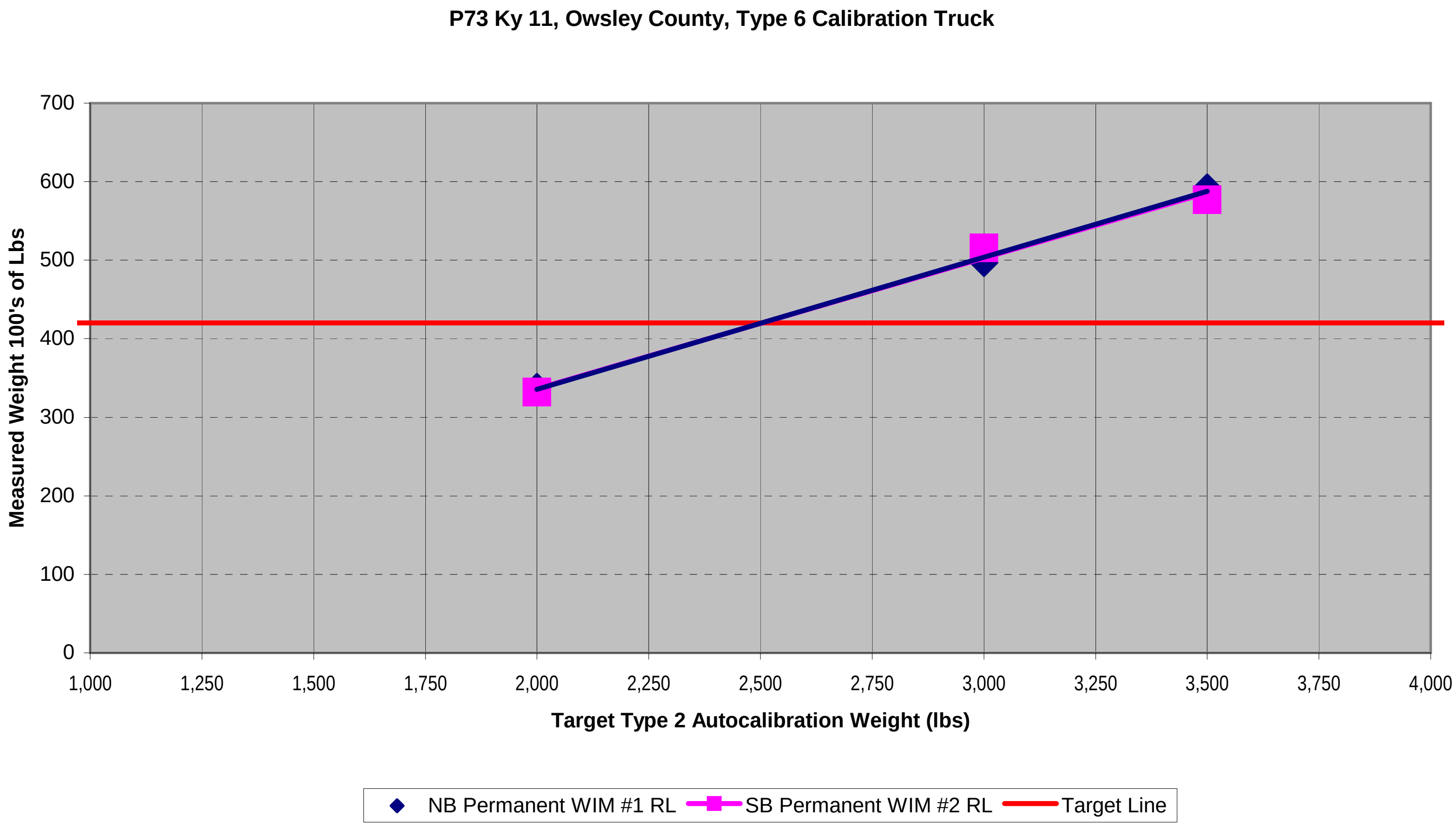
P53 Bluegrass Parkway, Woodford County, Type 6 Calibration Truck

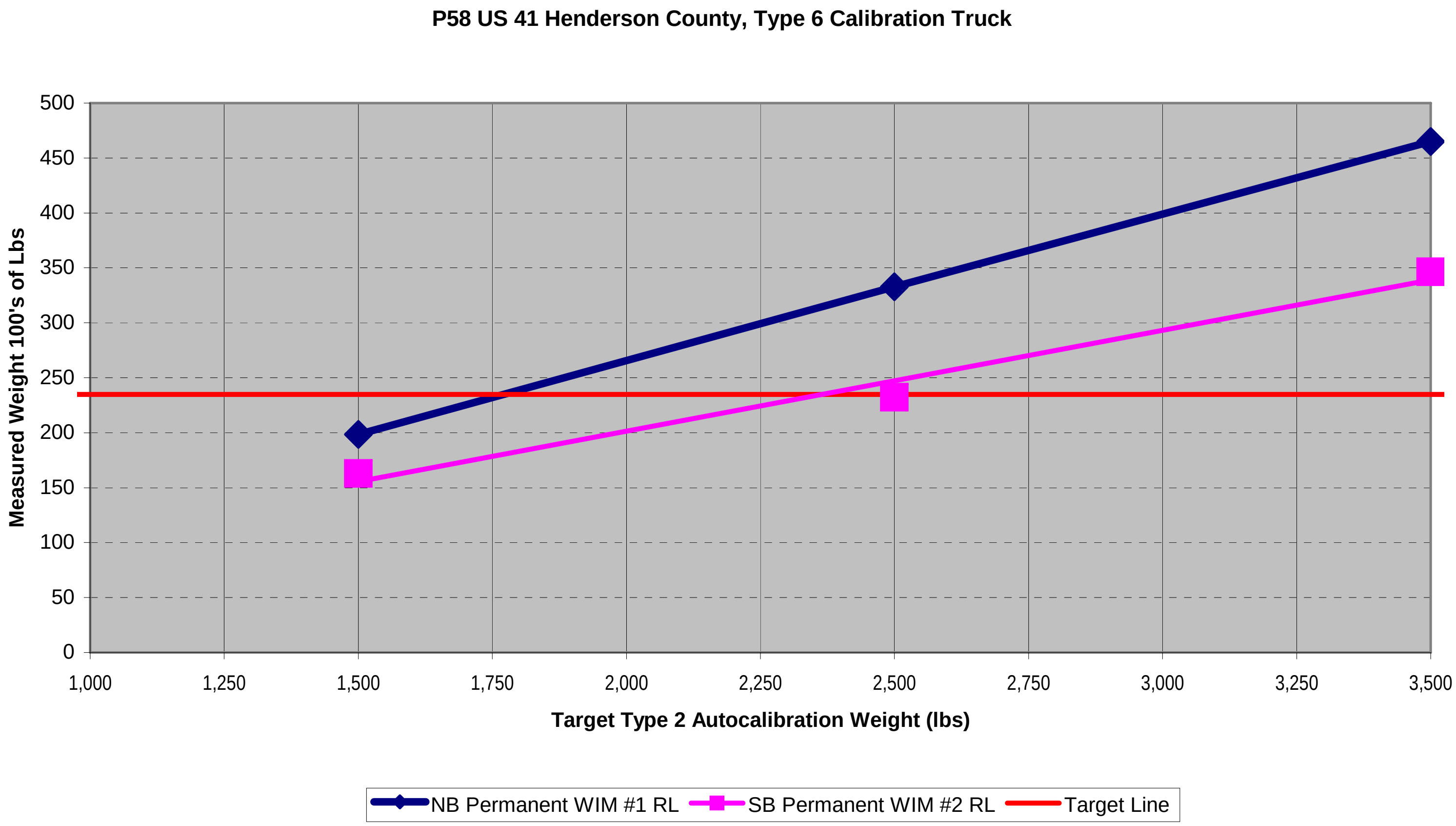



P74 I-64, Fayette County, Type 6 Calibration Truck
Measured Weight 100's of Lbs
450
400
350
300
250
200
150
100
7,000
7,500
8,000
8,500
9,000
9,500
10,000
10,500
11,000
11,500
12,000
12,500
13,000
13,500
14,000
14,500
15,000
Target Type 9 Autocalibration Weight (lbs)
EB Permanent WIM #1 RL
WB Permanent WIM #2 RL
Target Line


P20 Mt. Parkway, Clark County, Type 6 Calibration Truck
Measured Weight 100's of Lbs
700
650
600
550
500
450
400
350
300
250
200
1,000
1,250
1,500
1,750
2,000
2,250
2,500
2,750
3,000
3,250
3,500
3,750
4,000
Target Type 2 Autocalibration Weight (lbs)
EB Permanent WIM #1 RL
WB Permanent WIM #2 RL
Target Line

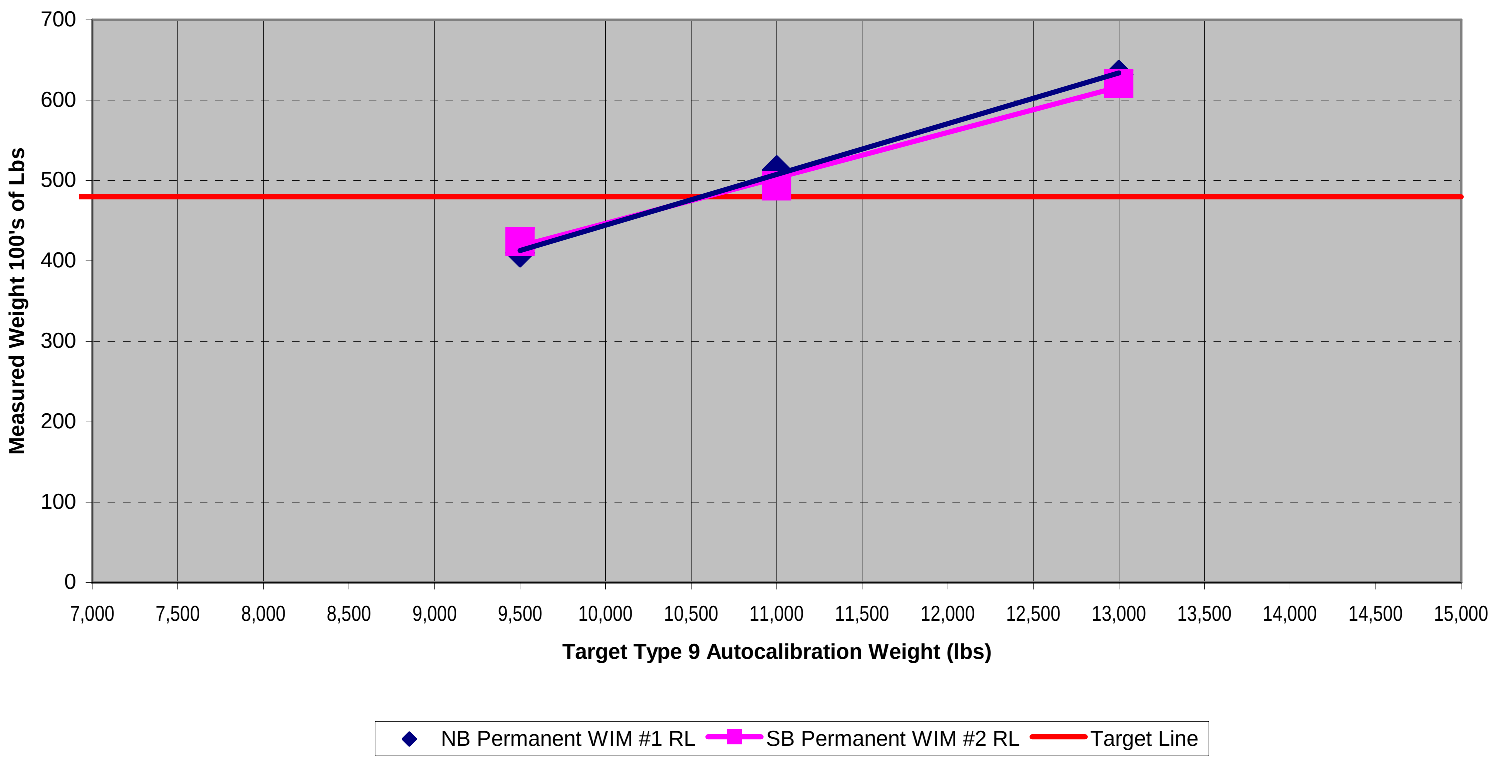

P80 US 31E, Jefferson County, Type 6 Calibration Truck
Measured Weight 100's of Lbs
800
700
600
500
400
300
200
100
0
1,000
1,250
1,500
1,750
2,000
2,250
2,500
2,750
3,000
3,250
3,500
Target Type 2 Autocalibration Weight (lbs)
NB Permanent WIM #1 RL
SB Permanent WIM #2 RL
Target Line

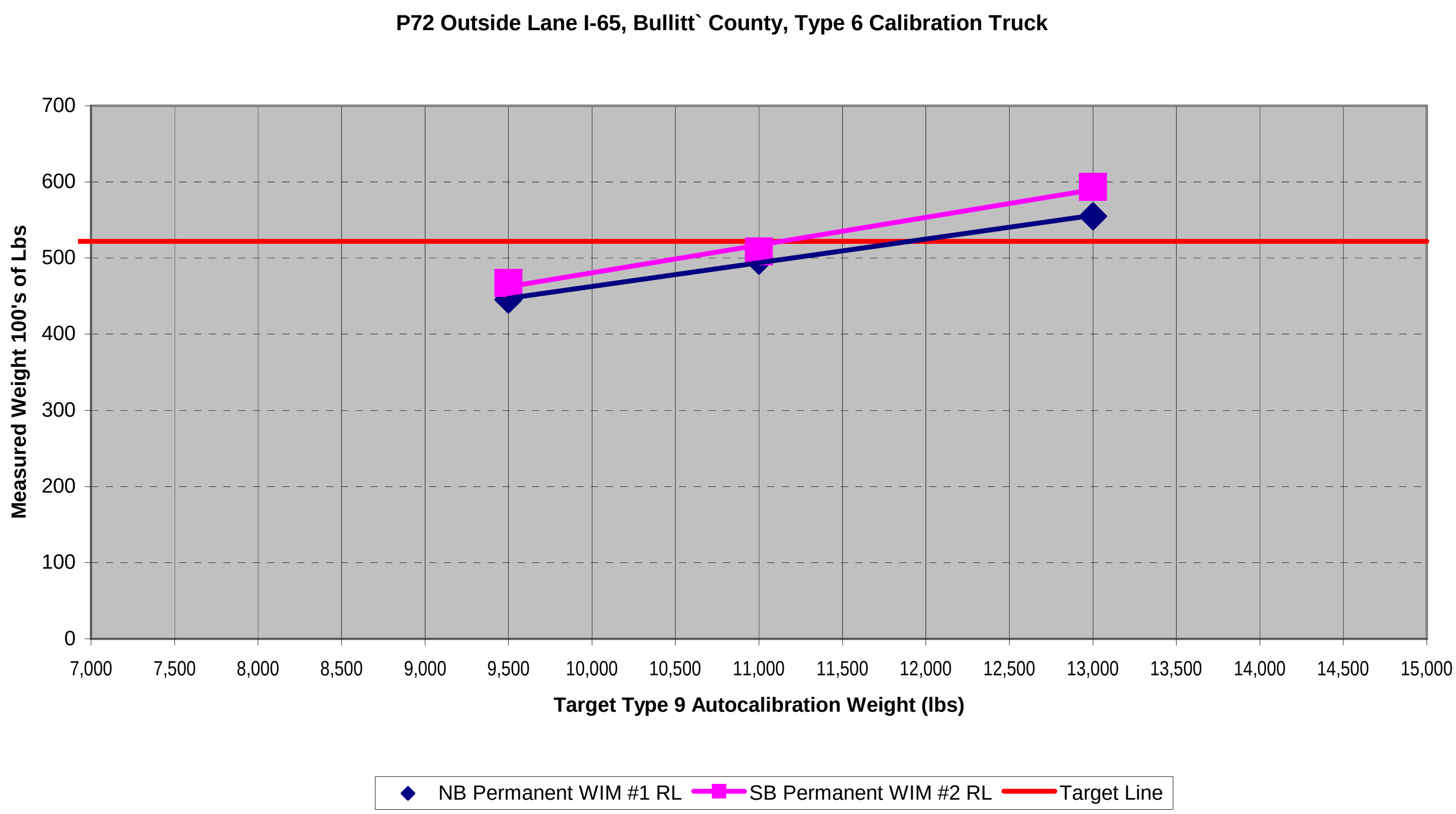

P73 Ky 11, Owsley County, Type 6 Calibration Truck
Measured Weight 100's of Lbs
0
100
200
300
400
500
600
700
1,000
1,250
1,500
1,750
2,000
2,250
2,500
2,750
3,000
3,250
3,500
3,750
4,000
Target Type 2 Autocalibration Weight (lbs)
NB Permanent WIM #1 RL
SB Permanent WIM #2 RL
Target Line



P58 US 41 Henderson County, Type 6 Calibration Truck
Measured Weight 100's of Lbs
500
450
400
350
300
250
200
150
100
50
0
1,000
1,250
1,500
1,750
2,000
2,250
2,500
2,750
3,000
3,250
3,500
Target Type 2 Autocalibration Weight (lbs)
NB Permanent WIM #1 RL
SB Permanent WIM #2 RL
Target Line

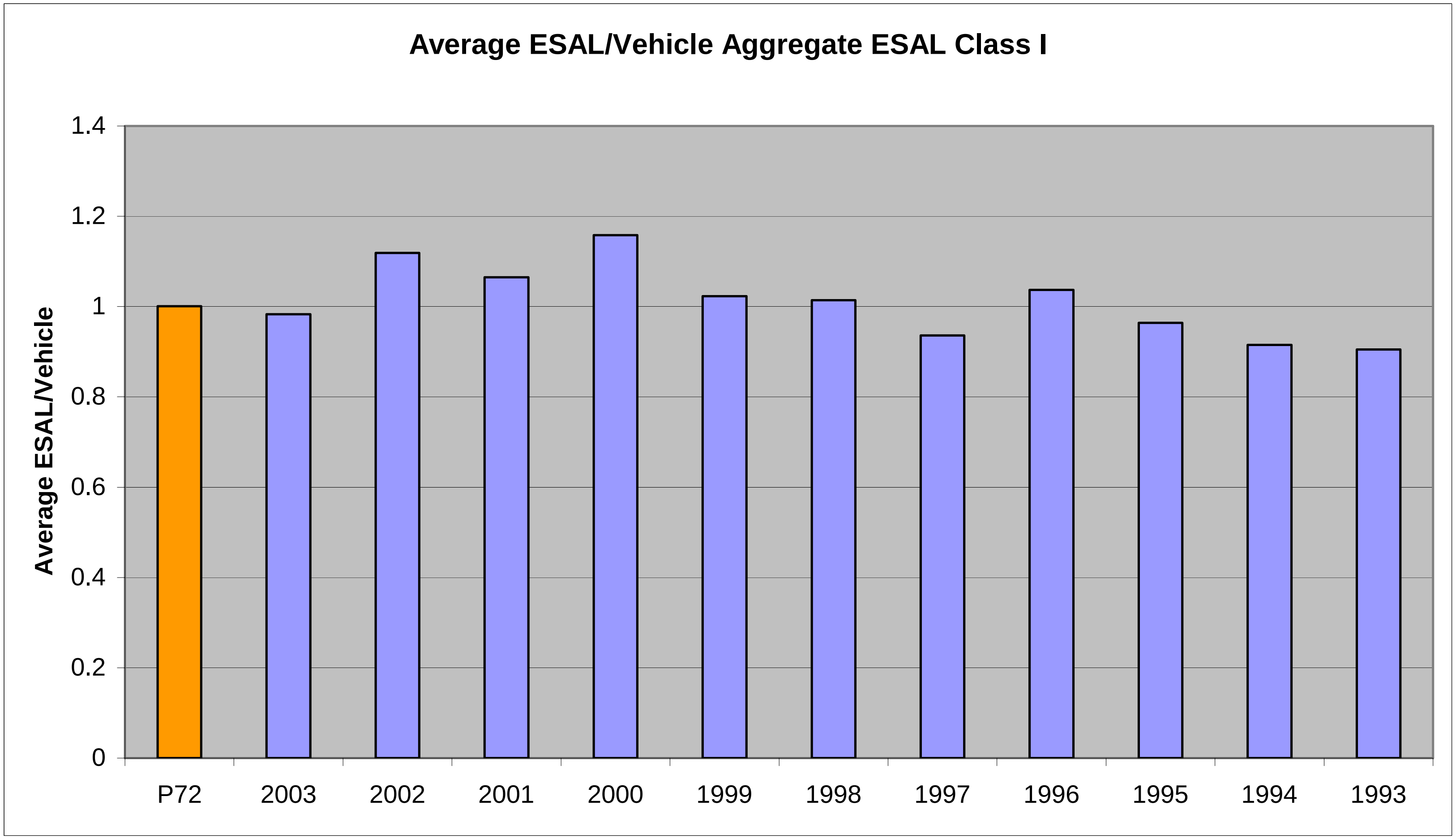
P72 Center Lane I-65, Bullitt County, Type 6 Calibration Truck

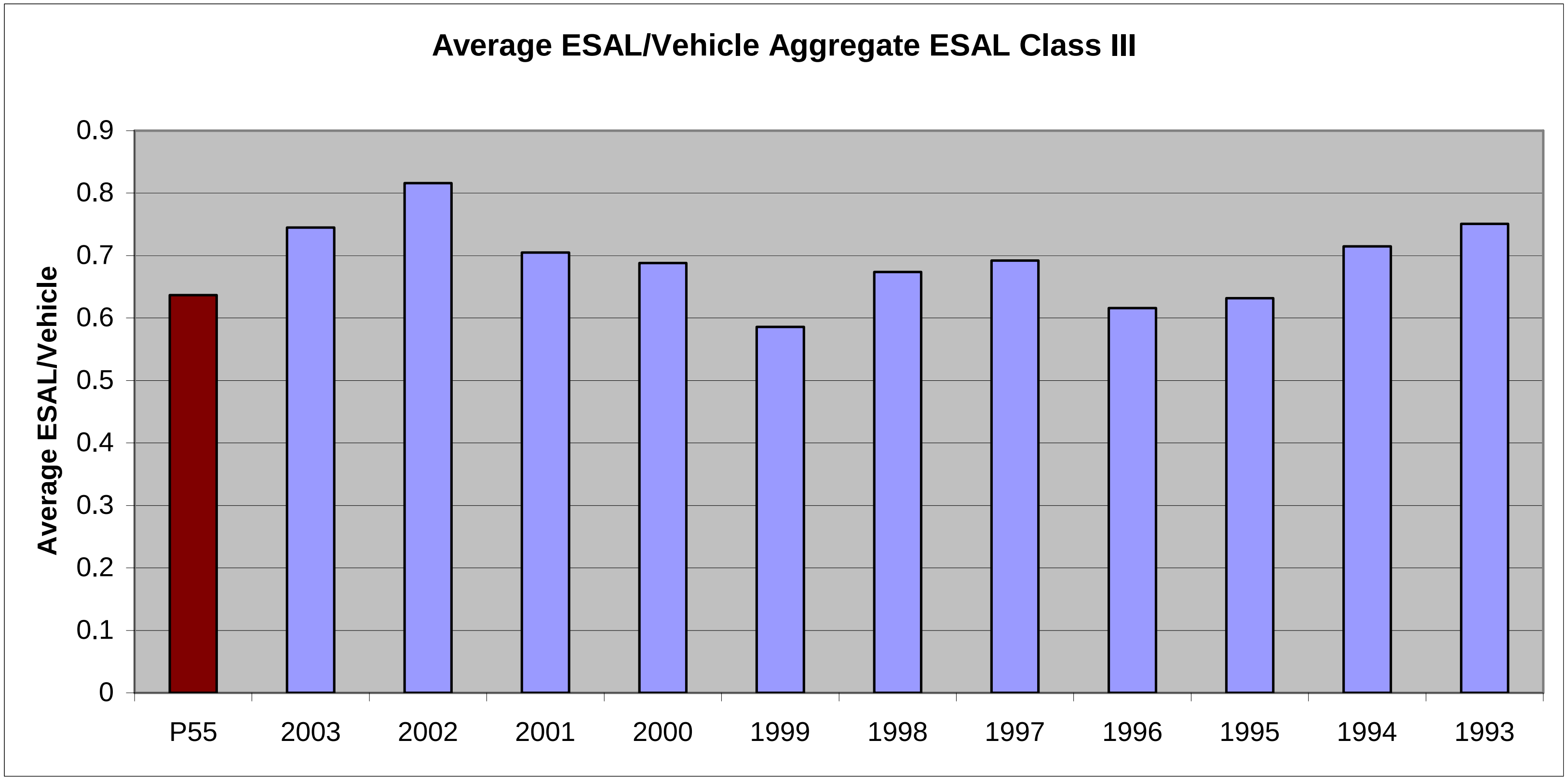


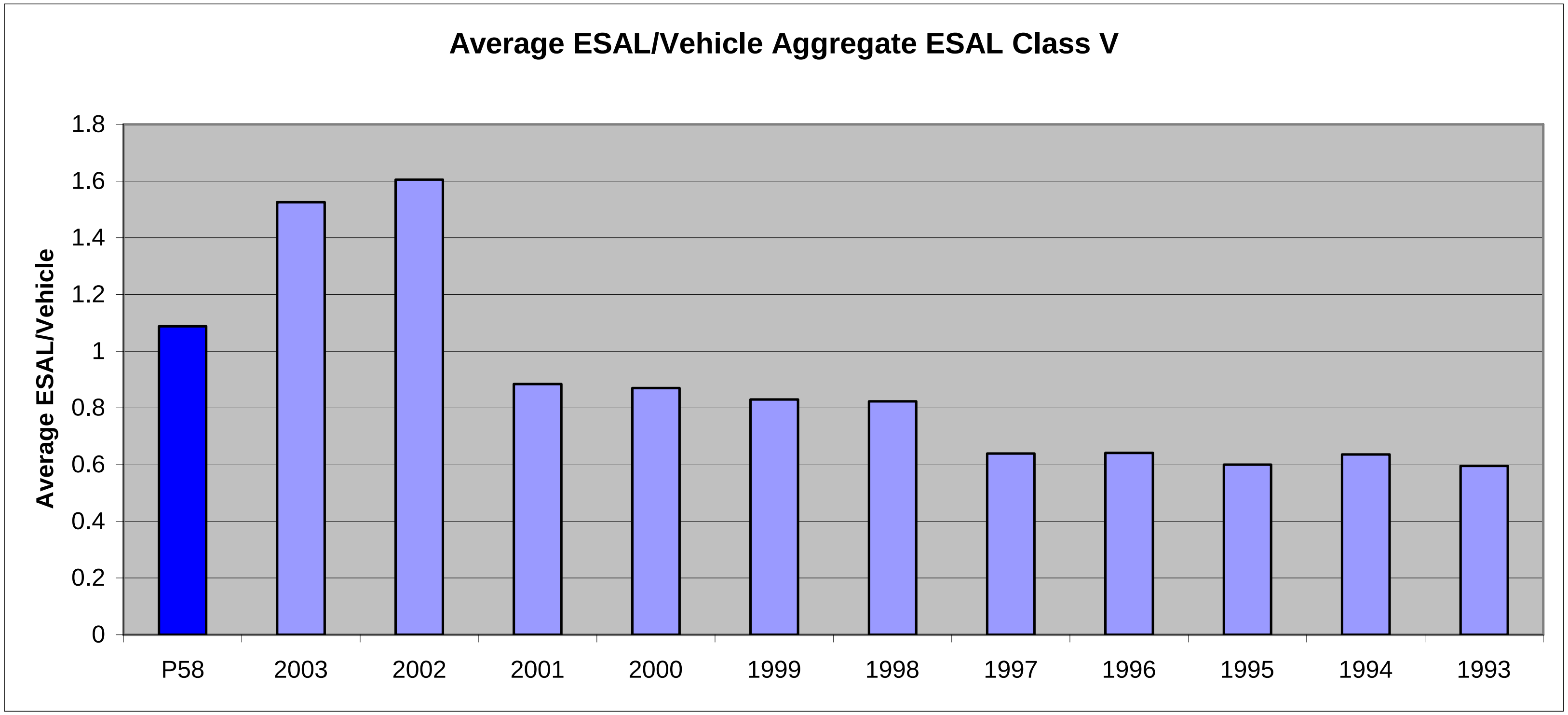

P72 Outside Lane I-65, Bullitt` County, Type 6 Calibration Truck
Measured Weight 100's of Lbs
700
600
500
400
300
200
100
0
7,000
7,500
8,000
8,500
9,000
9,500
10,000
10,500
11,000
11,500
12,000
12,500
13,000
13,500
14,000
14,500
15,000
Target Type 9 Autocalibration Weight (lbs)
NB Permanent WIM #1 RL
SB Permanent WIM #2 RL
Target Line

APPENDIX D

Summary of Calibrated Station ESALs


Average ESAL/Vehicle Aggregate ESAL Class I
Average ESAL/Vehicle
1.4
1.2
1
0.8
0.6
0.4
0.2
0
P72
2003
2002
2001
2000
1999
1998
1997
1996
1995
1994
1993


Average ESAL/Vehicle Aggregate ESAL Class III
Average ESAL/Vehicle
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
P55
2003
2002
2001
2000
1999
1998
1997
1996
1995
1994
1993


Average ESAL/Vehicle Aggregate ESAL Class V
Average ESAL/Vehicle
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
P58
2003
2002
2001
2000
1999
1998
1997
1996
1995
1994
1993