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Final Report

VALIDATION OF URBAN VEHICLE CLASSIFICATION SAMPLING METHDOLOGY

CARTER AND BURGESS, INC.
UNIVERSITY OF COLORADO AT DENVER
TRAFFIC RESEARCH AND ANALYSIS, INC.

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16. Abstract
The Mobility Analysis Section of the CDOT Division of Transportation Development (DTD) developed this study to determine whether the cluster count method developed by CDOT is statistically reliable for estimating vehicle classification on urban roadways with average daily traffic volumes exceeding 15,000 vehicles per day. Specifically, CDOT needed to assess whether or not the percentages of vehicles in the 13 FHWA vehicle classifications estimated by the cluster count method differ significantly from expected percentages obtained by 24-hour counts. Since vehicle classification is expensive to perform by manual observation over long periods of time, a statistically reliable method of estimating vehicle type percentages on urban roadways using a less time-consuming method is desirable. The study team utilized the chi-square statistical test to evaluate the similarity between vehicle classifications collected using the cluster count method and 24-hour vehicle counts collected using other data collection methods. Vehicle classification data were collected at 12 sites around Denver, Colorado that represented different roadway classes.

The statistical tests between the data collected using the cluster count method and the 24-hour counts revealed that the current cluster count method varied beyond an acceptable statistical similarity to the 24-hour counts. Upon reaching this conclusion, the study panel simulated various changes to the short duration count methodology in an effort to identify the greatest improvement in statistical accuracy. As a result of this study, the recommended short duration vehicle classification methodology requires vehicle counts to be performed for 15 minutes every hour for a 24-hour period. This method exhibits strong statistical similarity to the 24-hour classification counts for all roadway classes and study sites included in this analysis. This collection method is statistically accurate, easy for field personnel to understand and collect, and is about one-third of the cost of a manual 24-hour count.

The Mobility Analysis Section of DTD has developed a guidebook on the recommended short duration count methodology that will be available to CDOT staff, data collectors, consultants, and other public agencies. This guidebook outlines how to collect the short duration classification data, process and manage the data, and perform quality control checks.

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VALIDATION OF URBAN VEHICLE CLASSIFICATION SAMPLING METHODOLOGY

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Rod Mead, Bob Wycoff, CDOT ITS – Video camera at Simms and US 6

Costco, Arvada, CO – Roof access for video equipment

Radisson, Aurora, CO – Roof access for video equipment

Sheraton Four Points, Denver, CO – Roof access for video equipment

Denver Heating and Air, Englewood, CO – Roof access for video equipment

Bandimere Speedway, Morrison, CO – Property access for video equipment

EXECUTIVE SUMMARY

The Mobility Analysis Section of the Colorado Department of Transportation (CDOT) Division of Transportation Development (DTD) developed this study to determine whether the cluster count method developed by CDOT is statistically reliable for estimating vehicle classification on urban roadways with average daily traffic volumes exceeding 15,000 vehicles per day. Specifically, CDOT needed to assess whether or not the percentages of vehicles in the 13 FHWA vehicle classifications estimated by the cluster count method differ significantly from expected percentages obtained by 24-hour counts.

Since vehicle classification is expensive to perform by manual observation over long periods of time, a statistically reliable method of estimating vehicle type percentages on urban roadways using a less time-consuming method is desirable. There are electronic methods of estimating vehicle classifications; using tube counters, automated traffic recorders (ATR), radar, and image processing. There are several problems with these electronic counters in an urban setting; they are either permanent systems or dangerous for workers to install temporarily, they require calibration and maintenance, and they are less accurate when speeds are low or queuing occurs due to incidents or congestion which are more likely to occur in urban areas.

To achieve the objective, the study team developed a study design that utilized the chi-square statistical test to evaluate the similarity between vehicle classifications collected using the cluster count method and 24-hour vehicle counts collected using other data collection methods. Vehicle classification data were collected at 12 sites around Denver, Colorado that represented different roadway classes. This data, and the data that resulted from reducing the raw data, were stored in a relational database for processing and analysis.

The statistical tests between the data collected using the cluster count method and the 24-hour counts revealed that the current cluster count method varied beyond an acceptable statistical similarity to the 24-hour counts. Upon reaching this conclusion, the study panel decided to evaluate various changes to the cluster count methodology that would improve the accuracy.

The study panel developed a procedure for performing virtual cluster counts where the raw field collected data were sampled according to the revised cluster count methodology. Numerous variables in the data collection methodology were modified in an effort to identify the greatest improvement in statistical accuracy.

As a result of this study, the recommended short duration vehicle classification methodology requires vehicle counts to be performed for 15 minutes of every hour for a 24-hour period. This method exhibits strong statistical similarity to the 24-hour classification counts for all roadway classes and study sites included in this analysis. This collection method is statistically accurate, easy for field personnel to understand and collect, and is about one-third of the cost of a manual 24-hour count.

The results of this study indicate that there are statistically significant variations in vehicle classifications at a site for different collection dates. None of the 24-hour classifications with 13 vehicle classes were statistically similar to 24-hour classification counts taken at the same site on a different day. Only four out of twelve sites were statistically similar between different collection days when grouping into three classes. Another research study is recommended to determine the relationship between the average vehicle classification over a period of time, such as weekly or yearly, and a 24-hour classification count.

Implementation Statement

The Mobility Analysis Section of DTD has developed a guidebook on the recommended short duration count methodology that will be available to CDOT staff, data collectors, consultants, and other public agencies. This guidebook outlines how to collect the short duration classification data, process and manage the data, and perform quality control checks.

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INTRODUCTION

The Mobility Analysis Section of the CDOT Division of Transportation Development (DTD) developed this study to determine whether the cluster count method developed by CDOT is statistically reliable for estimating vehicle classification on urban roadways with average daily traffic volumes exceeding 15,000 vehicles per day. Specifically, CDOT needed to assess whether or not the percentages of vehicles in the 13 FHWA vehicle classifications (see Appendix A – FHWA Vehicle Classifications) estimated by the cluster count method differ significantly from expected percentages obtained by 24-hour counts.

Since vehicle classification is expensive to perform by manual observation over long periods of time, a statistically reliable method of estimating vehicle type percentages on urban roadways using a less time-consuming method is desirable. There are electronic methods of estimating vehicle classifications; using tube counters, automated traffic recorders (ATR), radar, and image processing. Tube counters are dangerous for workers to install on high volume roads that are typically found in urban areas. ATRs are permanent systems that can evaluate traffic at a few locations, but their cost generally prohibits extensive use. Radar and image processing techniques are also very expensive, depend heavily on proper setup and angle to provide accurate results, and use length-based algorithms to estimate the classification. All electronic counters require regular maintenance and calibration and are less accurate when speeds are low or queuing occurs due to incidents or congestion.

The current CDOT cluster counting method uses a series of short, manual counts taken at different sites within a small geographic area. A count is taken at four different times of day (2 peak hours and 2 off-peak hours) at each site of a cluster. The counting team moves between the sites of a cluster, located in fairly close proximity to one another, throughout the day. A count is ended at a given site after 200 vehicles per through lane are observed or after 45 minutes, whichever comes first. CDOT currently has more than 400 sites in the cluster counting program.

The purpose of this study was to assess the validity of the current cluster count methodology and make recommendations for improvements. A data collection study design was developed as the first task in the project. This study design outlined the statistics that would be used to compare the short duration classification counts to the 24-hour classification counts, the amount of data to collect, the locations to collect the data, and the methods used to classify vehicles at each location. The next task was to collect and manage the data. Classification data were collected twice at 12 different sites resulting in 24 short duration samples and twenty-four, 24-hour counts. The data were collected, processed, and stored in small time intervals for development and testing of a variety of cluster count scenarios in addition to the current methodology.

DATA COLLECTION STUDY DESIGN

The study design was a plan for how the data would be analyzed, what the sample size would be, how the data would be collected, and how to ensure the quality of the resulting data.

Statistics and Sample Size

A statistical analysis was needed to verify the validity of the cluster count vehicle classification method. Vehicle classification data is categorical data based on a random traffic sample (cluster count) of a 24-hour period. The Pearson chi-square statistic was selected to test the significance of the relationship between the cluster count of observed frequencies and expected frequencies based on the 24-hour sample. The value of the chi-square statistic and its significance level depends on the overall number of observations, the number of vehicle classes, and the difference between the observed cluster count and the 24-hour count in each vehicle class.

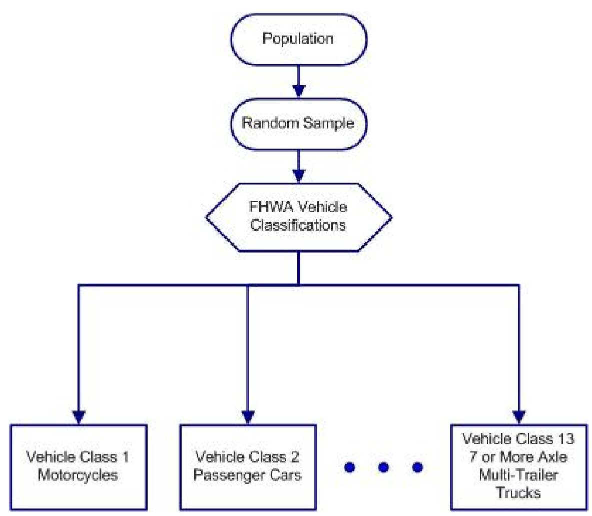

Figure 1: Vehicle Classification Sample

To ensure validity, the chi-square test requires random, independent observations and that the expected count be at least 5 vehicles for each vehicle class, since an expected count of less than 5 vehicles in any single class is not considered to be a reliable estimate of the probable count for that class. If the expected count for any vehicle class based on the 24-hour percentage of vehicles in that class was less than 5, then that vehicle class was grouped together with similar vehicle classes until the expected count was at least 5. The formula for the chi-square statistic is as follows:

$$X^2 = \sum_{i=1}^{k} \frac{(x_i - e_i)^2}{e_i}$$

Where:

k = number of vehicle classes

x_i *= observed frequency in vehicle class i (from cluster count)*

e_i *= expected frequency in a vehicle class i (total cluster count times vehicle class percentage from the 24-hour count)*

A larger chi-square statistic indicates larger differences between the two data sets, which results in a smaller p-value. A small p-value (such as 0.05) constitutes evidence that the two data sets do not represent the same population of vehicles. As the p-value increases, the agreement between the two datasets increases, with perfect agreement having a p-value of 1. The level of agreement considered sufficient for the comparisons of this study will be explained later in this report. The p-values that resulted from comparing the 24-hour count data to the cluster count data are summarized to assess the validity of the cluster count method.

Even though the number of sites sampled does not affect the validity of the chi-square test for any given location, it does address the question of whether the cluster counting method was reliable for different roadway facilities or volumes. To address this concern, three sites were sampled on two separate days for each of the following facility/average daily traffic (ADT) categories:

Table 1: Facility/ADT Categories

Facility/ADT Category
Lower Volume Urban Arterial (15,000 > ADT < 30,000)
Higher Volume Urban Arterial (> 30,000 ADT)
Urban Expressway
Urban Freeway

Under this sampling plan, Carter & Burgess collected 24-hour data and concurrent cluster counts resulting in twenty-four full-day comparisons and six comparisons per facility/ADT category.

Current Cluster Count Methodology

The cluster counting method, as developed by CDOT, uses a series of short, manual counts taken at different sites within a small geographic area. A count is taken at four different times of day (2 peak hours and 2 off-peak hours) at each site of a cluster. The counting team moved between the sites of a cluster, located in fairly close proximity to one another, throughout the day. A count is ended at a given site for one direction after 200 vehicles per through lane were observed or after 45 minutes, whichever came first. A JAMAR TDC-8 with a classification template was used for the cluster counts (see Figure 2).

Figure 2: TDC-8 with FHWA 13-Bin Template Classification

Cluster count data were collected at all sites using the current CDOT methodology during the following time periods:

Table 2: Cluster Count Collection Times

Period Name	Time Period
AM Peak	6:30-8:30 AM
AM Off Peak	9:30 AM-12:00 PM
PM Off Peak	1:00-3:30 PM
PM Peak	4:00-6:00 PM

24-hour Classification

Carter & Burgess utilized three different methods to collect 24-hour classification data.

Automatic Traffic Recorders

Two different Urban Freeway sites were chosen near existing CDOT automated traffic recorders (ATR). Carter & Burgess coordinated with CDOT to obtain the ATR data for the same days as the cluster counts and video data. The ATR data was logged in 5-minute bins, which is the smallest bin possible because of storage limitations of the ATR equipment. Digital video was collected at these sites for two different hours of the day and reduced to manual classification counts to verify the ATR data. This video also coincided with two different cluster count time periods. The video was reduced using the VehicleClassifier program into 5-minute intervals.

MetroCount Tubes

MetroCount portable classification tubes were used for the Urban Arterials with low volumes and at other cluster count sites where significant queuing did not occur and each lane could be captured separately. The MetroCount unit logged each vehicle with a timestamp, number of axles, space between axles, and the Scheme F classification. These 24-hour tube counts were verified with two 1-hour manual counts obtained from concurrent video recorded during the AM and PM peak, which also coincided with two different cluster count periods. The video was reduced using the VehicleClassifier program into 5-minute intervals.

24-Hour Video

Figure 3: Archos AV140

Twenty-four-hour digital video was collected at sites where location and lighting permitted and other data collection methods could not be used. Video was recorded digitally using the Archos AV140 media recorder, eliminating the need to change videotapes every 2 hours. All video was burned onto

DVD-R media and magnetic backup tape. The video data was reduced to 5-minute interval classification counts using the VehicleClassifier program.

Public Relations and Safety

Carter & Burgess contacted the CDOT Public Relations Office, the Colorado State Patrol and relevant law enforcement agencies each week during field data collection to keep them informed of data collection efforts within the CDOT right-of-way (ROW). A list of contacts and a letter from CDOT stating the purpose of the project was given to each field technician in case they were contacted by law enforcement personnel. At any sites where video cameras were used within CDOT ROW a vehicle with rotating lights was parked off the shoulder, a 'Survey Crew' sign (W21-6 or similar) was displayed, and field personnel wore safety vests.

Study Sites

The following table lists the cluster count sites and the data collection methods that were used at each location. Detailed site information, such as average annual daily traffic (AADT) and the number of lanes per direction, are provided for the 24-hour test sites but not for adjacent cluster count sites.

Table 3: Study Sites

Cluster #	Site #	Site Description	Category	AADT	Lanes / Direction	Data Collection Methods				
						Cluster Count	24-Hour Video	ATR (CDOT ID)	Metro Count	2-Hour Video
4	13	On Colorado Blvd N/O Cherry Creek S Blvd	Higher Volume Urban Arterial	54,900	3	Yes	Yes	No	No	No
	14	On Cherry Creek S Blvd W/O Colorado Blvd	Lower Volume Urban Arterial	23,200	1	Yes	Yes	No	Yes	Yes
	15	On Alameda Ave W/O Holly St	Adjacent Cluster Site			Yes	No	No	No	No
	16	On Holly St S/O Alameda Ave	Adjacent Cluster Site			Yes	No	No	No	No
17	65	On Simms at US-6	Higher Volume Urban Arterial	43,900	3	Yes	Yes	No	No	No
	66	On US-6 E/O Simms	Adjacent Cluster Site			Yes	No	No	No	No

Cluster #	Site #	Site Description	Category	AADT	Lanes / Direction	Data Collection Methods: Cluster Count	24-Hour Video	ATR (CDOT ID)	Metro Count	2-Hour Video
	67	On SH 391 S/O SH 40	Adjacent Cluster Site			Yes	No	No	No	No
	68	On SH 391 S/O SH 6	Adjacent Cluster Site			Yes	No	No	No	No
23	95	On Wadsworth S/O 52nd Ave	Higher Volume Urban Arterial	64,200	3	Yes	Yes	No	No	No
	96	On 52nd Ave E/O Wadsworth	Adjacent Cluster Site			Yes	No	No	No	No
	97	On SH 121 S/O I-70	Adjacent Cluster Site			Yes	No	No	No	No
	98	On I-70 E/O Jct. I-76	Adjacent Cluster Site			Yes	No	No	No	No
38	156	On US 36 E/O Wadsworth	Urban Freeway	80,800	2	Yes	No	Yes (504)	No	Yes
	157	On SH 287 E/O Jct. SH 121	Adjacent Cluster Site			Yes	No	No	No	No
	159	On SH 121 S/O W. 1st Ave. Jct SH 287	Adjacent Cluster Site			Yes	No	No	No	No
	160	On SH 121 S/O 120th	Adjacent Cluster Site			Yes	No	No	No	No
43	179	On C470 E/O Wadsworth	Adjacent Cluster Site			Yes	No	No	No	No
	180	On SH 121 S/O C-470	Lower Volume Urban Arterial	19,900	2	Yes	No	No	Yes	Yes
	181	On Kipling Pkwy. N/O C470	Adjacent Cluster Site			Yes	No	No	No	No
44	182	On SH 285 W/O C470	Adjacent Cluster Site			Yes	No	No	No	No
	183	On C470 S/O SH 285	Adjacent Cluster Site			Yes	No	No	No	No
	184	On SH 285 E/O C470	Urban Freeway	26,100	2	Yes	No	No	Yes	Yes
	185	On SH 8 W/O C470	Adjacent Cluster Site			Yes	No	No	No	No
	186	On C-470 at Morrison Rd	Urban Freeway	73,600	2	Yes	No	Yes (512)	No	Yes
45	187	On SH 85 S/O Mineral	Adjacent Cluster Site			Yes	No	No	No	No
	188	On SH 75 N/O Ken Caryl/Mineral	Lower Volume Urban Arterial	16,200	1	Yes	No	No	Yes	Yes
	189	On Santa Fe at C-470	Adjacent Cluster Site			Yes	No	No	No	No
	190	On C-470 W/O Santa Fe	Adjacent Cluster Site			Yes	No	No	No	No
48	201	On SH 285 W/O SH 75	Adjacent Cluster Site			Yes	No	No	No	No
	202	On SH 285 W/O SH 177	Adjacent Cluster Site			Yes	No	No	No	No
	203	On Santa Fe at Hampden	Adjacent Cluster Site			Yes	No	No	No	No
	204	On Hampden W/O Santa Fe	Urban Expressway	63,400	2	Yes	Yes	No	No	No

Cluster #	Site #	Site Description	Category	AADT	Lanes / Direction	Data Collection Methods: Cluster Count	24-Hour Video	ATR (CDOT ID)	Metro Count	2-Hour Video
	205	On SH 88 N/O SH 285	Adjacent Cluster Site			Yes	No	No	No	No
49	206	On Hampden Ave E/O SH 83	Adjacent Cluster Site			Yes	No	No	No	No
	207	On Peoria St N/O Yale Ave	Adjacent Cluster Site			Yes	No	No	No	No
	208	On SH 83 S/O I-225	Urban Expressway	67,600	3	Yes	Yes	No	No	No
	209	On SH 83 S/O SH 30	Adjacent Cluster Site			Yes	No	No	No	No
	210	On SH 30 S/O SH 83	Adjacent Cluster Site			Yes	No	No	No	No
59	248	On SH 119 N/O Jct. SH 157 & 119	Adjacent Cluster Site			Yes	No	No	No	No
	249	On SH 157 S/O SH 119	Urban Expressway	35,900	2	Yes	No	No	Yes	Yes
	250	On SH 119 W/O Jct. SH 157	Adjacent Cluster Site			Yes	No	No	No	No
	251	On US 36 S/O SH 119	Adjacent Cluster Site			Yes	No	No	No	No

Note: N/O – North of, S/O – South of, E/O – East of, W/O – West of

Cluster #4 –Colorado Blvd & Cherry Creek Blvd

Site #13, On Colorado Blvd N/O Cherry Creek S Blvd, was used as a validation site for the category Higher Volume Urban Arterial. Twenty four-hour video data was collected from the roof of the Sheraton Four Points hotel on the southeast corner of Colorado Boulevard and Cherry Creek S Blvd.

Site #14, On Cherry Creek S Blvd W/O Colorado Blvd, was used as a validation site for the category Lower Volume Urban Arterial. MetroCount classification tubes were used and 24-hour video data was also collected from the roof of the Sheraton Four Points hotel. This site was used to compare the two 24-hour classification methods.

Manual cluster counts were collected at all other sites within the cluster when time permitted including Site #15, On Alameda Ave W/O Holly St and Site #16, On Holly St S/O Alameda Ave.

Cluster #17 – Simms & US 6

Site #65, On Simms at US-6, was used as a validation site for the category Higher Volume Urban Arterial. Twenty-four -hour video data was collected using a traffic camera owned by CDOT near the eastbound entrance ramp to US-6 at Simms. The video was recorded from the CDOT Traffic Operation Center (TOC).

Manual cluster counts were collected at all other sites within the cluster when time permitted including Site #66, On US-6 E/O Simms; Site #67, On SH 391 S/O SH 40; and Site #68, On SH 391 S/O SH 6.

Cluster #23 – Wadsworth & I-70

Site #95, On Wadsworth S/O 52nd Ave, was used as a validation site for the category Higher Volume Urban Arterial. Twenty-four -hour video data was collected from the roof of Costco on the southwest corner of 52nd and Wadsworth.

Manual cluster counts were collected at all other sites within the cluster when time permitted including Site #96, On 52nd Ave E/O Wadsworth; Site #97, On SH 121 S/O I-70; and Site #98, On I-70 E/O Jct. I-76.

Cluster #38 – US 36 & Wadsworth

Site #156, On US 36 E/O Wadsworth, was used as a validation site for the category Urban Freeway. CDOT ATR was used to collect 24-hour classification data. Two different hours of video verification were collected from the Old Wadsworth overpass within CDOT ROW.

Manual cluster counts were collected at all other sites within the cluster when time permitted including Site #157, On SH 287 E/O Jct. SH 121; Site #159, On SH 121 S/O W. 1st Ave. Jct SH 287; and Site #160, On SH 121 S/O 120th.

Cluster #43 – C-470 & Wadsworth

Site #180, On SH 121 (Wadsworth) S/O C-470, was used as a validation site for the category Lower Volume Urban Arterial. MetroCount classification tubes were used to collect 24-hour vehicle classification data. Four MetroCount units were used; one for each lane of through traffic. Two different hours of video verification were collected from the hill on the southwest corner of C-470 and Wadsworth, south of the eastbound exit ramp.

Manual cluster counts were collected at all other sites within the cluster when time permitted including Site #179, On C470 E/O Wadsworth and Site #181, On Kipling Pkwy. N/O C470.

Cluster #44 – SH 285 & C-470

Site #184, On SH 285 E/O C470 was used as a validation site for the category Urban Freeway. MetroCount classification tubes were used to collect 24-hour vehicle classification data. Four MetroCount units were used; one for each lane of through traffic. Two different hours of video verification were collected from the hill on the north side of SH 285 between C-470 and Kipling.

Site #186, On C-470 at Morrison Rd was used as a validation site for the category Urban Freeway. CDOT ATR was used to collect 24-hour classification data. Two different hours of video verification were collected from the Bandimere Speedway property on the west side of C-470. The speedway property was outside CDOT ROW and provided a clear view of C-470 near ATR 512.

Manual cluster counts were collected at all other sites within the cluster when time permitted including Site #182, On SH 285 W/O C470; Site #183, On C470 S/O SH 285; and Site #185, On SH 8 W/O C470

Cluster #45 – SH 75 & Mineral

Site #188, On SH 75 (Platte Canyon Rd) N/O Ken Caryl/Mineral was used as a validation site for the category Low Volume Urban Arterial. MetroCount classification tubes were used to collect 24-hour vehicle classification data. Two MetroCount units were used; one for each lane of through traffic. Two different hours of video verification were collected from the hill on the east side of Platte Canyon Rd near a gravel driveway.

Manual cluster counts were collected at all other sites within the cluster when time permitted including Site #187, On SH 85 S/O Mineral; Site #189, On Santa Fe at C-470; and Site #190, On C-470 W/O Santa Fe.

Cluster #48 – Hampden & Santa Fe

Site #204, On Hampden W/O Santa Fe, was used as a validation site for the category Urban Expressway. Twenty four -hour video data was collected from the roof of Denver Heating and Air on the north side of Hampden.

Manual cluster counts were collected at all other sites within the cluster when time permitted including Site #201, On SH 285 W/O SH 75; Site #202, On SH 285 W/O SH 177; Site #203, On Santa Fe at Hampden; and Site #205, On SH 88 N/O SH 285.

Cluster #49 – Parker Rd & I-225

Site #208, On SH 83 (Parker Rd) S/O I-225, was used as a validation site for the category Urban Expressway. Twenty four -hour video data was collected from the roof of the Radisson Inn on the northeast quadrant of the Parker Rd/I-225 interchange.

Manual cluster counts were collected at all other sites within the cluster when time permitted including Site #206, On Hampden Ave E/O SH 83; Site # 207, On Peoria St N/O Yale Ave; Site #209, On SH 83 S/O SH 30; and Site #210, On SH 30 S/O SH 83

Cluster #59 –SH 157 & SH 119

Site #249, On SH 157 (Foothills Pkwy) S/O SH 119, was used as a validation site for the category Urban Expressway. MetroCount classification tubes were used to collect 24-hour vehicle classification data. Four MetroCount units were used; one for each lane of through traffic. Two different hours of video verification were collected from the hill on the east side of Foothills Pkwy near a bike path.

Manual cluster counts were collected at all other sites within the cluster when time permitted including Site #248, On SH 119 N/O Jct. SH 157 & 119; Site #250, On SH 119 W/O Jct. SH 157; and Site #251, On US 36 S/O SH 119.

24-hour Comparison Assumptions

Electronic classification data will differ slightly from manual classification for some of the FHWA classes. Electronic counters used for this project used the Scheme F algorithm to classify vehicles. This algorithm is based on the number of axles and the distance between axles. Historically, electronic classifiers have had difficulty distinguishing between the following classes:

- Class 2 (passenger cars) and Class 3 (other 2-axle, 4-tire single-unit vehicles; i.e. pickup trucks and sport utility vehicles [SUVs])

- Class 3 (other 2-axle, 4-tire single-unit vehicles; i.e. pickup trucks and SUVs) and Class 5 (2-axle, 6-tire single-unit trucks)

If the 24-hour and cluster count data showed significant differences between Class 2 and 3 or Class 3 and 5, these classes were grouped for the analysis.

Quality Control Plan

Vehicle classification data were collected on Tuesdays, Wednesdays, or Thursdays to avoid potential end of week variations. Since all data was collected on two separate days, each cluster count and 24-hour count could be verified by comparing the corresponding data on a different day. If the classification data showed a discrepancy at the same site for different days, another cluster count and 24- hour count was performed and the outlying data was discarded. All electronic data was verified with video and reduced manual counts for at least two different hours of the day. The video verification was also used to verify two of the four cluster count periods. The video reduction counts were spot checked for each site and direction that an employee reduced by having another person perform vehicle classification counts for the same time period.

DATA COLLECTION AND MANAGEMENT

The data that was collected during this study was stored in an electronic database to facilitate data storage, reduction and analysis. This section describes the structure of that electronic database and the procedures used to reduce the raw field data into a format that could be uploaded into the database. In addition, this section describes the results of the data collection efforts, and the results of the quality control checks described in the study design.

Database Design

Carter & Burgess stored the data for this project in a relational database using the Microsoft SQL Server (MSSQL) database software. This relational database contained numerous tables of information and each table contained multiple columns of data. Figure 4 shows the entity relationship diagram for the main portion of the database.

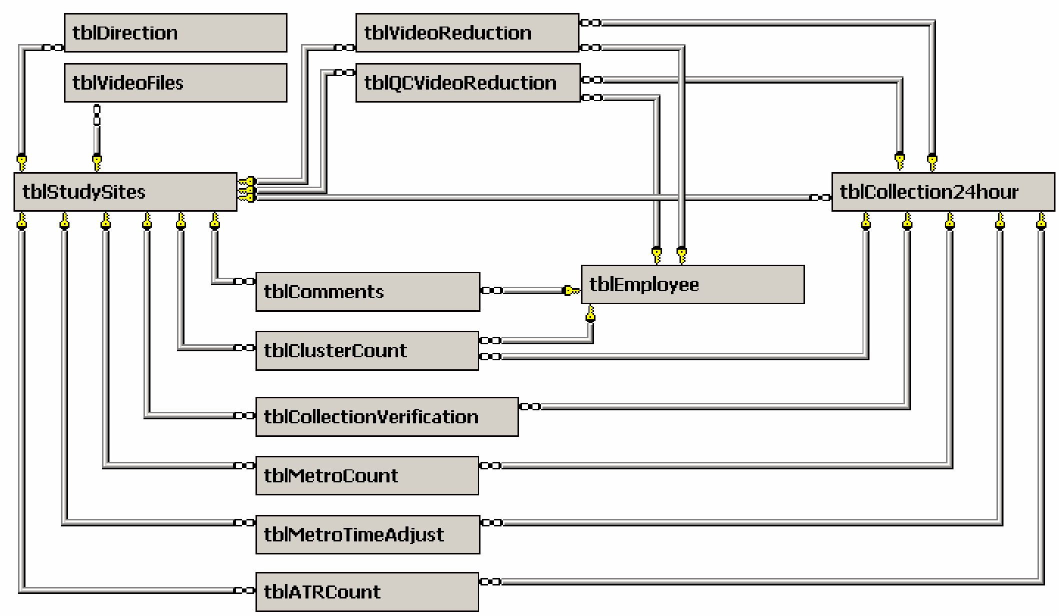

Figure 4: Database Diagram

The light grey boxes shown on Figure 4 represent each table in the main portion of the database and the lines between the grey boxes represent the relationships (i.e., columns of information that

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are common to each table) between the tables. A description of each table shown in Figure 4 follows in Table 4:

Table 4: Database Table Description

Table Name	Description
tblDirection	List of travel directions by site (A relationship between video reduction directions such as closest to the camera and the actual direction)
tblVideoFiles	List of digital video files with collection location and times (The video files were generated by the Archos recorder and renamed based on site and collection date)
tblStudySites	Sample sites or adjacent sites with the sample cluster used for this study (Select cluster count sites from the previous cluster count program. Site was the identifier used in all other tables)
tblVideoReduction	Manual classification reduced from digital video with counts in 5-minute bins
tblQCVideoReduction	Video reduction quality control checks. (5-minutes of video for every unique employee, site, direction record in tblVideoReduction)
tblCollection24Hour	Collection times for all 24-hour classification counts (One record represents a 24-hour collection period with the start time, end time and date)
tblComments	Questions/comments raised by employees during video reduction (Includes the video file, direction and time of the comment)
tblClusterCount	Short duration manual classification counts collected using CDOT methodology (Four records for each site, direction and collection day)
tblCollectionVerification	Collection times for video verification of electronic classification counts (1-hour digital video collection times related by site and collection day)
tblMetroCount	Individual vehicle report from MetroCount tubes (One record for every vehicle that crossed the tubes)
tblMetroTimeAdjust	Time adjustment applied to tblMetroCount to synchronize with video timestamp (Time calibration applied to tblMetroCount where the time differed from the video time)
tblATRCount	CDOT ATR Classification Data in 5-minute counts (One record for each 5-minutes by direction, lane, and collection day)
tblEmployee	Employees that reduced video

A description of the columns that are contained in each of the tables listed above is contained in Appendix B – Database Dictionary, at the end of this document.

Data Reduction

The four different classification data types described in the study design, cluster counts, MetroCount tubes, CDOT ATR, and digital video, were uploaded into MSSQL for data analysis and quality control checks. The following sections describe how each dataset was transferred from field data into the database. Please refer to Appendix B – Database Dictionary for table and field definitions and Appendix C – Sample Field Data for examples of raw field data for each data collection methods described below.

Cluster Counts

The cluster count data was recorded in the field using a JAMAR TDC-8 board (see Figure 2) and then transcribed to a field sheet designed by TRA. The cluster count data was entered into an

Excel spreadsheet and imported into the MSSQL table ‘tblClusterCount’. The cluster count data was collected and stored by direction but not by lane.

MetroCount Reduction

The MetroCount unit logs information about each axle that passes over it. The Traffic Executive software was used to export the individual vehicle report into a text file. This fixed format text file was then imported into the MSSQL table, ‘tblMetroCount’. The MetroCount data were stored as individual vehicles by direction and lane; SQL queries were used to aggregate the data into 5-minute bins similar to the ATR and video classification database tables.

ATR Reduction

Permanently placed CDOT ATRs sampled 13 classes of vehicles based on the FHWA Scheme F axle classification method. The sensor configurations were inductance loop - piezoelectric strip - inductance loop. Electronic logging devices stored the vehicle counts for the 13 classes every 5 minutes. The resulting 24-hour reports were delivered as text files to Carter & Burgess. These fixed format files were then imported into the MSSQL table, ‘tblATRCount’. The ATR data was stored in the database by direction and lane in the original 5-minute bins.

Video Reduction

Over 630 hours of video were recorded and reduced during this study. To facilitate reducing this video information, Carter & Burgess developed a computer application that was used by the video reduction staff. This program is named VehicleClassifier. Figure 5 shows a screenshot of the program.

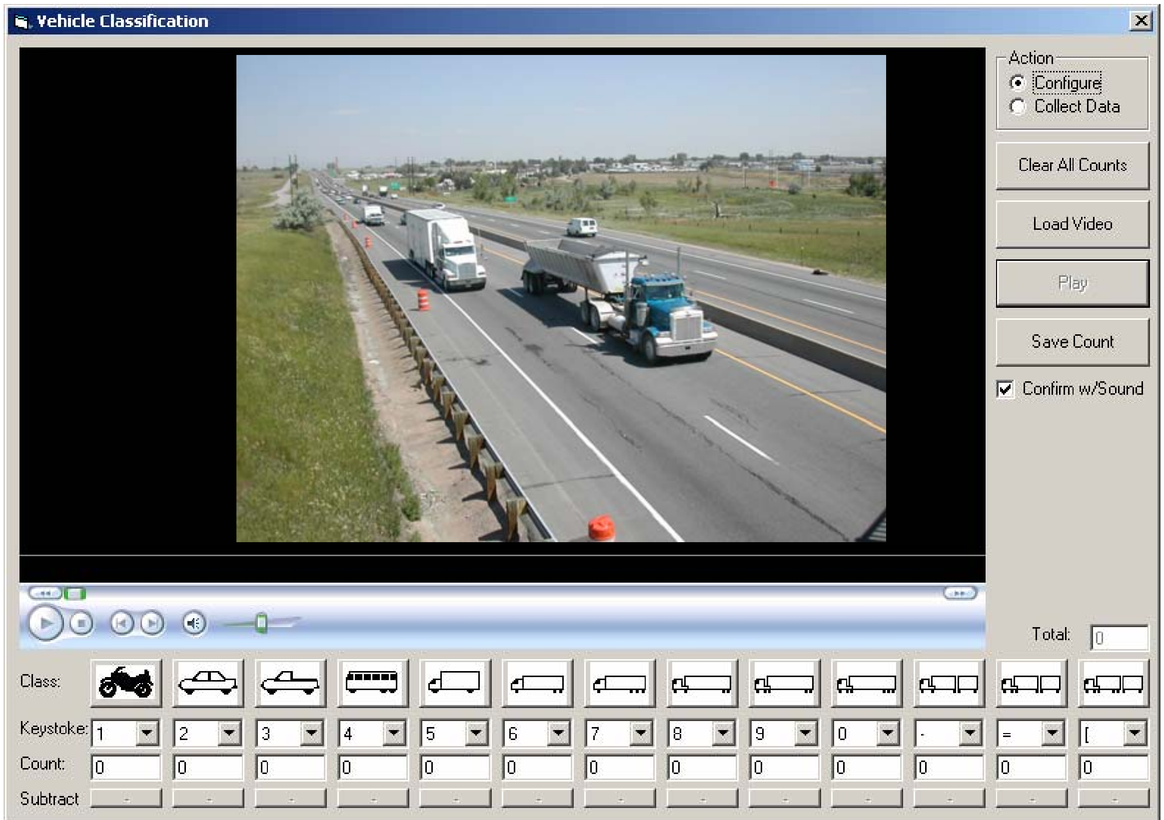


Figure 5: VehicleClassifier Program Screenshot

Project team members used the VehicleClassifier program by clicking the ‘Load Video’ button, selecting a video file (AVI) from a DVD and clicking the ‘Play’ button. After five minutes of counting vehicles, users would stop the video and click the ‘Save Count’ button. The program reads information from the video file name such as the site where the video was recorded and the collection date and prompts the user for the start and end time for the count, and the direction of traffic that they were counting. This information was saved with the counts by vehicle class onto the hard drive of the user. The comma delimited text file from the VehicleClassifier was imported in the MSSQL table, ‘tblVideoReduction’ (or ‘tblQCVideoReduction’ for quality control checks). The video reduction data was stored in the database by direction in 5-minute bins.

Data Collection Results

This section describes the attempts at data collection during the project as well as the quality control process and results.

Collection Times and Issues

Table 5: Data Collection Attempts

Cluster #	Site #	Site Description	Data Collection Methods: Cluster Count	24-Hour Video	ATR (CDOT ID)	Metro Count	2-Hour Video	Collection Dates & Issues
4	13	On Colorado Blvd N/O Cherry Creek S Blvd	Yes	Yes	No	No	No	8/19/03 – Video Failure 9/3/03 9/8/03
	14	On Cherry Creek S Blvd W/O Colorado Blvd	Yes	Yes	No	Yes	Yes	8/19/03 9/3/03
17	65	On Simms at US-6	Yes	Yes	No	No	No	8/26/03 – TOC Video Failure 9/17/03 9/24/03
23	95	On Wadsworth S/O 52nd Ave	Yes	Yes	No	No	No	8/27/03 9/15/03
38	156	On US 36 E/O Wadsworth	Yes	No	Yes (504)	No	Yes	9/16/03 9/24/03
43	180	On SH 121 S/O C-470	Yes	No	No	Yes	Yes	9/18/03 9/22/03 – MetroCount Failure 9/30/03
44	184	On SH 285 E/O C470	Yes	No	No	Yes	Yes	8/19/03 9/2/03
	186	On C-470 at Morrison Rd	Yes	No	Yes (512)	No	Yes	8/19/03 9/2/03 - ATR Failure 9/17/03
45	188	On SH 75 N/O Ken Caryl/Mineral	Yes	No	No	Yes	Yes	8/21/03 9/11/03 - MetroCount Failure 9/17/03 - Video Failure 11/11/03
48	204	On Hampden W/O Santa Fe	Yes	Yes	No	No	No	9/17/03 9/24/03
49	208	On SH 83 S/O I-225	Yes	Yes	No	No	No	9/9/03 9/22/03
59	249	On SH 157 S/O SH 119	Yes	No	No	Yes	Yes	9/25/2003 9/25/03

Table 5 summarizes when data were collected at each site. Some uncontrollable issues resulted in re-collection of data at some sites:

- At Site #13 on 8/20/03, the video equipment overheated and shut down while on the roof.
- At Site #65 on 8/26/03, the remote camera at the Traffic Operations Center was moved due to an accident on US-6.
- At Site #180 on 9/22/03, a MetroCount box was run over by a car.
- At Site #186 on 9/3/03, the CDOT ATR on C-470 at Morrison Road failed to save data.
- At Site #188 on 9/11/03, a MetroCount tube came loose and was punctured. A videotape for verification was lost for the collection on 9/17/03.

Quality Control Results

The quality control plan outlined in the study design was implemented and each classification count and method was verified. Detailed QA/QC graphs and descriptions are located in Appendix D – Quality Control Results. The following list summarizes the quality control checks, results, and corrections.

- One-hour MetroCount versus 1-hour Video Reduction
  - MetroCount underestimated classes 3 and 5 and overestimated class 2
  - This QC check found one MetroCount file that was labeled in the wrong direction. This problem was corrected in the database.
- One-hour ATR versus 1-hour Video Reduction
  - The two ATR sites used in this study underestimated classes 1, 3, 4, and 5 and overestimated class 2.
- Twenty four-hour ATR; Day 1 versus Day 2
  - The chi-square test shows that the classifications are different between the two collection days at both sites even after grouping into 3 classes (passenger cars, single unit trucks, and multi-unit trucks). Comparing the ATR data to the two-hours of video reduction at these sites did not reveal any problems with the data on either day.
- Twenty four-hour MetroCount; Day 1 versus Day 2

    - The chi-square test shows that the classifications are different between the two collection days at all five sites for 13 classes but two of five sites were similar when grouped into three classes.
    - One comparison revealed excess class 6 counts caused by a bad data file, which was corrected with help from the manufacturer.
- Twenty four-hour video reduction; Day 1 versus Day 2
    - The chi-square test shows that the classifications are different between the two collection days at all five sites with 13 classes but two of five sites were similar in one direction when grouped into three classes.
- Video Reduction for Each Employee
    - The most common error was miscounting class 3 as class 5. Approximately 48 hours of video was reduced a second time to correct video reduction problems identified from the quality control checks.

DATA ANALYSIS

Application of Chi-Square Test

As described in the study design (page 2), the chi-square statistic was used as a goodness of fit test between the short duration cluster counts and the 24-hour expected counts. The observed frequencies for each vehicle class were the cluster counts. The expected frequencies were the total cluster count sample multiplied by the percent of each vehicle class from the 24-hour count. The p-value obtained from the chi-square distribution was used as the primary indicator of how accurate the cluster count frequencies matched the 24-hour frequencies. A p-value greater than or equal to 0.10 indicates there is insufficient evidence to conclude that the observed and expected frequencies are significantly different. This study also used the p-value as an indicator of goodness of fit; with higher p-values representing a better fit.

If the expected count based on the 24-hour percentages for any vehicle class was less than 5, those vehicle classes were grouped with adjacent or similar vehicle classes until the count was at least 5. Since there are two adjacent classes for all but classes 1 and 13, the most similar one should always be picked (i.e. a class 3 SUV should be grouped with a class 2 passenger car instead of a class 4 bus). An algorithm was developed to accomplish this task automatically and with consistency for the statistical analysis. A table in Appendix E – Chi-Square Grouping Algorithm, shows where the algorithm added all possible combinations of adjacent classes if there were less than 5 expected observations in any one class.

Additional grouping of classes was considered to help compare data from different classification methods. The quality control checks demonstrate that the manual count frequencies do not match the electronic count frequencies for classes 2, 3, and 5. This study was designed for high volume urban roadways and over 90% of the vehicles were in classes 2 and 3. Class 5 could not be grouped with class 3 in a logical way but classes 2 and 3 were grouped for the analysis to account for the different collection methods. The first grouping was the standard three-bin classification group of passenger cars (classes 1 to 3), single unit trucks (classes 4 to 7), and multi-unit trucks (classes 8 to 13). The second grouping combined classes 2 and 3 resulting in 12 classes, while the third grouping removed classes 2 and 3 resulting in 11 classes.

Analysis of Existing Cluster Count Methodology

The performance of CDOT's existing cluster count methodology was assessed by using the chi-square test to compare the distribution of the manual short duration classification counts to the 24-hour counts. Prior to performing the chi-square test, the 24-hour counts were converted to expected frequencies by multiplying the percent of each classification by the total cluster count sample. Table 6 shows the results of the chi-square comparison. The results in Table 6 are sorted by roadway class to show how the current methodology performed for each type of roadway. The column labeled "Source of Data" indicates the type of 24-hour data that was used in the comparison. The rightmost columns, labeled "P-Value", contain the resulting p-value calculated from the chi-square test on the original 13 classes of vehicles and when grouping the classes into 3 classes. The p-value for 13 classes was used when comparing the manual cluster counts to the video data and the p-value for 3 classes was used when comparing the manual cluster count to electronic data (ATR and MetroCount). Higher p-values indicate a better statistical similarity between the cluster count data and the 24-hour data. For the purposes of this study, p-values greater than or equal to 0.10 represent adequate statistical proof that the cluster count was not different than the 24-hour data.

As shown in Table 6, seven of the 52 directional comparisons exhibited p-values greater than 0.10 when using all 13 vehicle classes and ten of the 52 comparisons exhibited p-values greater than 0.10 when using 3 vehicle classes. In general, the p-values are lower when comparing all 13 vehicle classes than when comparing the grouped 3 vehicle classes. Higher volume urban arterials seem to exhibit higher statistical similarity between the cluster count data and the 24-hour data. However, urban freeways show significant statistical differences for all comparisons.

Table 6: Results for Existing Cluster Count Methodology

Higher Volume Urban Arterial Site	Source of Data	Traffic Direction	Collection Date	P-Value 13 Classes	P-Value 3 Classes
On Colorado Blvd N/O Cherry Creek S Blvd	Video	Northbound	09/08/2003	0.029	0.080
On Colorado Blvd N/O Cherry Creek S Blvd	Video	Northbound	09/03/2003	0.001	0.521
On Colorado Blvd N/O Cherry Creek S Blvd	Video	Southbound	09/03/2003	0.001	0.001
On Colorado Blvd N/O Cherry Creek S Blvd	Video	Southbound	09/08/2003	0.004	0.010
On Simms at US-6	Video	Northbound	09/24/2003	0.409	0.831
On Simms at US-6	Video	Northbound	09/17/2003	0.781	0.740
On Simms at US-6	Video	Southbound	09/17/2003	0.748	0.737
On Simms at US-6	Video	Southbound	09/24/2003	0.008	0.045
On Wadsworth S/O 52nd Ave	Video	Northbound	08/27/2003	0.009	0.033
On Wadsworth S/O 52nd Ave	Video	Northbound	09/15/2003	0.001	0.013
On Wadsworth S/O 52nd Ave	Video	Southbound	09/15/2003	0.040	0.068
On Wadsworth S/O 52nd Ave	Video	Southbound	08/27/2003	0.079	0.025
Lower Volume Urban Arterial Site	**Source of Data**	**Traffic Direction**	**Collection Date**	**P-Value 13 Classes**	**P-Value 3 Classes**
On Cherry Creek S Blvd W/O Colorado Blvd	MetroCount	Eastbound	08/19/2003	0.001	0.001
On Cherry Creek S Blvd W/O Colorado Blvd	MetroCount	Eastbound	09/03/2003	0.001	0.898
On Cherry Creek S Blvd W/O Colorado Blvd	MetroCount	Westbound	09/03/2003	0.001	0.001
On Cherry Creek S Blvd W/O Colorado Blvd	MetroCount	Westbound	08/19/2003	0.001	0.001
On Cherry Creek S Blvd W/O Colorado Blvd	Video	Eastbound	08/19/2003	0.045	0.897
On Cherry Creek S Blvd W/O Colorado Blvd	Video	Eastbound	09/03/2003	0.142	0.082
On Cherry Creek S Blvd W/O Colorado Blvd	Video	Westbound	09/03/2003	0.404	0.958
On Cherry Creek S Blvd W/O Colorado Blvd	Video	Westbound	08/19/2003	0.051	0.187
On SH 121 S/O C-470	MetroCount	Northbound	09/18/2003	0.001	0.009
On SH 121 S/O C-470	MetroCount	Northbound	09/30/2003	0.001	0.001
On SH 121 S/O C-470	MetroCount	Southbound	09/30/2003	0.001	0.005
On SH 121 S/O C-470	MetroCount	Southbound	09/18/2003	0.001	0.001

Site	Source of Data	Traffic Direction	Collection Date	13 Classes	3 Classes
On SH 75 N/O Ken Caryl/Mineral	MetroCount	Northbound	08/21/2003	0.001	0.001
On SH 75 N/O Ken Caryl/Mineral	MetroCount	Northbound	11/11/2003	0.001	0.001
On SH 75 N/O Ken Caryl/Mineral	MetroCount	Southbound	11/11/2003	0.001	0.001
On SH 75 N/O Ken Caryl/Mineral	MetroCount	Southbound	08/21/2003	0.001	0.001

Urban Expressway				P-Value	
Site	Source of Data	Traffic Direction	Collection Date	13 Classes	3 Classes
On Hampden W/O Santa Fe	Video	Eastbound	09/17/2003	0.001	0.002
On Hampden W/O Santa Fe	Video	Eastbound	09/24/2003	0.001	0.001
On Hampden W/O Santa Fe	Video	Westbound	09/24/2003	0.001	0.001
On Hampden W/O Santa Fe	Video	Westbound	09/17/2003	0.001	0.006
On SH 157 S/O SH 119	MetroCount	Northbound	09/29/2003	0.001	0.005
On SH 157 S/O SH 119	MetroCount	Northbound	09/25/2003	0.001	0.001
On SH 157 S/O SH 119	MetroCount	Southbound	09/25/2003	0.001	0.031
On SH 157 S/O SH 119	MetroCount	Southbound	09/29/2003	0.001	0.001
On SH 83 S/O I-225	Video	Eastbound	09/09/2003	0.001	0.001
On SH 83 S/O I-225	Video	Eastbound	09/22/2003	0.005	0.079
On SH 83 S/O I-225	Video	Westbound	09/22/2003	0.854	0.814
On SH 83 S/O I-225	Video	Westbound	09/09/2003	0.451	0.273

Urban Freeway				P-Value	
Site	Source of Data	Traffic Direction	Collection Date	13 Classes	3 Classes
On C-470 at Morrison Rd	ATR	Eastbound	08/19/2003	0.001	0.001
On C-470 at Morrison Rd	ATR	Eastbound	09/17/2003	0.001	0.001
On C-470 at Morrison Rd	ATR	Westbound	09/17/2003	0.001	0.001
On C-470 at Morrison Rd	ATR	Westbound	08/19/2003	0.001	0.001
On SH 285 E/O C470	MetroCount	Eastbound	08/19/2003	0.001	0.001
On SH 285 E/O C470	MetroCount	Eastbound	09/02/2003	0.001	0.004
On SH 285 E/O C470	MetroCount	Westbound	09/02/2003	0.001	0.001
On SH 285 E/O C470	MetroCount	Westbound	08/19/2003	0.001	0.001
On US 36 E/O Wadsworth	ATR	Eastbound	09/16/2003	0.001	0.001
On US 36 E/O Wadsworth	ATR	Eastbound	09/24/2003	0.001	0.001
On US 36 E/O Wadsworth	ATR	Westbound	09/24/2003	0.001	0.001
On US 36 E/O Wadsworth	ATR	Westbound	09/16/2003	0.001	0.001

Note: Highlighted cells have a p-value greater than 0.10

Using the results shown in Table 6, the study panel concluded that the current cluster count methodology does not adequately capture the vehicle classification of the site with a high degree of statistical confidence. This conclusion, as well as the desire to identify a cluster count methodology that would provide good statistical results, led to an analysis where the data collection methodology was varied. Several graphs were developed to explore the classification patterns of the 24-hour data. Figures 6 through 8 show the normalized percent (percent of each class total) by hour for each class, averaged for all 24-hour counts collected in this study, with a

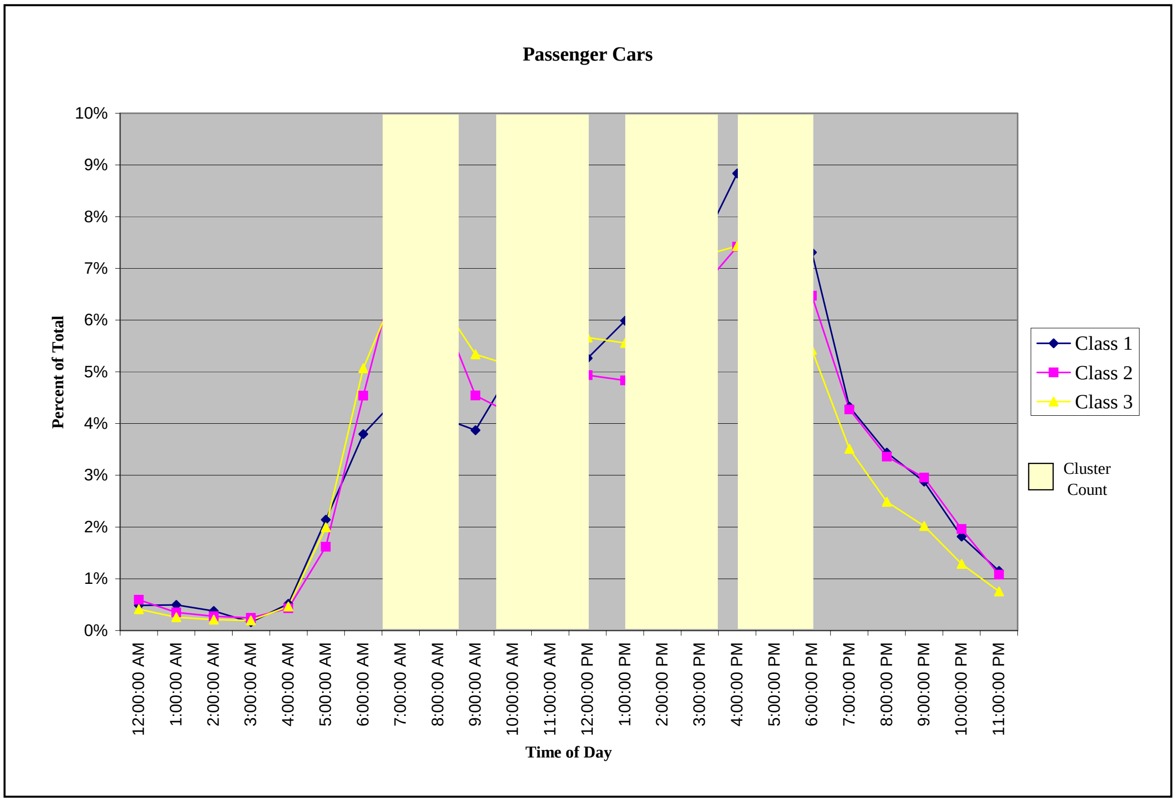


Figure 6: Normalized Percent Class by Hour for Passenger Cars

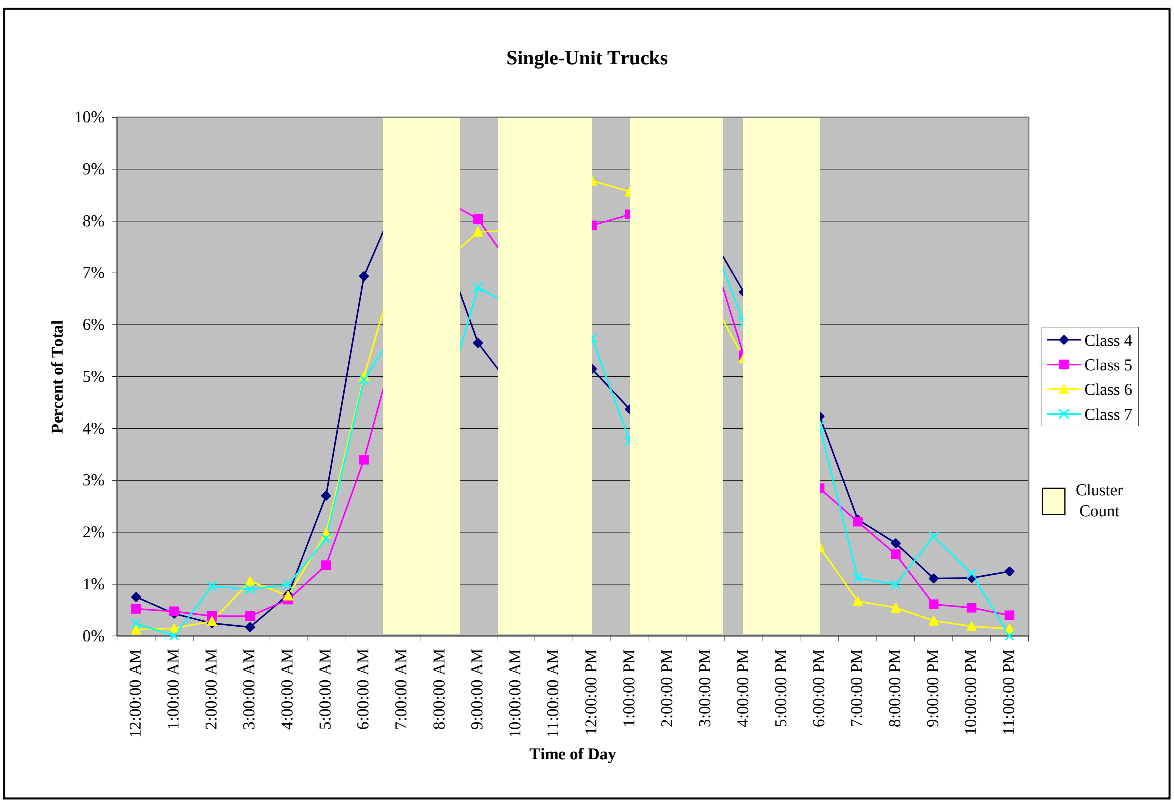


Figure 7: Normalized Percent Class by Hour for Single-Unit Trucks

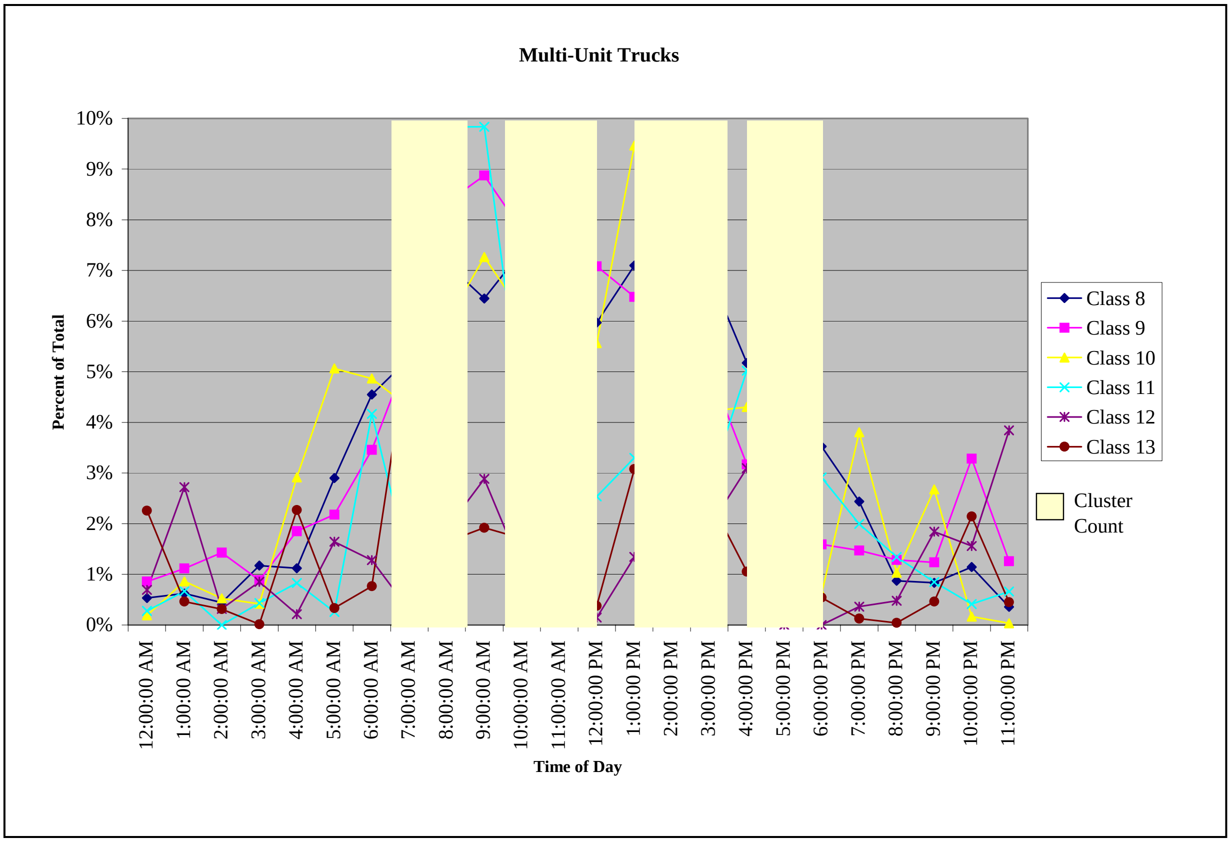


Figure 8: Normalized Percent Class by Hour for Multi-Unit Trucks

separate graph for passenger cars (Figure 6), single-unit trucks (Figure 7), and multi-unit trucks (Figure 8). The current cluster count time periods are shown with shaded rectangles. These graphs reveal that the mix of vehicles is noticeably different between night time and daylight hours and that the current time intervals do not capture the change in relative percentages that occur during non-daylight hours.

Virtual Cluster Count Analysis

In order to identify a cluster count methodology that would result in better statistical similarity to the expected data, Carter & Burgess performed numerous virtual cluster counts and calculated the chi-square statistic for each. These cluster counts are "virtual" because new cluster counts were not collected in the field for each of the tested methodologies. Instead, short duration counts were generated from the 5-minute data in the 24-hour classification datasets using the methodology being tested. These virtual cluster count results were then compared to the original 24-hour data using the chi-square statistic to evaluate the performance of the methodology.

The variables that were varied during the evaluation of virtual cluster count methodologies include minimum number of vehicles and minimum count duration. The minimum number of vehicles is the minimum total number of vehicles that must be observed before stopping the count. For this project, we tested methodologies that had minimum number of vehicles between 200 and 1000 vehicles. The minimum count duration is the minimum time that counting must continue. For this project, we tested methodologies that varied minimum count duration between 5 minutes and 60 minutes.

In addition to these variables, we also tested how adding additional count times to the methodology affected the performance. As described in the previous section (page 25), one of the factors that was thought to contribute to the low statistical accuracy of the original cluster count methodology was the lack of data collection times during the early morning and late evening, when the mix of vehicle classes is appreciably different than during the daytime hours. This belief was confirmed by testing the performance of a 12-hour long, daytime cluster count.

Table 7: Final Four Virtual Cluster Count Methodologies

Methodology	Minimum Number of Vehicles	Count Duration (minutes) Minimum	Count Duration (minutes) Maximum	Number of Start Times	Comments
Original Methodology	200	5	45	4	A count is taken at four different times of day (2 peak hours and 2 off-peak hours) at each site of a cluster. A count is ended at a given site after 200 vehicles per through lane are observed or after 45 minutes, whichever comes first.
7-60/30	none	varies	varies	7	A count is taken at seven times during the day. The first count is performed for one hour duration during the early morning, before the morning peak. The remaining counts are performed during and after the morning peak. Each of these counts is 30 minutes duration and occur approximately every 3 hours.
8-40/20	none	varies	varies	8	A count is taken at eight times during the day. The first and last counts are 40 minutes long and occur before the morning peak and after the evening peak, respectively. The other four counts are performed every 2 hours for 20 minutes each.
15 Minutes Every Hour	none	15	15	24	A count is performed approximately every hour for 15 minutes duration throughout the day.

Even though the 12-hour count provided for a large number of vehicles to be observed, the results were worse than the classification estimates from the current methodology when compared to the 24-hour data.

Table 7 lists the final four virtual cluster count methodologies that were tested; the original methodology and the three virtual cluster count scenarios with highest p-value after testing over 30 different methodologies. The original cluster count methodology was included in the evaluation as a baseline over which improvements would be identified.

In Table 7, the column labeled "Minimum Number of Vehicles" is the total number of vehicles that had to be counted during a counting session before the count could be terminated. The methodologies that display "none" in this column did not end after counting a certain number of vehicles but instead counted for the required duration. The columns labeled "Count Duration" show the minimum and maximum time that counting was performed during a counting session. The column labeled "Number of Start Times" indicates the number of times that counts were performed at a location for each direction during the day.

Figure 9 displays a graphical representation of the methodologies and their start times. The times

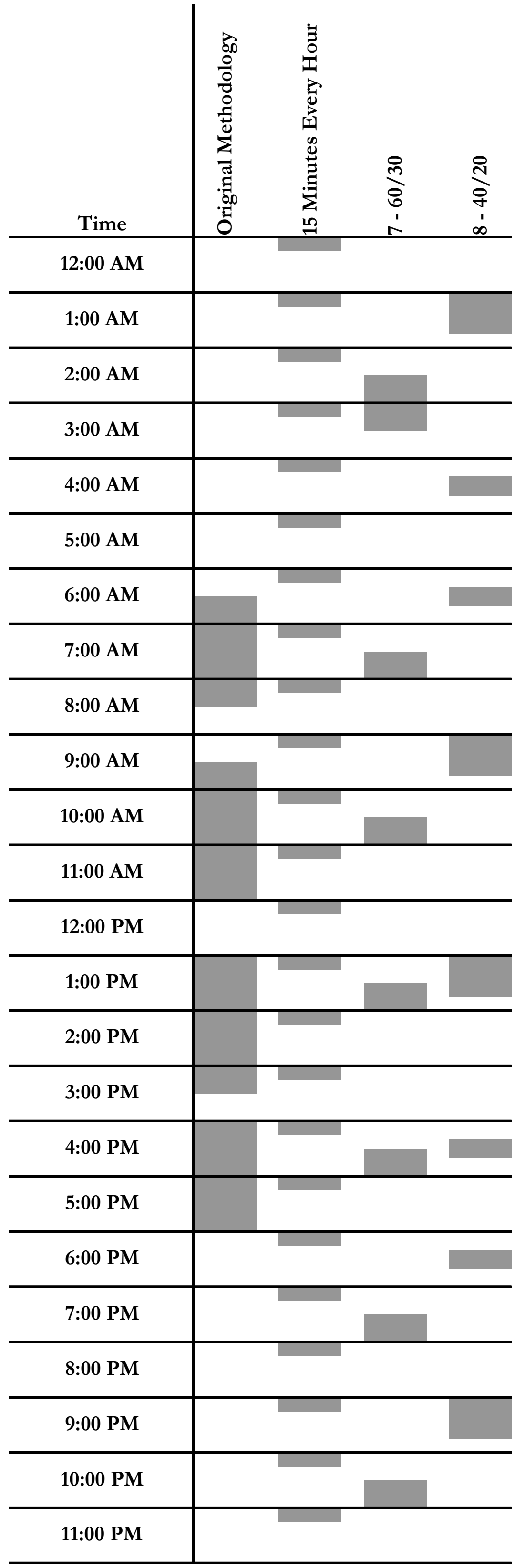


Figure 9: Virtual Cluster Count Collection Times

throughout the day are listed on the left hand side of the figure and each of the final four methodologies are listed across the top. The shaded areas in the body of the figure represent those times when the methodology might be collecting vehicle count data, depending on the other methodology criteria.

Virtual cluster counts were generated for each of these methodologies by sampling the vehicle counts from the 24-hour datasets. Since the 24-hour datasets include counts for every 5 minutes, the total vehicle count was iteratively compared to the methodology criteria to identify when counting should stop. These cluster count results were then compared to the original 24-hour data using the chi-square test. The results of these comparisons are shown in Table 8.

Table 8: Statistical Comparison of Virtual Cluster Counts Methodologies

Roadway Class	Methodology	Number of Comparisons: P-value >= 0.10	Number of Comparisons: P-value < 0.10	Percent of P-values >= 0.10	P-value Statistics: Minimum	Average	Maximum	Avg-Std	Avg+Std
Higher Volume Urban Arterial									
	15 Minutes Every Hour	12	0	100	0.14	0.69	0.99	0.45	0.87
	7 - 60/30	11	1	91	0.03	0.54	0.95	0.24	0.89
	8 - 40/20	10	2	83	0.00	0.51	0.98	0.17	0.83
	Original Methodology	5	7	41	0.00	0.22	0.68	-0.04	0.57
Lower Volume Urban Arterial									
	15 Minutes Every Hour	15	1	93	0.01	0.68	0.98	0.43	0.87
	7 - 60/30	15	1	93	0.09	0.65	0.94	0.41	0.84
	8 - 40/20	16	0	100	0.41	0.68	0.89	0.53	0.94
	Original Methodology	8	8	50	0.00	0.31	0.92	-0.02	0.59
Urban Expressway									
	15 Minutes Every Hour	12	0	100	0.14	0.57	0.99	0.30	0.86
	7 - 60/30	8	4	66	0.02	0.37	0.79	0.05	0.69
	8 - 40/20	11	1	91	0.06	0.49	0.81	0.27	0.75
	Original Methodology	6	6	50	0.00	0.20	0.66	-0.02	0.58
Urban Freeway									
	15 Minutes Every Hour	11	1	91	0.06	0.53	0.94	0.26	0.78
	7 - 60/30	10	2	83	0.08	0.42	0.74	0.19	0.71
	8 - 40/20	10	2	83	0.01	0.50	0.89	0.22	0.78
	Original Methodology	0	12	0	0.00	0.03	0.08	0.00	0.41

The “Number of Comparisons” column displays the number of directional virtual cluster counts that were compared to the original 24-hour data that had p-values greater than or equal to 0.10 (indicating statistical similarity) and p-values less than 0.10. The “Percent of p-value >= 0.10” column displays the percentage of comparisons that have p-values greater than or equal to 0.10. The right-hand columns labeled “P-value Statistics” display the minimum, average, maximum and lower and upper 98 percent confidence interval.

As shown, the 15 Minutes Every Hour methodology has the highest percentage of comparisons with a p-value greater than or equal to 0.10. In addition, the average p-value for this methodology was the highest for all roadway classes. The Original Methodology exhibited the lowest statistical significance, with the lowest percentage of comparisons with a p-value greater than or equal to 0.10 and the lowest average p-value.

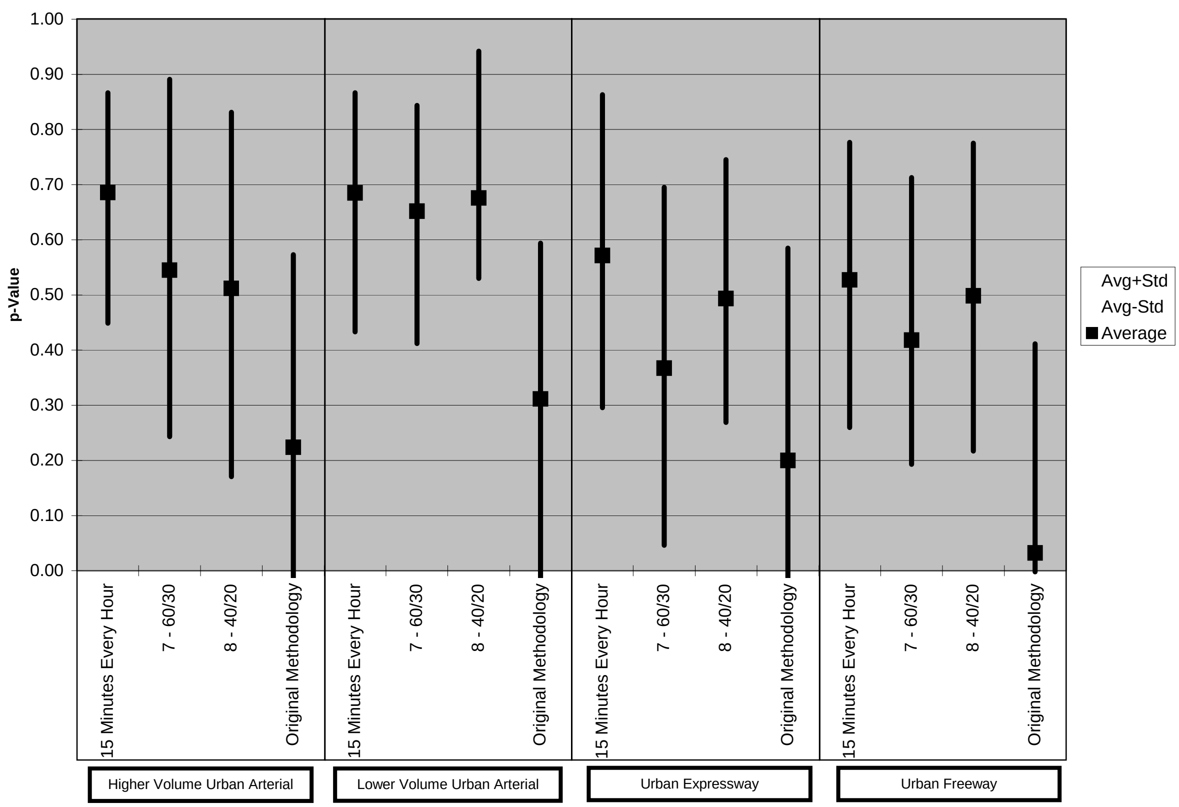


Figure 10: Graph of Average P-Values for Virtual Cluster Count Methodologies

Figure 10 shows the average and 98 percent confidence intervals for the methodologies. The dark square in the approximate middle of the line is the average p-value. As shown, the original methodology had an appreciably lower range of p-values than the other methodologies.

As shown in Figure 10, the 15 Minutes Every Hour methodology had a smaller confidence interval and higher average p-value for higher volume urban arterial roadways than any of the other methodologies. For lower volume urban arterial roadways, the 15 Minutes Every Hour, 7 - 60/30 and 8 – 40/20 methodologies exhibited similar confidence intervals and similar average p-values that were significantly above the p-value for the Original Methodology. For urban expressway roadways, the 8 – 40/20 methodology exhibited a smaller confidence interval than the 15 Minutes Every Hour and the 7 – 60/30 methodology but a lower average p-value than the 15 Minutes Every Hour, which had the highest p-value. For urban freeways, the 15 Minutes Every Hour and 7 – 60/30 methodologies exhibited similar confidence intervals but the average value for the 15 Minutes Every Hour methodology was the highest of the methodologies that were tested.

Upon review of Figure 10, the study panel decided that additional criteria beyond accuracy should be considered in evaluating and selecting the best methodology. To assist in this decision, the panel ranked each methodology as well as the 24-hour count according to three criteria: accuracy, cost and ease of implementation. The average p-value was used as the accuracy rank (1 is the most accurate) and the normalized value was calculated as the average p-value multiplied by 10. The cost rank was calculated from the cost estimate for each methodology obtained from two traffic collection vendors and then normalized between 1 and 10 with 10 as the lowest cost. These per site cost estimates were based on the amount of labor for two field technicians to classify vehicles according to the methodologies listed in Table 7. It was also assumed that only one site could be classified for the 24-hour count and two sites could be classified for the other three methodologies during a 24-hour period. The study panel developed the ease of collection rank based on the count duration, the ability of field personnel to understand the methodology, and the ability to collect vehicle classification with current count board technology. Each of the five methodologies was ranked in order with 1 as the easiest to collect. Each criterion was then weighted according to values provided by CDOT; accuracy was considered most important and assigned a weight of 10, cost a weight of 7 and ease of collection a weight of 5. These weights where multiplied by the normalized ranking and then summed as the total weighted score for each methodology.

Table 9 shows the results of this evaluation. As shown, the 15 Minutes Every Hour Methodology has the highest score (151.9). The 24 hour count and 7-60/30 methodology had the lowest scores. It is worth noting that the original methodology scores highest when only considering cost plus ease of collection while the 15 Minutes Every Hour methodology scores highest when including the accuracy score.

Table 9: Cost Benefit Analysis of Virtual Cluster Count Methodologies

				Normalized Ranking			Weighted Scores 10	Weighted Scores 7	Weighted Scores 5	
Scenario Name	Average p-Value	Cost Per Site	Ease of Collection Rank	Accuracy	Cost	Ease of Collection	Accuracy	Cost	Ease of Collection	Total Score
24-hour Count	1.00	$2,300	5	10.0	1.0	1.0	100.0	7.0	5.0	112.0
Original Methodology	0.20	$170	1	2.0	10.0	10.0	20.1	70.0	50.0	140.1
7 - 60/30	0.51	$665	4	5.1	7.9	3.3	50.8	55.4	16.3	122.4
8 - 40/20	0.56	$675	3	5.6	7.9	5.5	55.5	55.1	27.5	138.1
15 Minutes Every Hour	0.62	$815	2	6.2	7.3	7.8	62.2	50.9	38.8	151.9

FIELD VERIFICATION

The 15 Minutes Every Hour method ranked the highest overall when considering accuracy, cost, and ease of collection. However, the study panel recognized that the results were based on simulated short duration counts. The study team decided to perform a field test using the two best performing virtual count methods; 8-40/20 and 15 Minutes Every Hour to test the field accuracy and ease of collection.

Study Design

The field study was designed to test the accuracy of both methods for one higher volume urban arterial and one lower volume urban arterial. At these sites, 24-hour video was recorded while two field crews classified vehicles; one using the 15 Minutes Every Hour methodology and the other using the 8-20/40 methodology. The field study was also designed to test the ease of collection. This was accomplished by having the same field crew classify vehicles at the same site for two 24-hour periods; the first day using the 15 Minutes Every Hour methodology and the second day using the 8-20/40 methodology. Table 10 summarizes the study sites and collection methods used for the field verification.

Table 10: Study Sites And Collection Methods Used For Field Verification

Site	Site Description	Facility/ADT Category	Data Collection Methods		
			24 - 15 minute	8 - 40/20 minute	24-hour video
11/4/2004 - Test Accuracy					
21	On SH40(Colfax) E/O I-70	Lower Volume Urban Arterial	Yes	Yes	Yes
256	On US-6 E/O Colfax	Urban Freeway	Yes	Yes	No
257	On Colfax E/O US-6	Lower Volume Urban Arterial	23 of 24 counts	No	No
11/18/2004 - Test Accuracy					
51	On Havana S/O Parker	Higher Volume Urban Arterial	Yes	Yes	Yes
258	On Havana N/O Parker	Higher Volume Urban Arterial	Yes	Yes	No
259	On Parker E/O Havana	Higher Volume Urban Arterial	16 of 24 counts	No	No
10/21/2004 - Test Ease of Collection					
252	On Hwy 58 W/O MacIntyre	Urban Freeway	Yes	No	No
253	On US-6 E/O Hwy 58	Urban Freeway	Yes	No	No
11/16/2004 - Test Ease of Collection					
252	On Hwy 58 W/O MacIntyre	Urban Freeway	No	Yes	No
253	On US-6 E/O Hwy 58	Urban Freeway	No	Yes	No
11/2/2004 - Test Ease of Collection					
254	On I-25 S/O 23rd St	Urban Freeway	Yes	No	No
255	On 15th St at I-25	Lower Volume Urban Arterial	Yes	No	No
11/9/2004 - Test Ease of Collection					
254	On I-25 S/O 23rd St	Urban Freeway	No	Yes	No
255	On 15th St at I-25	Lower Volume Urban Arterial	No	Yes	No

Methodology Results

Table 11 shows the results of the chi-square test between the 24-hour count and short duration classification count for each methodology and direction. These high p-values (> 0.10) indicate that both methodologies are statistically similar to the 24-hour vehicle classification. The average p-value for both directions at both test sites was 0.74 for the 15-minute every hour method and 0.72 for the 8-40/20 method.

Table 11: Field Verification Chi-Squared Results of Short Duration Counts Versus 24-Hour Counts

Site Description	Direction	Methodology	p-value (13 Bin)
On Havana S/O Parker	Northbound	24 - 15 minutes	0.57
On Havana S/O Parker	Southbound	24 - 15 minutes	0.58
On Havana S/O Parker	Northbound	8 - 40/20 minutes	0.80
On Havana S/O Parker	Southbound	8 - 40/20 minutes	0.83
On SH 40 (Colfax) E/O I-70	Eastbound	24 - 15 minutes	0.93
On SH 40 (Colfax) E/O I-70	Westbound	24 - 15 minutes	0.89
On SH 40 (Colfax) E/O I-70	Eastbound	8 - 40/20 minutes	0.27
On SH 40 (Colfax) E/O I-70	Westbound	8 - 40/20 minutes	0.97

Quality Control

The procedures used for checking the field verification data revealed to the study team the importance of quality control on short duration counts. In Table 12, the 'Original Count' column shows the results for the original field data before quality control. According to the original

Table 12: Importance of Quality Control on Short Duration Classification Counts

			p-value (13 Bin)	
Site Description	Direction	Methodology	Original Count	Corrected Count
On Havana S/O Parker	Southbound	24 - 15 minutes	0.04	0.58
On SH 40 (Colfax) E/O I-70	Eastbound	24 - 15 minutes	0.03	0.93
On SH 40 (Colfax) E/O I-70	Westbound	24 - 15 minutes	0.01	0.89

(Note: highlighted cells are not statistically similar to 24-hour classification)

counts, three result rows had a p-value less than 0.10, signifying that the short duration counts were not statistically similar to the 24-hour classification counts. During the quality control checks, it was determined that a couple of field technicians did not classify vehicles correctly while collecting short duration counts. The manual counts with errors were recounted using the digital video and the chi-squared results were recalculated as shown in the 'Corrected Count' column. The field test revealed to the study team that the quality of each short duration count is just as important as the chosen methodology. If one field technician misclassifies vehicles during one shift of a 24-hour period, the short duration count will not statistically represent the 24-hour classification.

Ease of Collection

The field technicians were interviewed after each collection period to help the study team rate the ease of collection for the two methodologies (see Appendix F). Most of the negative comments were related the 8-40/20 methodology and the long count duration on high volume I-25 (urban freeway). The count boards used in the field had 5, 10 and 15-minute bins options so it was easier for the supervisor to download the 15-minute counts versus adding multiple counts together for the 20 and 40 minute counts.

Cost Benefit Analysis

The study team performed the same cost benefit analysis using the values from the field verification compared to a 24-hour manual classification count. The p-values were averaged across all sites and directions in the verification study and costs were revised based on actual field costs for the two methodologies.

Table 13: Cost Benefit Analysis of Field Verification Results

							Weighted Scores			
				Normalized Ranking			10	7	5	
Scenario Name	Average p-Value	Cost Per Site	Ease of Collection Rank	Accuracy	Cost	Collection	Accuracy	Cost	Ease of Collection	Total Score
24-hour Count	1.00	$2,300	3	10.0	1.0	1.0	100.0	7.0	5.0	112.0
8 - 40/20	0.72	$790	2	7.2	10.0	5.5	71.9	70.0	27.5	169.4
15 Minutes Every Hour	0.74	$894	1	7.4	9.4	10.0	74.3	65.7	50.0	189.9

Table 13 shows the result of this evaluation. Once again, the 15-minute every hour methodology resulted in the highest score. At the site SH 40 (Colfax) east of I-70, the technicians counting with the 15-minute every hour methodology were able to collect short duration counts for 23 of

24 hours at a nearby third site. In instances where it is possible to collect three sites, the cost per site for the 15-minute every hour would be reduced and the total score would increase. The time constraints of the 8-20/40 methodology do not allow collection at more than two sites.

The study team used the data and experience gathered as part of the field validation and selected the 15 Minutes Every Hour methodology as the recommended method for collecting future short duration classification counts to estimate 24-hour vehicle classification on high volume urban facilities.

CONCLUSION AND RECOMMENDATIONS

The study revealed that the original cluster count method is outside the parameters that are acceptable for a predictor of 24-hour vehicle classification. Further examination of the data indicated that even a 12-hour count during daylight hours does not statistically represent the 24-hour classification. Several virtual cluster count methodologies were developed and tested using the data collected at the beginning of the project. The three best performing cluster counts scenarios were compared to the original methodology and 24-hour counts. A cost benefit analysis was performed using accuracy from the statistical analysis, cost, and ease of collection as the criteria. This research resulted in the study team selecting the 15 Minutes Every Hour methodology as the recommended method for collecting future short duration classification counts. This vehicle classification method offers the following advantages:

- Statistically accurate
- Captures the variation in vehicle classes that occur during a 24-hour period
- One collection method that applies to all four urban roadway categories listed in Table 1
- Does not rely on the Scheme F algorithm for classifying vehicles as with electronic counts
- Easy for field personnel to understand and collect
- About one-third of the cost of a manual 24-hour count since fewer personnel can count multiple sites.

A guidebook has been developed that will supplement this report by describing the 15-minute every hour methodology in detail. This guidebook outlines how to collect the short duration classification data, process and manage the data, and outlines quality control procedures.

The quality control results of this study indicate that there are statistically significant variations in vehicle classifications at a site for different collection dates. None of the 24-hour classifications with 13 vehicle classes were statistically similar to 24-hour classification counts taken at the same site on a different day. Only four out of twelve sites were statistically similar between different collection days when grouping into three classes. Another research study is recommended to determine the relationship between the average vehicle classification over a period of time, such as weekly or yearly, and a 24-hour classification count.

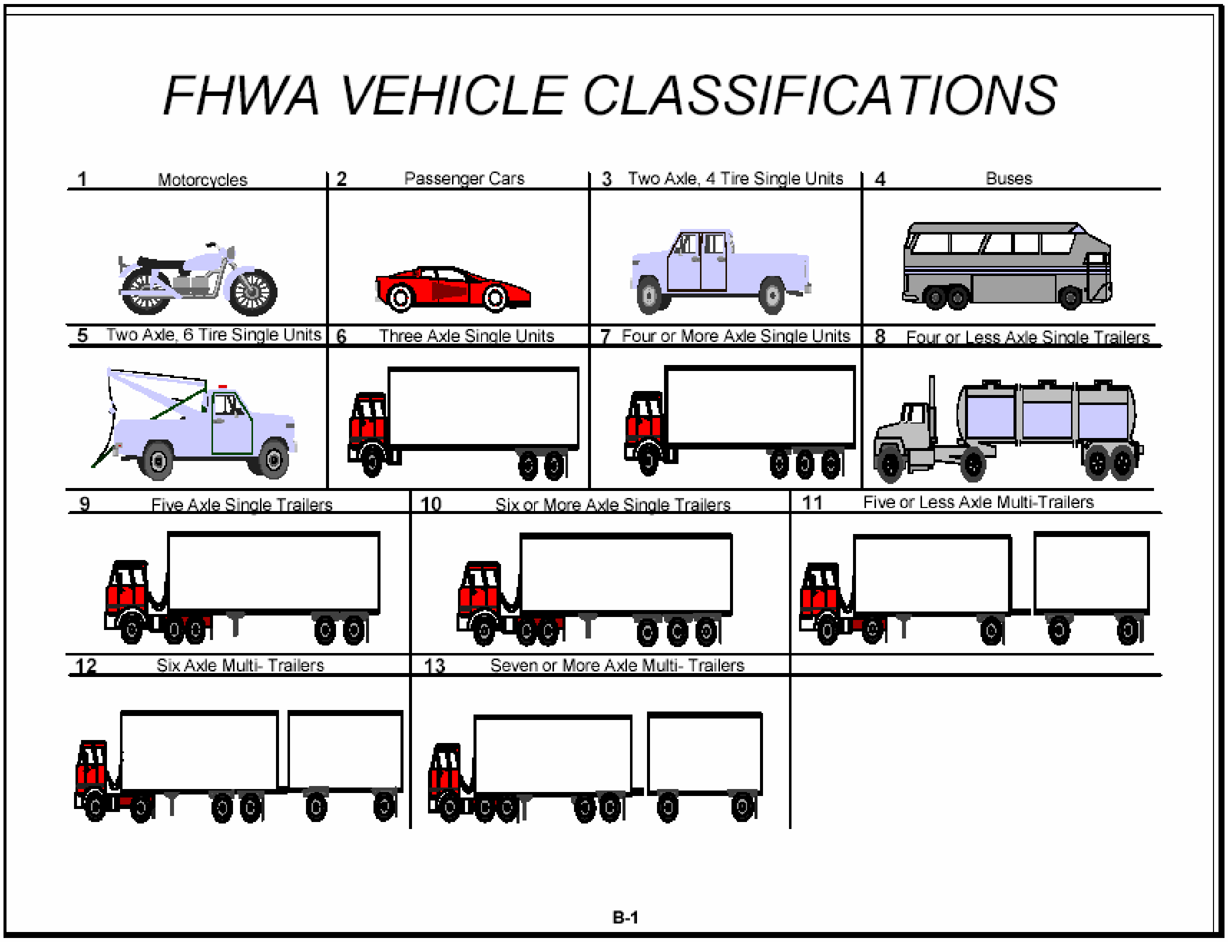
REFERENCES

Microcom Pty Ltd “MetroCount Vehicle Classifier System” <http://www.metrocount.com/products/automatic_traffic_recorder.html> (7 Aug 2003)

Hayter, Anthony. “Probablity and Statistics for Engineers and Scientists.” p. 518-532. PWS Publishing Company, 1996.

The Ohio Department of Transportation (ODOT) “FHWA Vehicle Classification Scheme F Report” <http://www.dot.state.oh.us/techservsite/availpro/Traffic_Survey/SchemeF/ FHWA_Scheme_F_Report.PDF> (17 September 2003)

APPENDIX A – FHWA VEHICLE CLASSIFICATIONS



Class 1- Motorcycles: All two- or three-wheeled motorized vehicles. Typical vehicles in this category have saddle type seats and are steered by handle bars rather than wheels. This category includes motorcycles, motor scooters, mopeds, motor-powered bicycles, and three-wheeled motorcycles.

Class 2- Passenger Cars: All sedans, coupes, and station wagons manufactured primarily for the purpose of carrying passengers and including those passenger cars pulling recreational or other light trailers.

Class 3- Other Two-Axle, Four-Tire, Single Unit Vehicles: All two-axle, four-tire, vehicles other than passenger cars. Included in this classification are pickups, panels, vans, and other vehicles such as campers, motor homes, ambulances, hearses, carryalls, and minibuses. Other two-axle, four-tire single unit vehicles pulling recreational or other light trailers are included in this classification.

Class 4- Buses: All vehicles manufactured as traditional passenger-carrying buses with two axles and six tires or three or more axles. This category includes only traditional buses (including school buses) functioning as passenger-carrying vehicles. Modified buses should be considered to be trucks and be appropriately classified.

Note: In reporting information on trucks the following criteria should be used:
a. Truck tractor units traveling without a trailer will be considered single unit trucks.
b. A truck tractor unit pulling other such units in a "saddle mount" configuration will be considered as one single unit truck and will be defined only by axles on the pulling unit.
c. Vehicles shall be defined by the number of axles in contact with the roadway. Therefore, "floating" axles are counted only when in the down position.
d. The term "trailer" includes both semi- and full trailers.

Class 5- Two-Axle, Six-Tire, Single Unit Trucks: All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., having two axles and dual rear wheels.

Class 6- Three-axle Single unit Trucks: All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., having three axles.

Class 7- Four or More Axle Single Unit Trucks: All trucks on a single frame with four or more axles.

Class 8- Four or Less Axle Single Trailer Trucks: All vehicles with four or less axles consisting of two units, one of which is a tractor or straight truck power unit.

Class 9- Five-Axle Single Trailer Trucks: All five-axle vehicles consisting of two units, one of which is a tractor or straight truck power unit.

Class 10- Six or More Axle Single Trailer Trucks: All vehicles with six or more axles consisting of two units, one of which is a tractor or straight truck power unit.

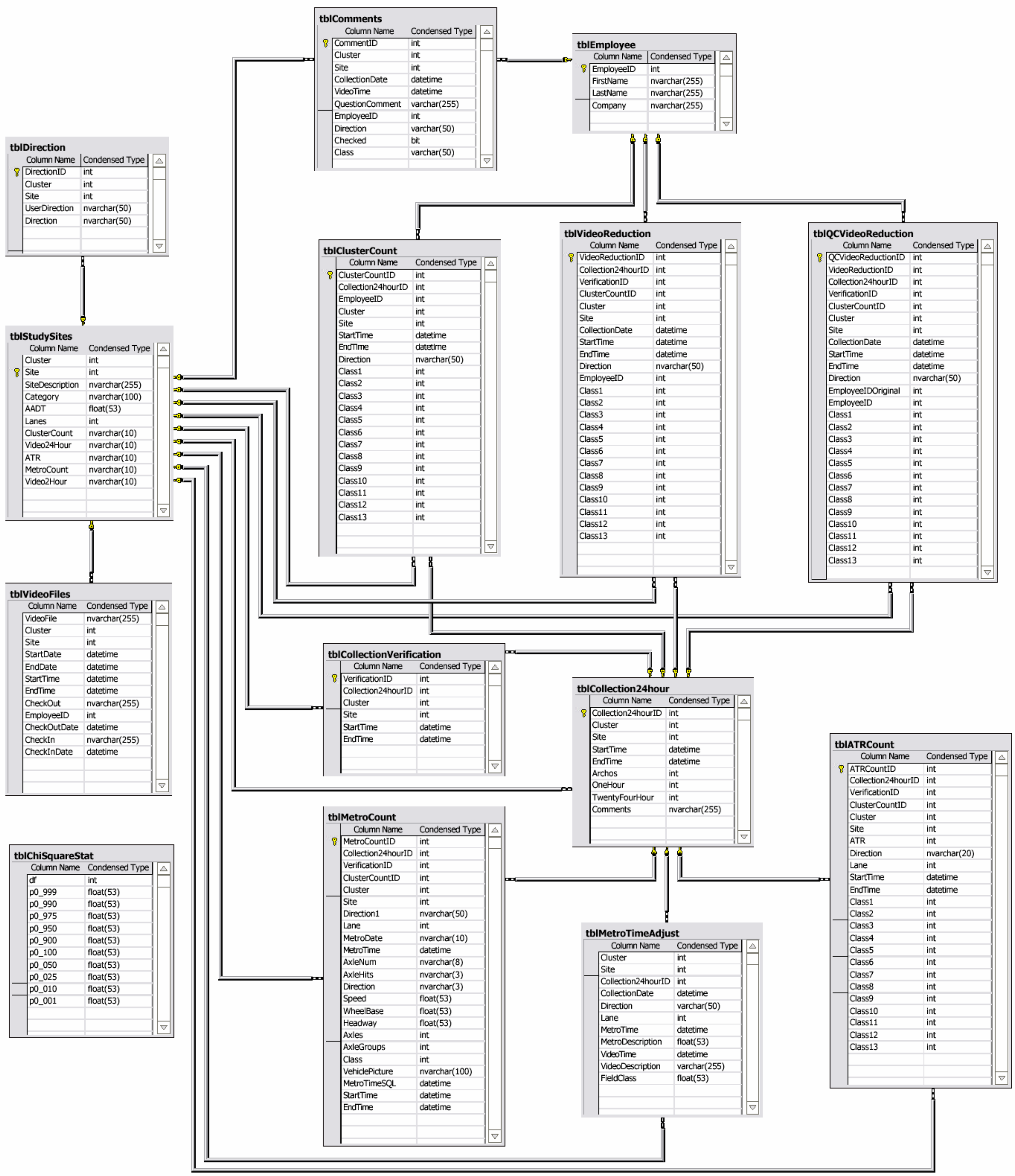
Class 11- Five or Less Axle Multi-Trailer Trucks: All vehicles with five or less axles consisting of three or more units, one of which is a tractor or straight truck power unit

Class 12- Six-Axle Multi-Trailer Trucks: All six-axle vehicles consisting of three or more units, one of which is a tractor or straight truck power unit.

Class 13- Seven or More Axle Multi-Trailer Trucks: All vehicles with seven or more axles consisting of three or more units, one of which is a tractor or straight truck power unit.

APPENDIX B – DATABASE DICTIONARY

CDOT DTD
Validation of Urban Vehicle Classification Sampling Methodology
Database Diagram - Classification Data



Carter::Burgess

DATA DICTIONARY

Data Type Synonyms for MSSQL and MS Access

The fields described in this data dictionary are based on MSSQL data types. If the data has been exported to MS Access, use the following table to determine the data type:

ACCESS	MSSQL
date/time	datetime
double	float, decimal
long integer	integer (int)
text	varchar, char

Legend

The following table describes the symbols and variables used in formulas and tables throughout this document:

SYMBOL	DESCRIPTION
*	Primary Key
i	Current record
N	Number of records

Tables

The following table describes the tabular data stored in the database. The prefix 'tbl' indicates tabular data.

TABLE	FIELD NAME	DATA TYPE	DESCRIPTION
tblATRCount			***CDOT ATR Classification Data 5-minute counts***
	*ATRCountID	integer	ATR record identifier
	Collection24hourID	integer	Identifier from tblCollection24hourID for the 24-hour period the data was collected
	VerificationID	integer	Verification identifier from tblVerificationID
	ClusterCountID	integer	Cluster Count identifier from tblClusterCount
	Cluster	integer	DTD cluster identifier from tblStudySites
	Site	integer	DTD site identifier from tblStudySites
	ATR	integer	DTD ATR number

TABLE	FIELD NAME	DATA TYPE	DESCRIPTION
	Direction	varchar	Direction of travel: Northbound, Southbound, Eastbound, Westbound
	Lane	integer	Directional laneage, lane 1 = curb or outside lane, lane 2 = inside lane
	StartTime	datetime	The 5-minute interval start time
	EndTime	datetime	The 5-minute interval end time
	Class1	integer	Motorcycles
	Class2	integer	Passenger Cars
	Class3	integer	Other Two-Axle, Four-Tire, Single Unit Vehicles (Pickup Truck, SUV)
	Class4	integer	Buses
	Class5	integer	Two-Axle, Six-Tire, Single Unit Trucks
	Class6	integer	Three-axle Single unit Trucks
	Class7	integer	Four or More Axle Single Unit Trucks
	Class8	integer	Four or Less Axle Single Trailer Trucks
	Class9	integer	Five-Axle Single Trailer Trucks
	Class10	integer	Six or More Axle Single Trailer Trucks
	Class11	integer	Five or Less Axle Multi-Trailer Trucks
	Class12	integer	Six-Axle Multi-Trailer Trucks
	Class13	integer	Seven or More Axle Multi-Trailer Trucks
tblChiSquareStat			***Critical points of the chi-square distribution***
	*df	integer	Degrees of freedom
	p0_999	float	Critical value for α = 0.999
	p0_990	float	Critical value for α = 0.990
	p0_975	float	Critical value for α = 0.975
	p0_950	float	Critical value for α = 0.950
	p0_900	float	Critical value for α = 0.900
	p0_100	float	Critical value for α = 0.100
	p0_050	float	Critical value for α = 0.050
	p0_025	float	Critical value for α = 0.025
	p0_010	float	Critical value for α = 0.010
	p0_001	float	Critical value for α = 0.001
tblClusterCount			***Short duration manual classification counts collected using previous CDOT methodology***
	*ClusterCountID	integer	Unique identifier for cluster count table. One record for each short duration count by site, collection date and direction
	Collection24hourID	integer	Identifier from tblCollection24hourID for the 24-hour period the data was collected
	EmployeeID	integer	Identifier from tblEmployee for the employee that collected the data
	Cluster	integer	DTD cluster identifier from tblStudySites
	Site	integer	DTD site identifier from tblStudySites
	StartTime	datetime	Start time for cluster count
	EndTime	datetime	End time for cluster count
	Direction	nvarchar(50)	Direction of travel: Northbound, Southbound, Eastbound, Westbound
	Class1	integer	Motorcycles
	Class2	integer	Passenger Cars
	Class3	integer	Other Two-Axle, Four-Tire, Single Unit Vehicles (Pickup Truck, SUV)

TABLE	FIELD NAME	DATA TYPE	DESCRIPTION
	Class4	integer	Buses
	Class5	integer	Two-Axle, Six-Tire, Single Unit Trucks
	Class6	integer	Three-axle Single unit Trucks
	Class7	integer	Four or More Axle Single Unit Trucks
	Class8	integer	Four or Less Axle Single Trailer Trucks
	Class9	integer	Five-Axle Single Trailer Trucks
	Class10	integer	Six or More Axle Single Trailer Trucks
	Class11	integer	Five or Less Axle Multi-Trailer Trucks
	Class12	integer	Six-Axle Multi-Trailer Trucks
	Class13	integer	Seven or More Axle Multi-Trailer Trucks
tblCollection24hour			***Collection times for 24-hour classification count***
	*Collection24hourID	integer	Identifier for the 24-hour period the data was collected
	Cluster	integer	DTD cluster identifier from tblStudySites
	Site	integer	DTD site identifier from tblStudySites
	StartTime	datetime	Start time for 24-hour collection period
	EndTime	datetime	End time for 24-hour collection period
tblCollectionVerification			***Collection times for 1-hour video verification of electronic classification counts***
	*VerificationID	integer	Record identifier for 1-hour video verification
	Collection24hourID	integer	Identifier from tblCollection24hourID for the 24-hour period the data was collected
	Cluster	integer	DTD cluster identifier from tblStudySites
	Site	integer	DTD site identifier from tblStudySites
	StartTime	datetime	Start time for video verification
	EndTime	datetime	End time for video verification
tblComments			***Questions/comments raised by employees during video reduction***
	*CommentID	integer	Record identifier for comment table
	Cluster	integer	DTD cluster identifier from tblStudySites
	Site	integer	DTD site identifier from tblStudySites
	CollectionDate	datetime	Date of data collection
	VideoTime	datetime	Time stamp on video
	QuestionComment	varchar(255)	Question or comment about a vehicle the video at VideoTime
	EmployeeID	integer	Identifier from tblEmployee for the employee that collected the data
	Direction	varchar(50)	Direction of travel: Northbound, Southbound, Eastbound, Westbound, Closest to camera, Furthest from camera
	Checked	bit	1 = question/comment was addressed, 0 = question or comment was ignored
	Class	varchar(50)	Vehicle class assigned to vehicle in question
tblDirection			***List of travel directions by site***
	*DirectionID	integer	Record identifier for direction table
	Cluster	integer	DTD cluster identifier from tblStudySites
	Site	integer	DTD site identifier from tblStudySites
	UserDirection	nvarchar(50)	Reference direction: closest to the camera, furthest from the camera
	Direction	nvarchar(50)	Direction of travel: northbound, southbound, eastbound, westbound

TABLE	FIELD NAME	DATA TYPE	DESCRIPTION
tblEmployee			***Employees for data collection***
	*EmployeeID	integer	Identifier for the employee that collected the data
	FirstName	nvarchar(255)	Employee's first name
	LastName	nvarchar(255)	Employee's last name
	Company	nvarchar(255)	The organization the employee works for
tblMetroCount			***Individual vehicle report from MetroCount tubes***
	*MetroCountID	integer	Identifier for the metro count table
	Collection24hourID	integer	Identifier from tblCollection24hourID for the 24-hour period the data was collected
	VerificationID	integer	Record identifier for 1-hour video verification
	ClusterCountID	integer	Unique identifier for cluster count table. One record for each short duration count by site, collection date and direction
	Cluster	integer	DTD cluster identifier from tblStudySites
	Site	integer	DTD site identifier from tblStudySites
	Direction1	nvarchar(50)	Direction from vehicle report
	Lane	integer	Directional laneage, lane 1 = curb or outside lane, lane 2 = inside lane
	MetroDate	nvarchar(10)	Date from metro report
	MetroTime	datetime	Time to the nearest second from the metro report
	AxleNum	nvarchar(8)	Unique vehicle identifier from metro report
	AxleHits	nvarchar(3)	The number of axle hits on the pair of metro tubes
	Direction	nvarchar(3)	Direction of travel: Northbound, Southbound, Eastbound, Westbound
	Speed	float	Vehicle speed (MPH)
	WheelBase	float	Wheelbase of vehicle
	Headway	float	Headway, or time since the last vehicle in the same direction
	Axles	integer	Number of axles in the vehicle
	AxleGroups	integer	Number of axle groups in the vehicle
	Class	integer	Vehicle classification
	VehiclePicture	nvarchar(100)	Scaled wheel picture of the vehicle
	MetroTimeSQL	datetime	Calibrated date and time based on tblMetroTimeAdjust
	StartTime	datetime	Start time of the 5-minute period. MetroTimeSQL is greater than or equal to this value
	EndTime	datetime	End time of the 5-minute period. MetroTimeSQL is less than this value
tblMetroTimeAdjust			***Time adjustment applied to tblMetroCount to synchronize with video timestamp***
	Cluster	integer	DTD cluster identifier from tblStudySites
	Site	integer	DTD site identifier from tblStudySites
	Collection24hourID	integer	Identifier from tblCollection24hourID for the 24-hour period the data was collected
	CollectionDate	datetime	Date of data collection
	Direction	varchar(50)	Direction of travel: Northbound, Southbound, Eastbound, Westbound
	Lane	integer	Directional laneage, lane 1 = curb or outside lane, lane 2 = inside lane
	MetroTime	datetime	Time to the nearest second from the metro report

TABLE	FIELD NAME	DATA TYPE	DESCRIPTION
	MetroDescription	float	Description of the vehicle from the metro report
	VideoTime	datetime	Time to the nearest second from the video
	VideoDescription	varchar(255)	Description of the vehicle from the video
	FieldClass	float	Vehicle classification from the video
tblModelClusterCount			***Virtual short duration counts for every site and direction based on criteria from tblModelScenarios***
	*ModelClusterCountID	integer	Unique identifier for virtual cluster count table. One record for each short duration count by site, collection date and direction
	ResultID	integer	Record identifier from modeled scenario results table
	ModelStartTimeID	integer	Record identifier for the modeled scenario start time table
	StartTime	datetime	Start time for the virtual cluster count
	EndTime	datetime	End time for the virtual cluster count
	MeetsCriteria	bit	1 = minimum volume and/or time constraints were met, 0 = not met
	Class1	integer	Motorcycles
	Class2	integer	Passenger Cars
	Class3	integer	Other Two-Axle, Four-Tire, Single Unit Vehicles (Pickup Truck, SUV)
	Class4	integer	Buses
	Class5	integer	Two-Axle, Six-Tire, Single Unit Trucks
	Class6	integer	Three-axle Single unit Trucks
	Class7	integer	Four or More Axle Single Unit Trucks
	Class8	integer	Four or Less Axle Single Trailer Trucks
	Class9	integer	Five-Axle Single Trailer Trucks
	Class10	integer	Six or More Axle Single Trailer Trucks
	Class11	integer	Five or Less Axle Multi-Trailer Trucks
	Class12	integer	Six-Axle Multi-Trailer Trucks
	Class13	integer	Seven or More Axle Multi-Trailer Trucks
tblModelScenarioResults			***Goodness of fit statistics for model cluster counts compared to 24-hour classification counts***
	*ResultID	integer	Record identifier from modeled scenario results table
	Site	integer	DTD site identifier from tblStudySites
	ScenarioID	integer	Record identifier for modeled scenarios table
	MeetsCriteria	bit	1 = minimum volume and/or time criteria were met, 0 = criteria not met
	DataSource	varchar(50)	Video Reduction, ATR, MetroCount
	Direction	varchar(50)	Direction of travel: Northbound, Southbound, Eastbound, Westbound
	Collection24hourID	integer	Identifier from tblCollection24hourID for the 24-hour period the data was collected
	Class1	integer	Motorcycles
	Class2	integer	Passenger Cars
	Class3	integer	Other Two-Axle, Four-Tire, Single Unit Vehicles (Pickup Truck, SUV)
	Class4	integer	Buses
	Class5	integer	Two-Axle, Six-Tire, Single Unit Trucks
	Class6	integer	Three-axle Single unit Trucks
	Class7	integer	Four or More Axle Single Unit Trucks
	Class8	integer	Four or Less Axle Single Trailer Trucks
	Class9	integer	Five-Axle Single Trailer Trucks

TABLE	FIELD NAME	DATA TYPE	DESCRIPTION
	Class10	integer	Six or More Axle Single Trailer Trucks
	Class11	integer	Five or Less Axle Multi-Trailer Trucks
	Class12	integer	Six-Axle Multi-Trailer Trucks
	Class13	integer	Seven or More Axle Multi-Trailer Trucks
	Class2_3	float	Class 2 + Class 3
	Class1to3	float	Sum of classes 1 to 3
	Class4to7	float	Sum of classes 4 to 7
	Class8to13	float	Sum of classes 8 to 13
	Class1to13	float	Sum of classes 1 to 13
	ExpClass1	float	Motorcycles factored by sample total and 24-hour total
	ExpClass2	float	Passenger Cars factored by sample total and 24-hour total
	ExpClass3	float	Other Two-Axle, Four-Tire, Single Unit Vehicles (Pickup Truck, SUV) factored by sample total and 24-hour total
	ExpClass4	float	Buses factored by sample total and 24-hour total
	ExpClass5	float	Two-Axle, Six-Tire, Single Unit Trucks factored by sample total and 24-hour total
	ExpClass6	float	Three-axle Single unit Trucks factored by sample total and 24-hour total
	ExpClass7	float	Four or More Axle Single Unit Trucks factored by sample total and 24-hour total
	ExpClass8	float	Four or Less Axle Single Trailer Trucks factored by sample total and 24-hour total
	ExpClass9	float	Five-Axle Single Trailer Trucks factored by sample total and 24-hour total
	ExpClass10	float	Six or More Axle Single Trailer Trucks factored by sample total and 24-hour total
	ExpClass11	float	Five or Less Axle Multi-Trailer Trucks factored by sample total and 24-hour total
	ExpClass12	float	Six-Axle Multi-Trailer Trucks factored by sample total and 24-hour total
	ExpClass13	float	Seven or More Axle Multi-Trailer Trucks factored by sample total and 24-hour total
	ExpClass2_3	float	expected Class 2 + expected Class 3
	ExpClass1to3	float	Sum of expected classes 1 to 3
	ExpClass4to7	float	Sum of expected classes 4 to 7
	ExpClass8to13	float	Sum of expected classes 8 to 13
	ExpClass1to13	float	Sum of expected classes 1 to 13
	ObsClass1	float	Motorcycles after chi-square grouping algorithm
	ObsClass2	float	Passenger Cars after chi-square grouping algorithm
	ObsClass3	float	Other Two-Axle, Four-Tire, Single Unit Vehicles (Pickup Truck, SUV) after chi-square grouping algorithm
	ObsClass4	float	Buses after chi-square grouping algorithm
	ObsClass5	float	Two-Axle, Six-Tire, Single Unit Trucks after chi-square grouping algorithm
	ObsClass6	float	Three-axle Single unit Trucks after chi-square grouping algorithm
	ObsClass7	float	Four or More Axle Single Unit Trucks after chi-square grouping algorithm
	ObsClass8	float	Four or Less Axle Single Trailer Trucks after chi-square grouping algorithm
	ObsClass9	float	Five-Axle Single Trailer Trucks after chi-square grouping algorithm

TABLE	FIELD NAME	DATA TYPE	DESCRIPTION
	ObsClass10	float	Six or More Axle Single Trailer Trucks after chi-square grouping algorithm
	ObsClass11	float	Five or Less Axle Multi-Trailer Trucks after chi-square grouping algorithm
	ObsClass12	float	Six-Axle Multi-Trailer Trucks after chi-square grouping algorithm
	ObsClass13	float	Seven or More Axle Multi-Trailer Trucks after chi-square grouping algorithm
	ObsClass2_3	float	Class 2 + Class 3 after chi-square grouping algorithm
	ObsClass1to3	float	Sum of classes 1 to 3 after chi-square grouping algorithm
	ObsClass4to7	float	Sum of classes 4 to 7 after chi-square grouping algorithm
	ObsClass8to13	float	Sum of classes 8 to 13 after chi-square grouping algorithm
	ObsClass1to13	float	Sum of classes 1 to 13 after chi-square grouping algorithm
	X2_Stat_1to13	float	Chi-square statistic for 13 classes
	X2_df_1to13	float	Degrees of freedom for 13 classes (number of non-zero classes – 1)
	X2_PValue_1to13	float	P-value for 13 classes
	X2_Pass_1to13	bit	1 = p-value for 13 classes greater than or equal to 0.1, 0 = p-value less than 0.1
	X2_Stat_3bin	float	Chi-square statistic for 3 class groups
	X2_df_3bin	float	Degrees of freedom for 3 class groups (number of non-zero class groups – 1)
	X2_PValue_3bin	float	P-value for 3 class groups
	X2_Pass_3bin	bit	1 = p-value for 3 class groups greater than or equal to 0.1, 0 = p-value less than 0.1
	X2_Stat_23	float	Chi-square statistic for 12 classes with 2 and 3 grouped
	X2_df_23	float	Degrees of freedom for 12 classes with 2 and 3 grouped (number of non-zero classes – 1)
	X2_PValue_23	float	P-value for 12 classes with 2 and 3 grouped
	X2_Pass_23	bit	1 = p-value for 12 classes with 2 and 3 grouped greater than or equal to 0.1, 0 = p-value less than 0.1
	X2_Stat_wo23	float	Chi-square statistic for 12 classes with 2 and 3 excluded
	X2_df_wo23	float	Degrees of freedom for 12 classes with 2 and 3 exluded (number of non-zero classes – 1)
	X2_PValue_wo23	float	P-value for 12 classes with 2 and 3 excluded
	X2_Pass_wo23	bit	1 = p-value for 12 classes with 2 and 3 excluded greater than or equal to 0.1, 0 = p-value less than 0.1
tblModelScenarios			***List of short duration count scenarios to test against 24-hour classification counts***
	*ScenarioID	integer	Record identifier for modeled scenarios table
	ScenarioName	varchar(255)	Short name of scenario
	MinVehiclesPerLane	integer	Minimum vehicle per lane required for each short duration count
	MinCountDuration	integer	Minimum count duration required for each short duration count
	ScenarioDescription	varchar(255)	Description of the scenario
	CostPerSite	float	A cost per site for each scenario
tblModelScenarioStartTimes			***Start and end times for each count for each scenario in tblModelScenarios***
	*ModelStartTimeID	integer	Record identifier for the modeled scenario start time table
	ScenarioID	integer	Record identifier for modeled scenarios table

TABLE	FIELD NAME	DATA TYPE	DESCRIPTION
	StartTime	datetime	Start time for each short duration count specified for each ScenarioID
	EndTime	datetime	End time for each short duration count specified for each ScenarioID
	Weight	float	Factor used on volume based scenarios to weight short duration counts based on the length of the time period it was supposed to represent
tblQAQCList			***List of quality control checks for field classification counts***
	QAQCListID	integer	Record identifier for QA\QC list table
	Comparison	varchar(100)	Description of comparison performed for current record
	ObsTable	varchar(50)	Observed table
	ExpTable	varchar(50)	Expected table
	ObsColumn	varchar(50)	Column in ObsTable with observed data for chi-square test
	ExpColumn	varchar(50)	Column in ExpTable with expected data for chi-square test
	CompareDates	bit	1 = compare different dates for the same source, 0 = compare the same date
tblQAQCResults			***Goodness of fit statistics for field cluster counts and quality control checks compared to 24-hour classification counts***
	QAQCResultID	integer	Record identifier for QA\QC results table
	QAQCListID	integer	Record identifier for QA\QC list table
	ObsColumn	varchar(50)	Column in ObsTable with observed data for chi-square test
	ObsColumnID	integer	Identifier for ObsColumn
	ExpColumn	varchar(50)	Column in ExpTable with expected data for chi-square test
	ExpColumnID	integer	Identifier for ExpColumn
	Site	integer	DTD site identifier from tblStudySites
	Collection24hourID	integer	Identifier from tblCollection24hourID for the 24-hour period the data was collected
	Direction	varchar(50)	Direction of travel: Northbound, Southbound, Eastbound, Westbound
	Class1	integer	Motorcycles
	Class2	integer	Passenger Cars
	Class3	integer	Other Two-Axle, Four-Tire, Single Unit Vehicles (Pickup Truck, SUV)
	Class4	integer	Buses
	Class5	integer	Two-Axle, Six-Tire, Single Unit Trucks
	Class6	integer	Three-axle Single unit Trucks
	Class7	integer	Four or More Axle Single Unit Trucks
	Class8	integer	Four or Less Axle Single Trailer Trucks
	Class9	integer	Five-Axle Single Trailer Trucks
	Class10	integer	Six or More Axle Single Trailer Trucks
	Class11	integer	Five or Less Axle Multi-Trailer Trucks
	Class12	integer	Six-Axle Multi-Trailer Trucks
	Class13	integer	Seven or More Axle Multi-Trailer Trucks
	Class2_3	float	Class 2 + Class 3
	Class1to3	float	Sum of classes 1 to 3
	Class4to7	float	Sum of classes 4 to 7
	Class8to13	float	Sum of classes 8 to 13
	Class1to13	float	Sum of classes 1 to 13
	ExpClass1	float	Motorcycles factored by sample total and 24-hour total

TABLE	FIELD NAME	DATA TYPE	DESCRIPTION
	ExpClass2	float	Passenger Cars factored by sample total and 24-hour total
	ExpClass3	float	Other Two-Axle, Four-Tire, Single Unit Vehicles (Pickup Truck, SUV) factored by sample total and 24-hour total
	ExpClass4	float	Buses factored by sample total and 24-hour total
	ExpClass5	float	Two-Axle, Six-Tire, Single Unit Trucks factored by sample total and 24-hour total
	ExpClass6	float	Three-axle Single unit Trucks factored by sample total and 24-hour total
	ExpClass7	float	Four or More Axle Single Unit Trucks factored by sample total and 24-hour total
	ExpClass8	float	Four or Less Axle Single Trailer Trucks factored by sample total and 24-hour total
	ExpClass9	float	Five-Axle Single Trailer Trucks factored by sample total and 24-hour total
	ExpClass10	float	Six or More Axle Single Trailer Trucks factored by sample total and 24-hour total
	ExpClass11	float	Five or Less Axle Multi-Trailer Trucks factored by sample total and 24-hour total
	ExpClass12	float	Six-Axle Multi-Trailer Trucks factored by sample total and 24-hour total
	ExpClass13	float	Seven or More Axle Multi-Trailer Trucks factored by sample total and 24-hour total
	ExpClass2_3	float	expected Class 2 + expected Class 3
	ExpClass1to3	float	Sum of expected classes 1 to 3
	ExpClass4to7	float	Sum of expected classes 4 to 7
	ExpClass8to13	float	Sum of expected classes 8 to 13
	ExpClass1to13	float	Sum of expected classes 1 to 13
	ObsClass1	float	Motorcycles after chi-square grouping algorithm
	ObsClass2	float	Passenger Cars after chi-square grouping algorithm
	ObsClass3	float	Other Two-Axle, Four-Tire, Single Unit Vehicles (Pickup Truck, SUV) after chi-square grouping algorithm
	ObsClass4	float	Buses after chi-square grouping algorithm
	ObsClass5	float	Two-Axle, Six-Tire, Single Unit Trucks after chi-square grouping algorithm
	ObsClass6	float	Three-axle Single unit Trucks after chi-square grouping algorithm
	ObsClass7	float	Four or More Axle Single Unit Trucks after chi-square grouping algorithm
	ObsClass8	float	Four or Less Axle Single Trailer Trucks after chi-square grouping algorithm
	ObsClass9	float	Five-Axle Single Trailer Trucks after chi-square grouping algorithm
	ObsClass10	float	Six or More Axle Single Trailer Trucks after chi-square grouping algorithm
	ObsClass11	float	Five or Less Axle Multi-Trailer Trucks after chi-square grouping algorithm
	ObsClass12	float	Six-Axle Multi-Trailer Trucks after chi-square grouping algorithm
	ObsClass13	float	Seven or More Axle Multi-Trailer Trucks after chi-square grouping algorithm
	ObsClass2_3	float	Class 2 + Class 3 after chi-square grouping algorithm
	ObsClass1to3	float	Sum of classes 1 to 3 after chi-square grouping algorithm
	ObsClass4to7	float	Sum of classes 4 to 7 after chi-square grouping algorithm

TABLE	FIELD NAME	DATA TYPE	DESCRIPTION
	ObsClass8to13	float	Sum of classes 8 to 13 after chi-square grouping algorithm
	ObsClass1to13	float	Sum of classes 1 to 13 after chi-square grouping algorithm
	X2_Stat_1to13	float	Chi-square statistic for 13 classes
	X2_df_1to13	float	Degrees of freedom for 13 classes (number of non-zero classes – 1)
	X2_PValue_1to13	float	P-value for 13 classes
	X2_Pass_1to13	bit	1 = p-value for 13 classes greater than or equal to 0.1, 0 = p-value less than 0.1
	X2_Stat_3bin	float	Chi-square statistic for 3 class groups
	X2_df_3bin	float	Degrees of freedom for 3 class groups (number of non-zero class groups – 1)
	X2_PValue_3bin	float	P-value for 3 class groups
	X2_Pass_3bin	bit	1 = p-value for 3 class groups greater than or equal to 0.1, 0 = p-value less than 0.1
	X2_Stat_23	float	Chi-square statistic for 12 classes with 2 and 3 grouped
	X2_df_23	float	Degrees of freedom for 12 classes with 2 and 3 grouped (number of non-zero classes – 1)
	X2_PValue_23	float	P-value for 12 classes with 2 and 3 grouped
	X2_Pass_23	bit	1 = p-value for 12 classes with 2 and 3 grouped greater than or equal to 0.1, 0 = p-value less than 0.1
	X2_Stat_wo23	float	Chi-square statistic for 12 classes with 2 and 3 excluded
	X2_df_wo23	float	Degrees of freedom for 12 classes with 2 and 3 exluded (number of non-zero classes – 1)
	X2_PValue_wo23	float	P-value for 12 classes with 2 and 3 excluded
	X2_Pass_wo23	bit	1 = p-value for 12 classes with 2 and 3 excluded greater than or equal to 0.1, 0 = p-value less than 0.1
tblQCVideoReduction			***Video reduction quality control checks. (5-minutes of video for every unique employee, site, direction record in tblVideoReduction)***
	*QCVideoReductionID	integer	Record identifier for tblQCVideoReduction
	VideoReductionID	integer	Record identifier for video reduction table
	Collection24hourID	integer	Identifier from tblCollection24hourID for the 24-hour period the data was collected
	VerificationID	integer	Record identifier for 1-hour video verification
	ClusterCountID	integer	Unique identifier for cluster count table. One record for each short duration count by site, collection date and direction
	Cluster	integer	DTD cluster identifier from tblStudySites
	Site	integer	DTD site identifier from tblStudySites
	CollectionDate	datetime	Date of data collection
	StartTime	datetime	Start time for 5-minute video reduction count
	EndTime	datetime	End time for 5-minute video reduction count
	Direction	nvarchar(50)	Direction of travel: closest to the camera, furthest from the camera, northbound, southbound, eastbound, westbound
	EmployeeIDOriginal	integer	Identifier from tblEmployee for the employee that reduced the original data
	EmployeeID	integer	Identifier from tblEmployee for the employee that reduced the data for quality control checks
	Class1	integer	Motorcycles
	Class2	integer	Passenger Cars
	Class3	integer	Other Two-Axle, Four-Tire, Single Unit Vehicles (Pickup Truck, SUV)
	Class4	integer	Buses

TABLE	FIELD NAME	DATA TYPE	DESCRIPTION
	Class5	integer	Two-Axle, Six-Tire, Single Unit Trucks
	Class6	integer	Three-axle Single unit Trucks
	Class7	integer	Four or More Axle Single Unit Trucks
	Class8	integer	Four or Less Axle Single Trailer Trucks
	Class9	integer	Five-Axle Single Trailer Trucks
	Class10	integer	Six or More Axle Single Trailer Trucks
	Class11	integer	Five or Less Axle Multi-Trailer Trucks
	Class12	integer	Six-Axle Multi-Trailer Trucks
	Class13	integer	Seven or More Axle Multi-Trailer Trucks
tblStudySites			***Sample sites or adjacent sites with the sample cluster used for this study***
	Cluster	integer	DTD cluster identifier. Multiple sites for one cluster
	*Site	integer	DTD unique site identifier.
	SiteDescription	nvarchar(255)	Location description of site
	Category	nvarchar(100)	Roadway category: Lower Volume Urban Arterial (15,000 > ADT < 30,000), Higher Volume Urban Arterial (> 30,000 ADT) Urban Expressway, Urban Freeway
	AADT	float	2002 AADT
	Lanes	integer	Directional laneage, lane 1 = curb or outside lane, lane 2 = inside lane
	ClusterCount	nvarchar(10)	Yes = cluster count collected at this site, No = cluster count not collected at this site
	Video24Hour	nvarchar(10)	Yes = 24-hour video recorded at this site, No = 24-hour video not recorded at this site
	ATR	nvarchar(10)	Yes = ATR data collected at this site (with CDOT ATR identifier), No = ATR data not collected at this site
	MetroCount	nvarchar(10)	Yes = MetroCount collected at this site, No = MetroCount not collected at this site
	Video2Hour	nvarchar(10)	Yes = 2-hours of video recorded at this site, No = 2-hours of video not recorded at this site
tblVideoFiles			***List of digital video files with collection location and times***
	VideoFile	nvarchar(255)	Video file name
	Cluster	integer	DTD cluster identifier from tblStudySites
	Site	integer	DTD site identifier from tblStudySites
	StartDate	datetime	Beginning date of video file
	EndDate	datetime	Ending date of video file
	StartTime	datetime	Start time of video file
	EndTime	datetime	End time of video file
	CheckOut	nvarchar(255)	Placeholder for the employee that borrowed the video
	EmployeeID	integer	Identifier from tblEmployee for the employee that collected the data
	CheckOutDate	datetime	Date the video was borrowed
	CheckIn	nvarchar(255)	Employee who returned the video
	CheckInDate	datetime	Date the video was returned

TABLE	FIELD NAME	DATA TYPE	DESCRIPTION
tblVideoReduction			***Manual classification counts in 5-minute bins from video reduction***
	*VideoReductionID	integer	Record identifier for video reduction table
	Collection24hourID	integer	Identifier from tblCollection24hourID for the 24-hour period the data was collected
	VerificationID	integer	Record identifier for 1-hour video verification
	ClusterCountID	integer	Unique identifier for cluster count table. One record for each short duration count by site, collection date and direction
	Cluster	integer	DTD cluster identifier from tblStudySites
	Site	integer	DTD site identifier from tblStudySites
	CollectionDate	datetime	Date of data collection
	StartTime	datetime	Start time for 5-minute video reduction count
	EndTime	datetime	End time for 5-minute video reduction count
	Direction	nvarchar(50)	Direction of travel: closest to the camera, furthest from the camera, northbound, southbound, eastbound, westbound
	EmployeeID	integer	Identifier from tblEmployee for the employee that collected the data
	Class1	integer	Motorcycles
	Class2	integer	Passenger Cars
	Class3	integer	Other Two-Axle, Four-Tire, Single Unit Vehicles (Pickup Truck, SUV)
	Class4	integer	Buses
	Class5	integer	Two-Axle, Six-Tire, Single Unit Trucks
	Class6	integer	Three-axle Single unit Trucks
	Class7	integer	Four or More Axle Single Unit Trucks
	Class8	integer	Four or Less Axle Single Trailer Trucks
	Class9	integer	Five-Axle Single Trailer Trucks
	Class10	integer	Six or More Axle Single Trailer Trucks
	Class11	integer	Five or Less Axle Multi-Trailer Trucks
	Class12	integer	Six-Axle Multi-Trailer Trucks
	Class13	integer	Seven or More Axle Multi-Trailer Trucks

APPENDIX C – SAMPLE FIELD DATA

MetroCount

MetroCount Traffic Executive
Individual Vehicles

Individual-36
DATASETS:

Site:	**[119SBIN] ^**
Direction:	3 - South bound, A hit first., **Lane:** 0
Survey Duration:	05:50 Thu 25 Sep 2003 to 10:35 Sun 28 Sep 2003
File:	C:\ClusterCB\VAL\119SBIN28SEP2003.EC0 (PlusB)
Identifier:	E208HRKF MC56-6 [MC55] (c)Microcom 02/03/01
Algorithm:	Factory default

PROFILE:

Filter time:	**05:50 Thu 25 Sep 2003 to 07:00 Fri 26 Sep 2003**
Included classes:	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
Speed range:	6 - 99 mph.
Direction:	North, East, South, West (bound)
Headway:	All
Scheme:	Scheme F
Name:	Factory default profile
Method:	Vehicle classification
Units:	Non-Metric (ft, mi, f/s, mph, lb, ton)

```
Axle Num Ht       Date     Time Dr Speed     Wb    Hdwy Ax Gp  Rho Cl Nm          Vehicle
00000abe 04 2003Sep25 07:01:05 AB  47.9   10.4     4.8  2  2 1.00  3 00000020  F3 o  o
00000ac2 04 2003Sep25 07:01:06 AB  43.8    8.8     1.2  2  2 1.00  2 00000020  F2 o o
00000ac6 04 2003Sep25 07:01:09 AB  55.4    8.5     2.9  2  2 1.00  2 00000020  F2 o o
00000aca 04 2003Sep25 07:01:10 AB  51.2   10.3     1.1  2  2 1.00  3 00000010  F3 o  o
00000ace 04 2003Sep25 07:01:16 AB  53.2    9.1     5.5  2  2 1.00  2 00000010  F2 o o
00000ad2 04 2003Sep25 07:01:21 AB  58.4    8.7     4.8  2  2 1.00  2 00000020  F2 o o
00000ad6 04 2003Sep25 07:01:23 AB  60.3    8.7     2.4  2  2 1.00  2 00000020  F2 o o
00000ada 04 2003Sep25 07:01:26 AB  62.7   10.0     2.8  2  2 1.00  3 00000020  F3 o  o
00000ade 04 2003Sep25 07:01:29 AB  55.4    9.7     3.3  2  2 1.00  2 00000020  F2 o o
00000ae2 04 2003Sep25 07:01:30 AB  56.6    8.3     0.7  2  2 1.00  2 00000020  F2 o o
00000ae6 04 2003Sep25 07:01:33 AB  61.4    8.2     3.4  2  2 1.00  2 00000020  F2 o o
00000aea 04 2003Sep25 07:01:37 AB  59.9    9.0     3.9  2  2 1.00  2 00000020  F2 o o
00000aee 06 2003Sep25 07:01:41 AB  53.7   33.8     3.4  3  3 1.00  8 00000020  F8 o  o      o
00000af4 04 2003Sep25 07:01:42 AB  51.8    9.8     1.6  2  2 1.00  2 00000020  F2 o o
```

Cluster Count Excel File

Site ID: 186 **Location: On C-470 at Morrison Rd**

Direction: EB

Date:	Time:	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13	Total 1-13	Total 4-7	Total 8-13
3-Sep	738-745	3	345	312	1	4	3	0	1	4	0	0	0	0	673	8	5
3-Sep	1028-1045	1	230	327	2	17	11	0	0	20	0	0	0	0	608	30	20
3-Sep	1407-1425	0	227	331	2	17	19	0	1	11	0	2	0	0	610	38	14
3-Sep	1709-1720	0	247	353	0	4	1	0	1	5	0	0	0	0	611	5	6
	Total	4	1049	1323	5	42	34	0	3	40	0	2	0	0	2502	81	45
	% of Total	0.16%	41.93%	52.88%	0.20%	1.68%	1.36%	0.00%	0.12%	1.60%	0.00%	0.08%	0.00%	0.00%		3.24%	1.80%

Direction: WB

Date:	Time:	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13	Total 1-13	Total 4-7	Total 8-13
3-Sep	715-729	0	257	300	0	12	11	0	2	21	1	0	0	0	604	23	24
3-Sep	1052-1115	6	215	330	1	10	18	0	1	28	0	0	0	0	609	29	29
3-Sep	1348-1403	1	242	321	5	7	9	0	0	15	0	0	0	0	600	21	15
3-Sep	1655-1703	1	283	329	2	3	2	0	0	0	3	0	0	0	623	7	3
	Total	8	997	1280	8	32	40	0	3	64	4	0	0	0	2436	80	71
	% of Total	0.33%	40.93%	52.55%	0.33%	1.31%	1.64%	0.00%	0.12%	2.63%	0.16%	0.00%	0.00%	0.00%		3.28%	2.91%
	Grand Total	12	2046	2603	13	74	74	0	6	104	4	2	0	0	4938	161	116
	% of Total	0.24%	41.43%	52.71%	0.26%	1.50%	1.50%	0.00%	0.12%	2.11%	0.08%	0.04%	0.00%	0.00%	100.00%	3.26%	2.35%

CDOT ATR

```
08/20/03          Colorado Department of Transportation, DTD          Page: 1
10:52:12                       Traffic Analysis
                             Empire Park, 606 B
                                303-757-9488

                    *** Axle Bin Classification (#202) ***

********************************************************************************
Site ID : 000512                                 Data Starts : 00:00 on 08/19/03
 Info 1 : ON SH 470 N/O                          Data Ends   : 23:55 on 08/19/03
 Info 2 : SH 8,MORRISON                          Adj. Factor : 1.000%
********************************************************************************
Lane #1 Info  : EB LANE 1
Modes         : AXLE
Sensors       : Pres-Axle-Pres     Sensor Spacing: 16.0'  (Loop Length=  6.0')
********************************************************************************
********************************************************************************
Lane #5 Info  : WB Lane 2
Modes         : AXLE
Sensors       : Pres-Axle-Pres     Sensor Spacing: 16.0'  (Loop Length=  6.0')
********************************************************************************

************************ Lane 5 Axle Bin Classification ************************
```

	#1 Cycle	#2 Cars	#3 2A-4T	#4 Buses	#5 2A-SU	#6 3A-SU	#7 4A-SU	#8 4A-ST	#9 5A-ST	#10 6A-ST	#11 5A-MT	#12 6A-MT	#13 Other	Total
11:00	0	59	18	0	2	2	0	0	3	0	0	0	0	84
11:05	0	62	16	0	1	4	0	0	1	0	0	0	0	84
11:10	0	61	13	0	1	1	0	3	4	0	0	0	0	83
11:15	0	67	17	0	1	2	0	0	1	0	0	0	0	88
11:20	1	61	14	0	0	1	1	0	4	0	0	0	0	82
11:25	0	67	24	0	1	1	0	2	3	0	0	0	0	98
11:30	0	59	22	0	0	2	0	1	5	0	0	0	0	89
11:35	0	60	16	0	0	2	0	0	4	0	0	0	0	82
11:40	0	76	15	1	2	1	0	1	3	0	0	0	0	99
11:45	0	57	18	0	4	1	0	0	1	0	0	0	0	81
11:50	0	68	18	0	0	0	0	1	0	1	0	0	0	88
11:55	0	47	18	0	0	1	0	0	5	0	0	0	0	71
Hour Totals	1	744	209	1	12	18	1	8	34	1	0	0	0	1029

Video Reduction Text File

```
EmployeeID,Cluster,Site,CollectionDate,StartTime,EndTime,Direction,Class1,Class2,Class3,Class4,Class5,Class6,Class7,Class8,Class9,Class10,Class11,Class12,Class13
34,4,14,8/20/2003,7:00 AM,7:05 AM,Closest to Camera,1,26,23,0,1,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:05 AM,7:10 AM,Closest to Camera,1,31,23,3,0,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:10 AM,7:15 AM,Closest to Camera,0,29,21,1,0,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:15 AM,7:20 AM,Closest to Camera,1,39,35,1,4,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:20 AM,7:25 AM,Closest to Camera,1,42,21,0,1,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:25 AM,7:30 AM,Closest to Camera,0,35,21,0,1,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:30 AM,7:35 AM,Closest to Camera,0,27,25,0,2,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:35 AM,7:40 AM,Closest to Camera,0,33,27,0,1,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:40 AM,7:45 AM,Closest to Camera,0,42,33,0,1,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:45 AM,7:50 AM,Closest to Camera,1,55,35,1,1,1,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:50 AM,7:55 AM,Closest to Camera,0,54,33,0,1,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:55 AM,8:00 AM,Closest to Camera,1,55,36,0,0,0,1,1,0,0,0,0,0
34,4,14,8/20/2003,7:00 AM,7:05 AM,Furthest from Camera,0,35,16,0,0,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:05 AM,7:10 AM,Furthest from Camera,0,29,26,0,0,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:10 AM,7:15 AM,Furthest from Camera,0,35,26,0,3,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:15 AM,7:20 AM,Furthest from Camera,1,40,25,0,0,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:20 AM,7:25 AM,Furthest from Camera,0,20,19,1,0,1,1,0,0,0,0,0,0
34,4,14,8/20/2003,7:25 AM,7:30 AM,Furthest from Camera,0,47,27,1,1,1,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:30 AM,7:35 AM,Furthest from Camera,1,35,20,1,0,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:35 AM,7:40 AM,Furthest from Camera,0,43,24,1,2,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:40 AM,7:45 AM,Furthest from Camera,0,45,21,0,1,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:45 AM,7:50 AM,Furthest from Camera,0,46,36,0,2,0,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:50 AM,7:55 AM,Furthest from Camera,0,39,26,0,0,1,0,0,0,0,0,0,0
34,4,14,8/20/2003,7:55 AM,8:00 AM,Furthest from Camera,0,44,25,0,3,0,0,0,0,0,0,0,0
```

Video Reduction File (viewed as .csv in Excel)

EmployeeID	Cluster	Site	CollectionDate	StartTime	EndTime	Direction	Class1	Class2	Class3	Class4	Class5	Class6	Class7	Class8	Class9	Class10	Class11	Class12	Class13
34	4	14	8/20/2003	7:00 AM	7:05 AM	Closest to Camera	1	26	23	0	1	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:05 AM	7:10 AM	Closest to Camera	1	31	23	3	0	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:10 AM	7:15 AM	Closest to Camera	0	29	21	1	0	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:15 AM	7:20 AM	Closest to Camera	1	39	35	1	4	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:20 AM	7:25 AM	Closest to Camera	1	42	21	0	1	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:25 AM	7:30 AM	Closest to Camera	0	35	21	0	1	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:30 AM	7:35 AM	Closest to Camera	0	27	25	0	2	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:35 AM	7:40 AM	Closest to Camera	0	33	27	0	1	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:40 AM	7:45 AM	Closest to Camera	0	42	33	0	1	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:45 AM	7:50 AM	Closest to Camera	1	55	35	1	1	1	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:50 AM	7:55 AM	Closest to Camera	0	54	33	0	1	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:55 AM	8:00 AM	Closest to Camera	1	55	36	0	0	0	1	1	0	0	0	0	0
34	4	14	8/20/2003	7:00 AM	7:05 AM	Furthest from Camera	0	35	16	0	0	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:05 AM	7:10 AM	Furthest from Camera	0	29	26	0	0	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:10 AM	7:15 AM	Furthest from Camera	0	35	26	0	3	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:15 AM	7:20 AM	Furthest from Camera	1	40	25	0	0	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:20 AM	7:25 AM	Furthest from Camera	0	20	19	1	0	1	1	0	0	0	0	0	0
34	4	14	8/20/2003	7:25 AM	7:30 AM	Furthest from Camera	0	47	27	1	1	1	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:30 AM	7:35 AM	Furthest from Camera	1	35	20	1	0	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:35 AM	7:40 AM	Furthest from Camera	0	43	24	1	2	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:40 AM	7:45 AM	Furthest from Camera	0	45	21	0	1	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:45 AM	7:50 AM	Furthest from Camera	0	46	36	0	2	0	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:50 AM	7:55 AM	Furthest from Camera	0	39	26	0	0	1	0	0	0	0	0	0	0
34	4	14	8/20/2003	7:55 AM	8:00 AM	Furthest from Camera	0	44	25	0	3	0	0	0	0	0	0	0	0

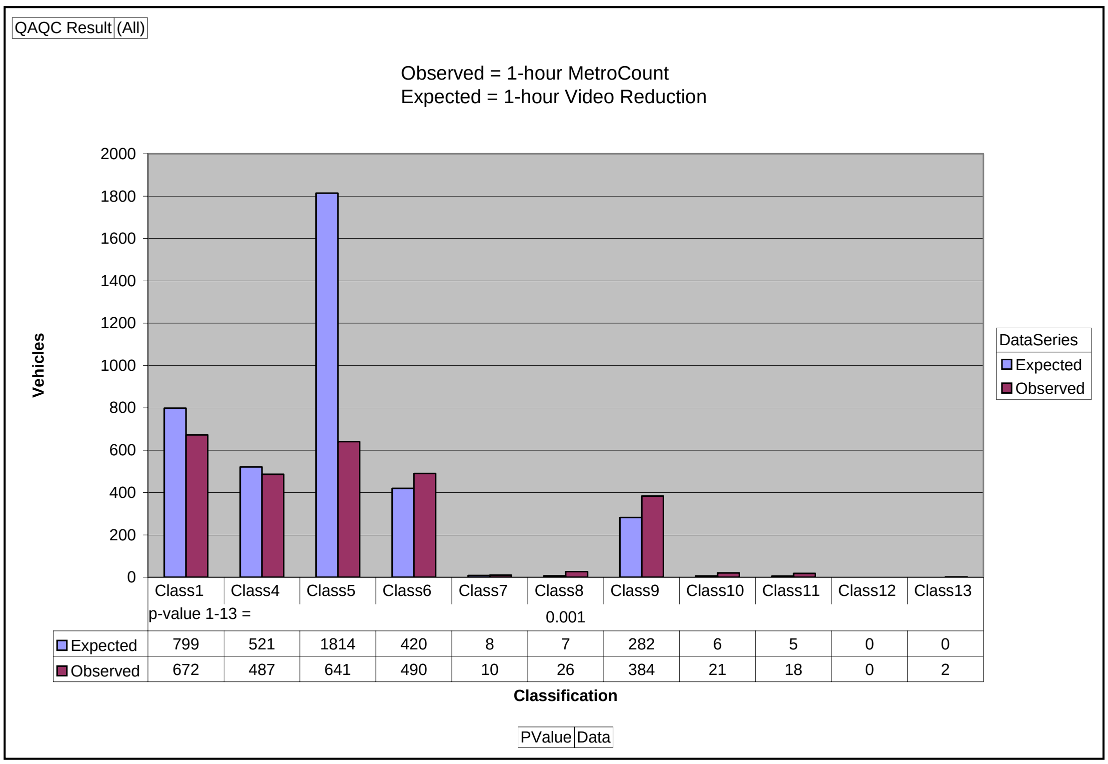
APPENDIX D – QUALITY CONTROL RESULTS

Since this study is on urban vehicle classification, classes 2 and 3 (passenger cars) make up over 90% of all vehicles for every site. The graphs of classes 2 and 3 are presented separately to help display the results.

1-hour Metro Count versus 1-hour Video Reduction

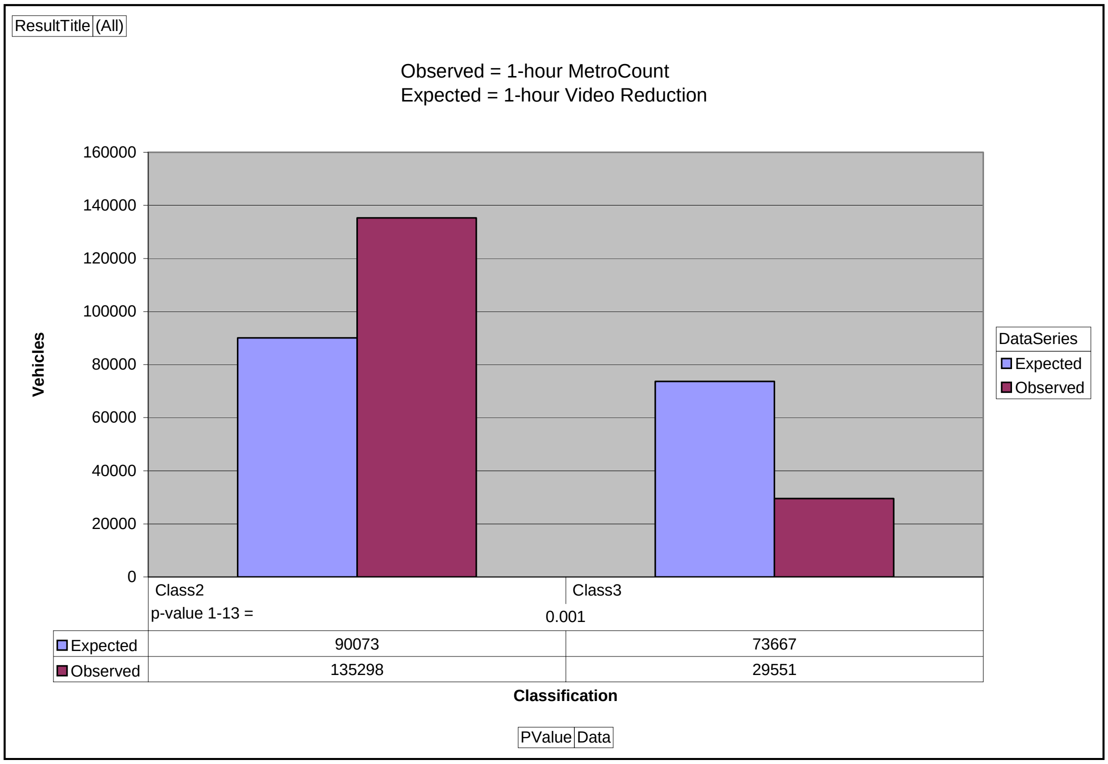
General Problems

- Metro Count underestimates Class 5



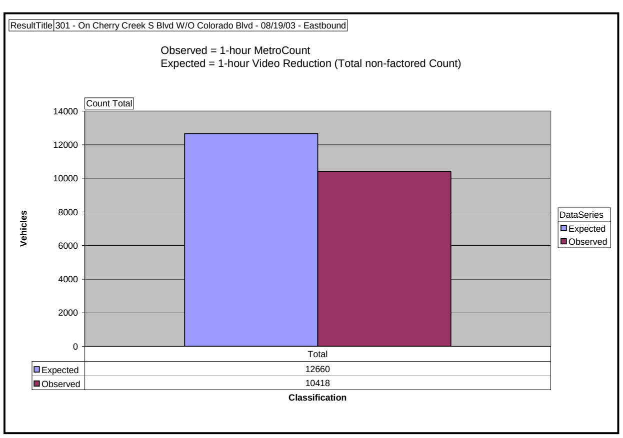
General Problems

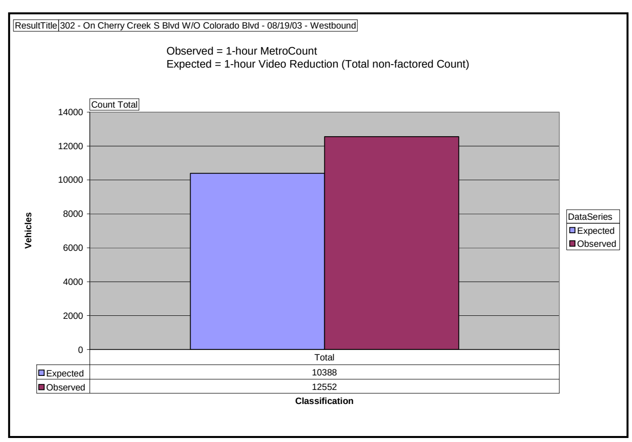
- Metro Count over estimates Class 2, under estimates Class 3



Specific Errors

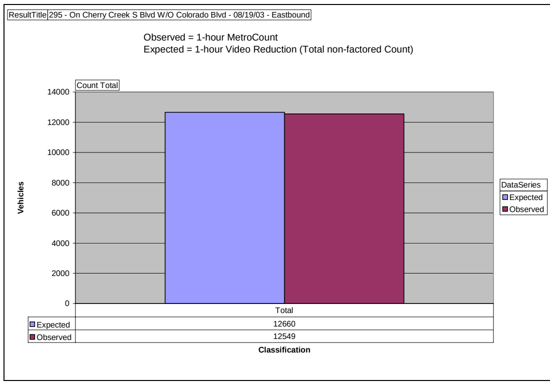
- Difference in one hour count by direction for 1-hour video reduction and 1-hour MetroCount on Cherry Creek Blvd w/o Colorado on 8/19/03
  - Solution – watch video again to determine which direction is wrong and then switch directions in the database.

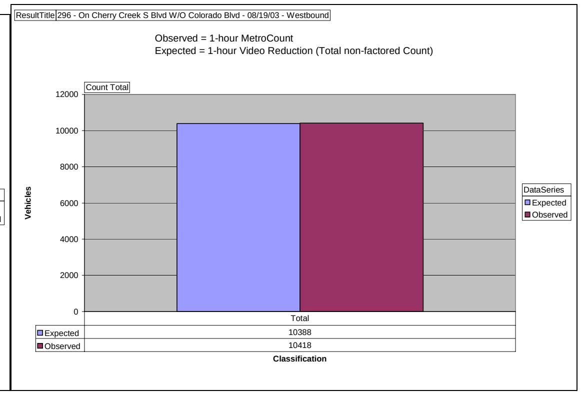




Correction

- MetroCount datafile was named with the wrong direction. The direction was fixed within the database.



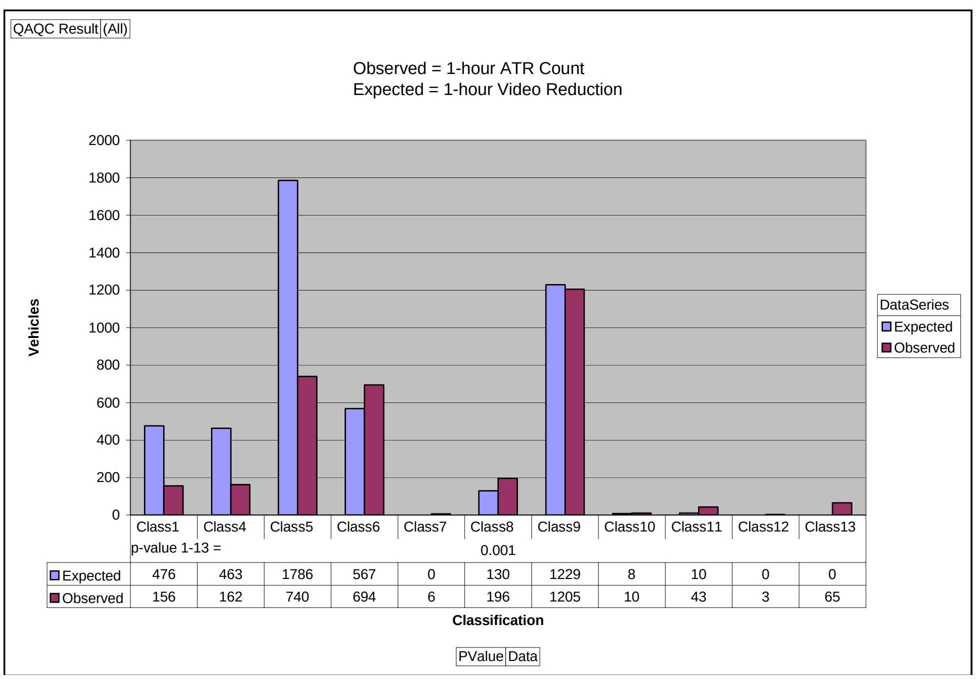


1-hour ATR Count versus 1-hour Video Reduction

No specific errors

General Problems

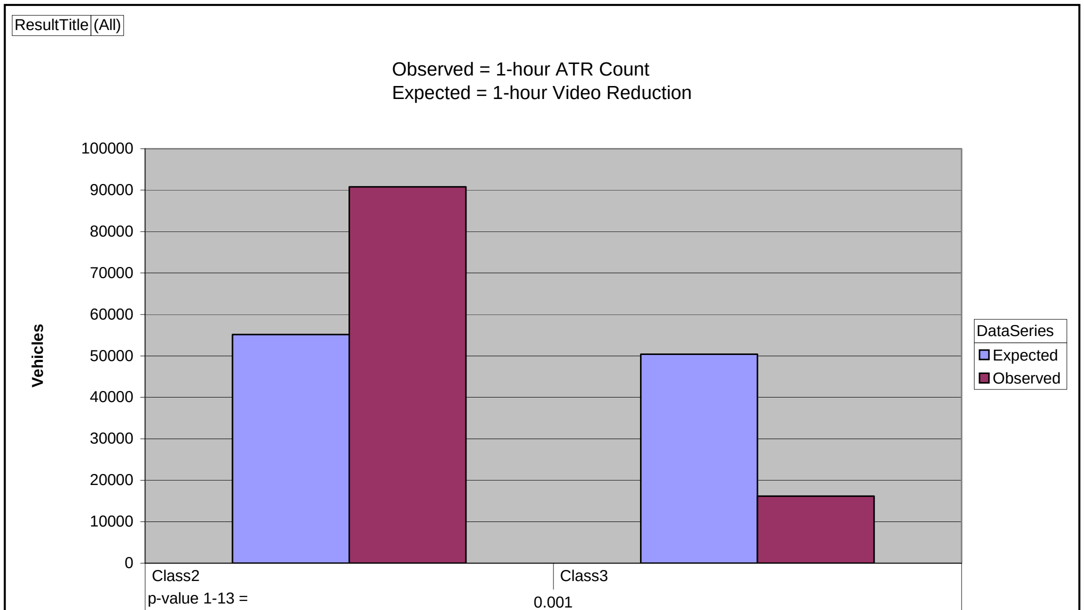
- ATR underestimates Class 1, 4, & 5



Carter::Burgess

General Problems

- ATR over estimates Class 2, under estimates Class 3



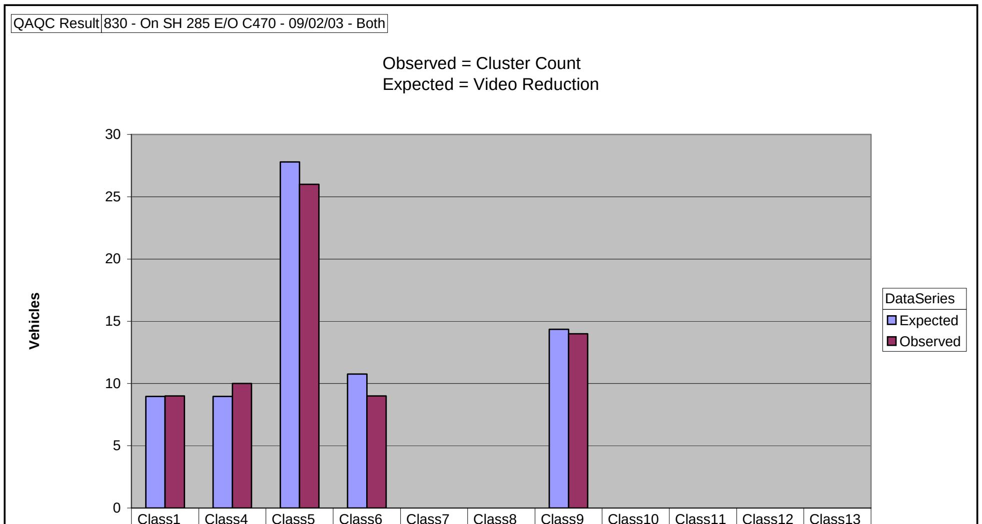
	Class2	Class3
Expected	55166	50429
Observed	90798	16186

Carter::Burgess

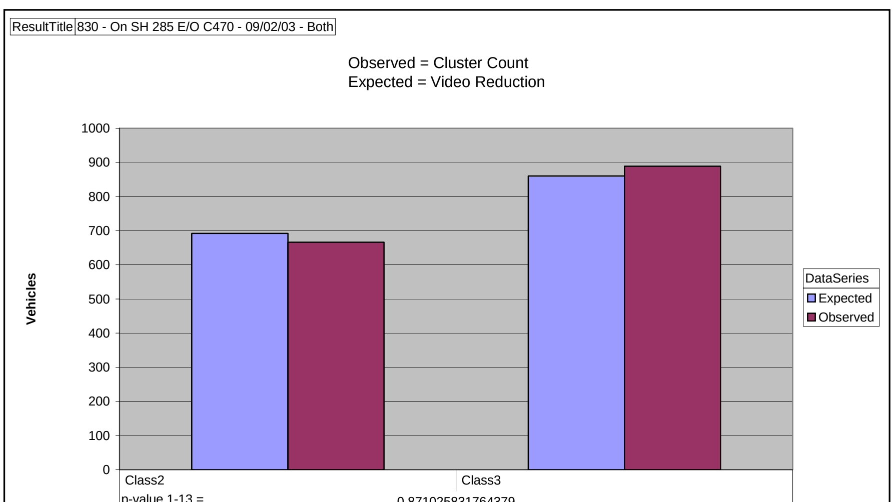
Cluster Count versus Video Reduction (Sum of 5-min intervals)

No specific errors

No general problems



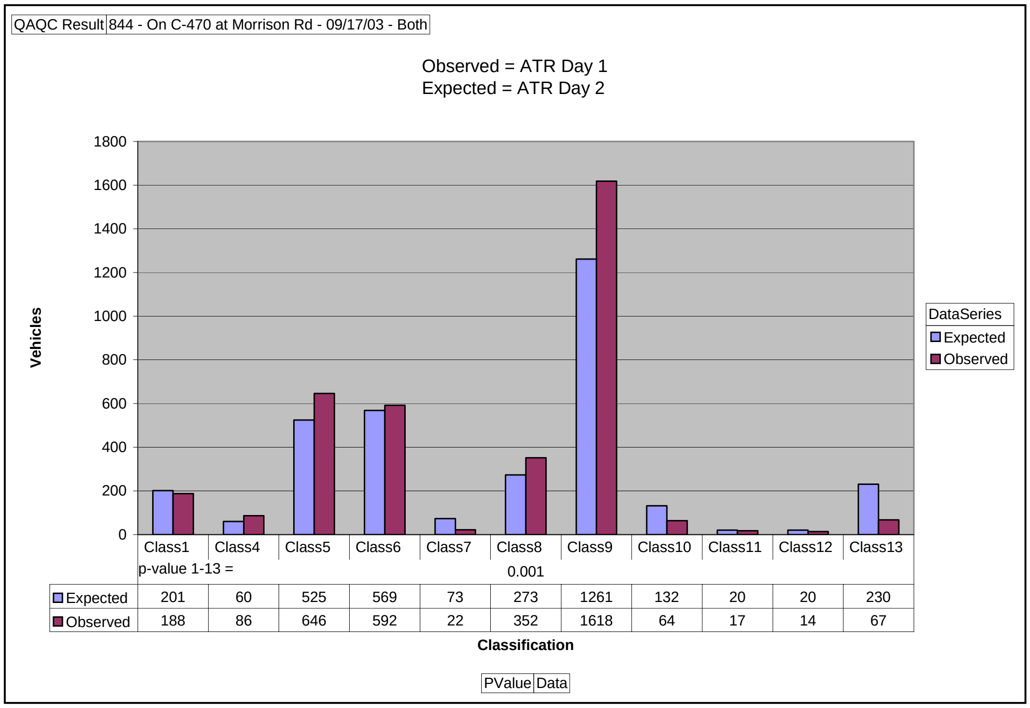
	Class1	Class4	Class5	Class6	Class7	Class8	Class9	Class10	Class11	Class12	Class13
Expected	9	9	28	11	0	0	14	0	0	0	0
Observed	9	10	26	9	0	0	14	0	0	0	0



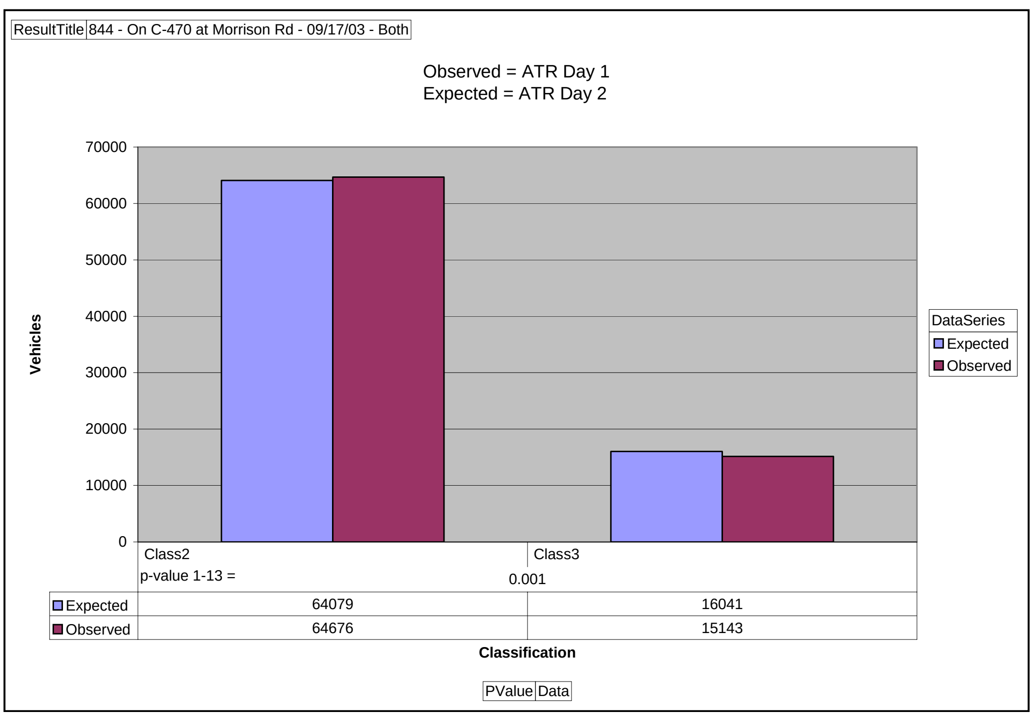
	Class2	Class3
Expected	692	860
Observed	666	889

24-hour ATR– Day 1 versus Day 2

No general problems, no specific problems



	Class1	Class4	Class5	Class6	Class7	Class8	Class9	Class10	Class11	Class12	Class13
Expected	201	60	525	569	73	273	1261	132	20	20	230
Observed	188	86	646	592	22	352	1618	64	17	14	67



	Class2	Class3
Expected	64079	16041
Observed	64676	15143

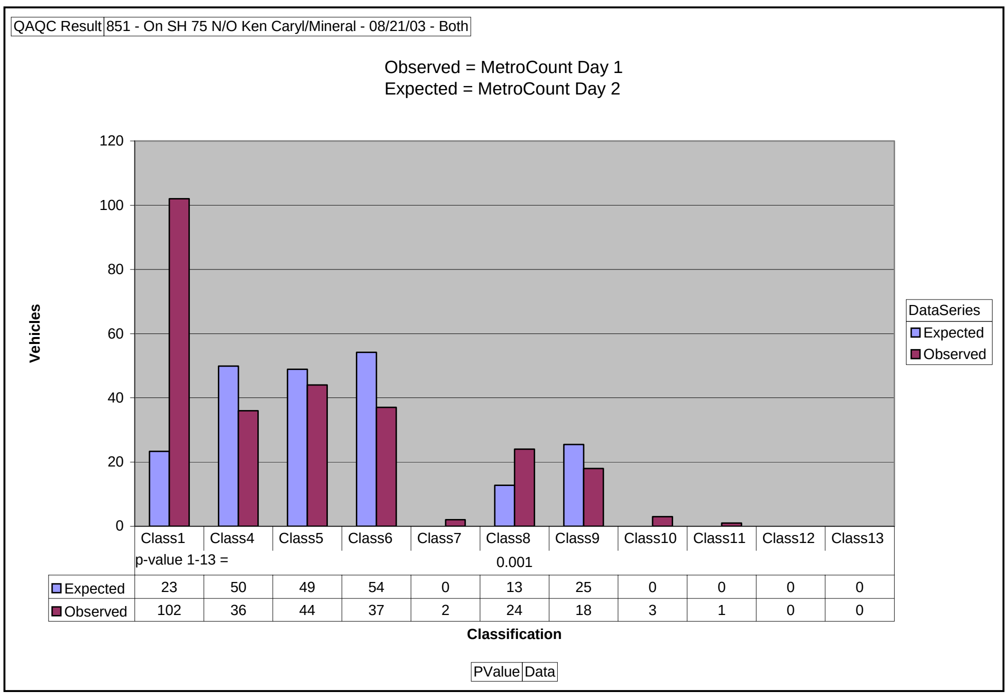
24-hour Metro Count– Day 1 versus Day 2

Specific Errors

- (Same error as video verification) Difference in one hour count by direction for 1-hour video reduction and 1-hour MetroCount on Cherry Creek Blvd w/o Colorado on 8/19/03
    - Solution – watch video again to determine which direction is wrong and then switch directions in the database.

Specific Problem

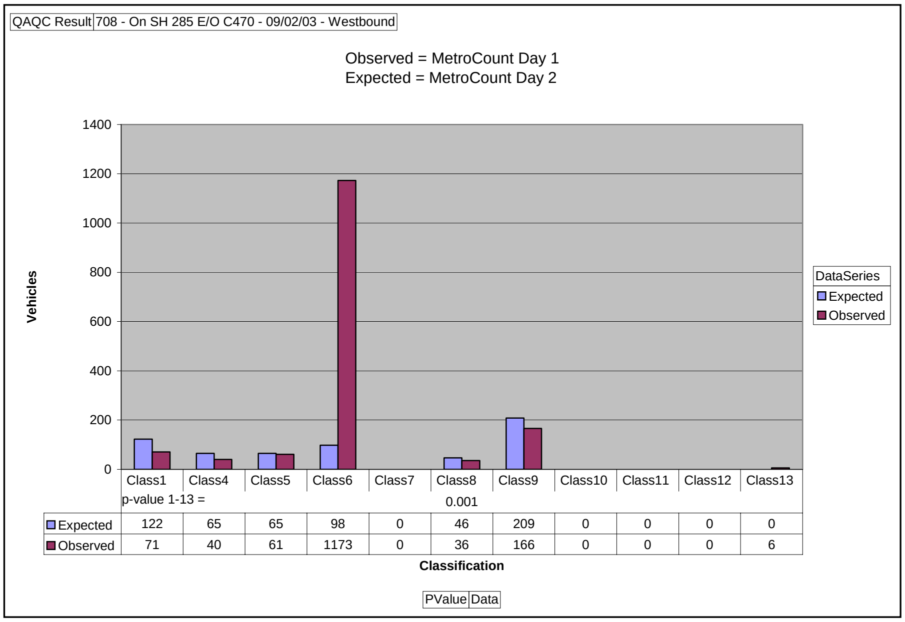
- Result 851 – Metro Day 1 vs. Day 2 – TRA will check why Class 1 is high on this day versus the previous day and check the video if the time corresponds to video verification times.



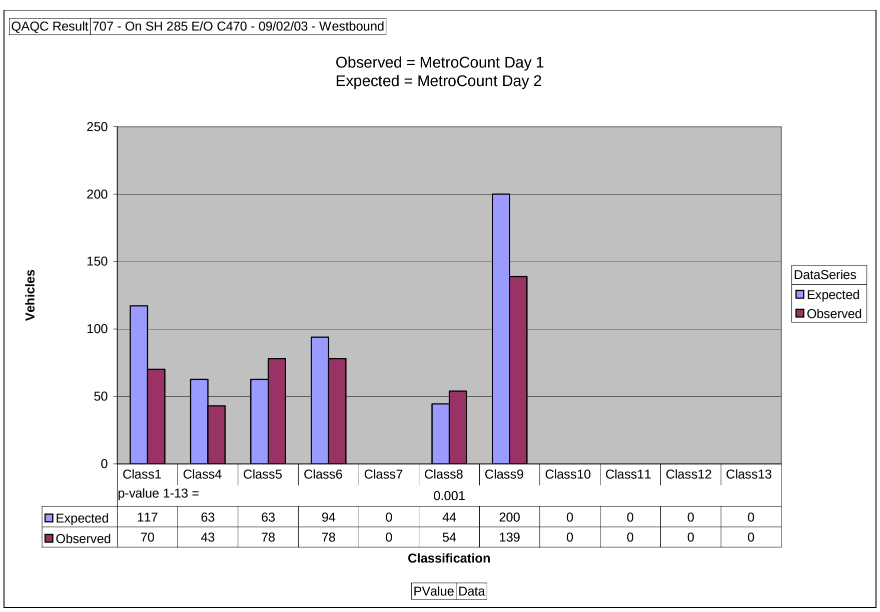
- TRA confirmed more motorcycles were present on 8/21/04 due to weather conditions

Specific Errors

- Excessive Class 6 count on WB SH285 e/o C470 on 9/2/03 in the outside lane.
    - o Solution – TRA identified a tube error. TRA fixed the metro file with assistance from the manufacturer. C&B will import the new metro file.



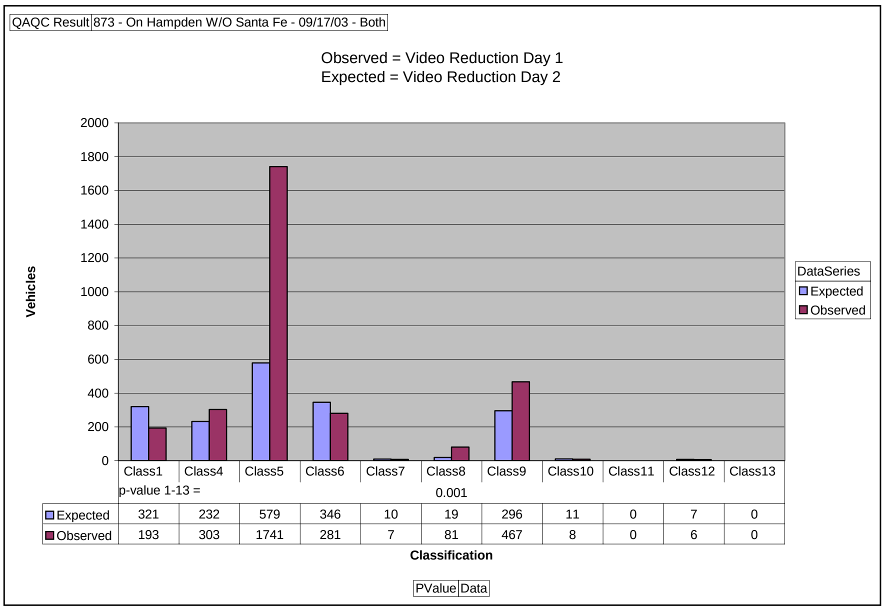
- Corrected



24-hour Video Reduction – Day 1 versus Day 2

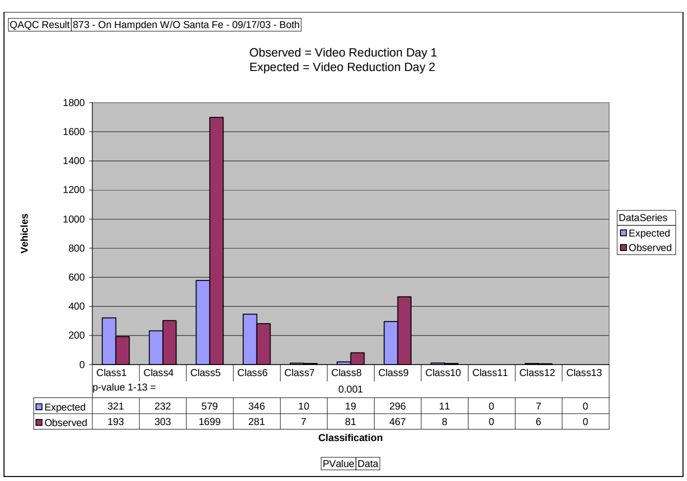
Specific Errors

- Excessive Class 5 count on Hampden w/o Santa Fe on 9/17/03
  - Solution – Identify employee counting this site and reduce video again.



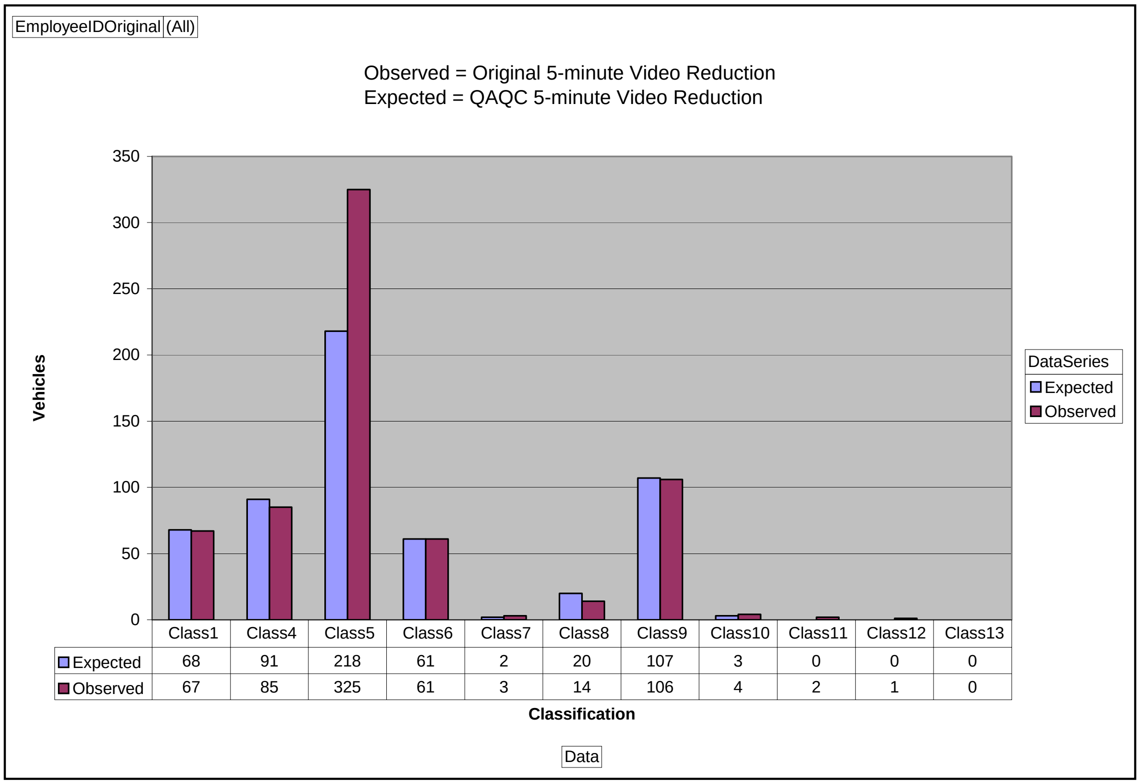
	Class1	Class4	Class5	Class6	Class7	Class8	Class9	Class10	Class11	Class12	Class13
Expected	321	232	579	346	10	19	296	11	0	7	0
Observed	193	303	1741	281	7	81	467	8	0	6	0

  - Correcting the video reduction problems helped but did not fix the discrepancy in Class 5 counts between the two days.



	Class1	Class4	Class5	Class6	Class7	Class8	Class9	Class10	Class11	Class12	Class13
Expected	321	232	579	346	10	19	296	11	0	7	0
Observed	193	303	1699	281	7	81	467	8	0	6	0

Check Video Reduction for each Employee

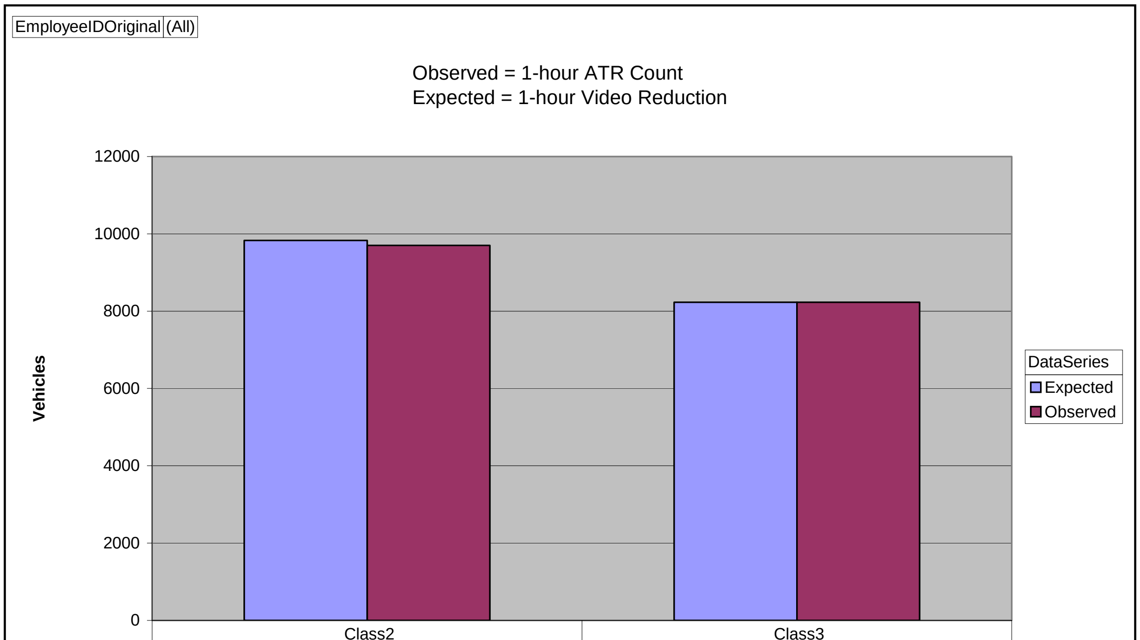


	Class1	Class4	Class5	Class6	Class7	Class8	Class9	Class10	Class11	Class12	Class13
Expected	68	91	218	61	2	20	107	3	0	0	0
Observed	67	85	325	61	3	14	106	4	2	1	0

Video reduction was checked by reducing a 5-minute interval for each employee at each site for each direction they reduced (113 5-minute intervals). The most common error was over counting Class 5 by miscounting Class 3.

Carter::Burgess

Overall, classes 2 & 3 were counted correctly

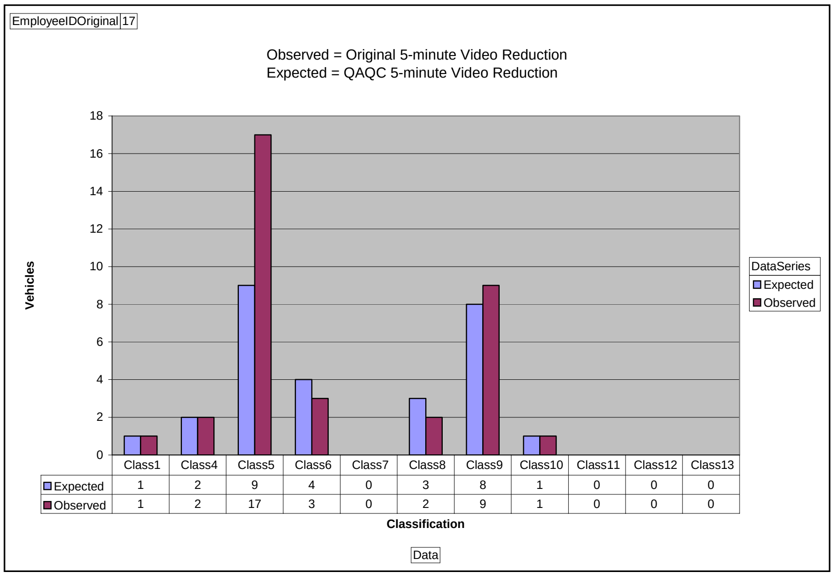


	Class2	Class3
Expected	9829	8232
Observed	9701	8233

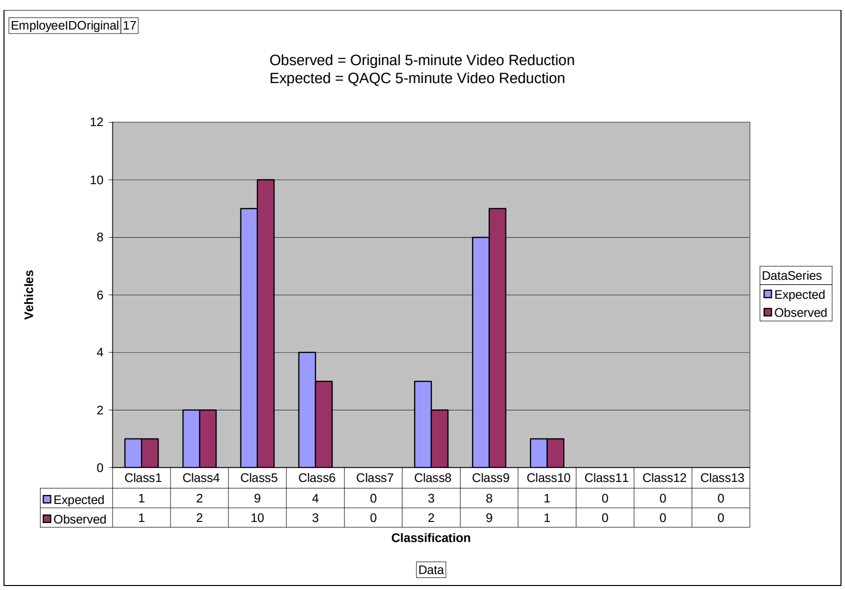
Carter::Burgess

Specific Errors

- Excessive Class 5 by employee 17.
  - o Solution – perform video reduction again for Class 5 for all intervals this employee reduced.



- Corrected



APPENDIX E – CHI-SQUARE GROUPING ALGORITHM

Legend

(red)	If sum of these classes > 0 & < 5
(blue)	Group with this class

passenger			single unit trucks				multi-unit trucks					
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13

passenger			single unit trucks				multi-unit trucks					
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9	10	11	12	13
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APPENDIX F – FIELD OBSERVATIONS

TRAFFIC RESEARCH & ANALYSIS, INC.

Specializing in Traffic Data Collection

VALIDATION OF SHORT DURATION URBAN VEHICLE CLASSIFICATION METHODOLOGIES

FIELD OBSERVATIONS

Prepared by Erik Ny

July 11, 2005

Overview

This report's purpose is to illustrate the experiences during the practical study of the 40/20 methodology and the 15/24 methodology.

- Field Technicians and Supervisors expressed a preference for the 40/20 methodology. Yet, no strong objections were expressed for the 15/24 methodology.
- 40 minute intervals proved difficult with high traffic volumes.
- Both too much (40/20 methodology) and too little (15/24 methodology) downtime was seen as a problem, depending on the methodology.

Methodologies

Using two methodologies, the 40/20 methodology and the 15/24 methodology, we provided data for a statistical comparison, and through interviews, staff has tried to compare the experiences of the technicians and supervisors who participated in this study. Both the methodologies mentioned above are not described in detail in this document as they have been covered elsewhere.

Where video recording of traffic was captured and reduced, both of the aforementioned methodologies were used simultaneously using two different teams of technicians. Where no video recording was made, the different methodologies were captured at different times, and an effort was made to keep the same team of technicians for both collection methodology sessions, although this was not always possible. However, the core group consisted of the same personnel.

Observations

A concern that the night shift needed the same number of technicians as the day shift due to safety concerns proved unfounded. It was emphasized that no technician had to work a night shift alone if they felt uncomfortable, but it did not prove to be an issue. Traffic volumes did not warrant more than one technician either, except at I-25 south of 23rd Street where two technicians worked the night shift.

Hwy 58 W/O MacIntyre; US-6 E/O Hwy 58, 15/24

The one time two people worked the night shift, it was immediately apparent that two people was excessive. Because this was the first day of the study, the technicians were unable to compare methodologies or circumstances, and comments focused on scheduling concerns:

"I thought it would be hard to stay awake, but I didn't find that difficult at all." (Brian, night shift)

"Not much time for breaks, just enough for a visit to the bathroom or to buy a sandwich." (Chuck & Phil, morning shift)

"No problems. With a dinner break halfway through, it was easy." (Philip, evening shift)

I-25 S/O 23rd St; 15th St @ I-25, 15/24

Due to technical problems, we had to re-visit this location, and we learned several things that we adjusted for subsequent counts. Depth vision changes with the lighting, and the first instinct to divide the heavily trafficked I-25 by lanes (Technician A count lane 1 and 2, technician B count lane 3 and 4) proved difficult and inaccurate as the techs started confusing which vehicles were in which lanes.

The second time the same site was counted, the traffic was divided by class category. Technician A counted category 2 and 3 vehicles (passenger vehicles, SUVs and Pickups), while technician B counted all other categories. This seemed to work better. Since four technicians were working at the same time, and 15th Street had very light traffic, the technicians took turns counting the second site, giving the other two technicians a longer break.

"Much better than dividing the traffic by lanes." (Chuck, morning shift)

"Easy to lose track of what you last counted when the traffic starts backing up." (Phil, counting 2's and 3's during the morning shift)

"Hectic on I-25, but overall very easy." (Neil, evening shift)

I-25 S/O 23rd St; 15th St @ I-25, 40/20

Based on the knowledge gained at the previous location on the I-25, we found that counting high-volume traffic on the I-25 for 40 minutes was very stressful. Almost every technician mentioned similar circumstances:

"I don't know if you can do this for 40 minutes and say honestly that you got everything right." (Chuck, morning shift)

"After a while, I started feeling lost in all the cars passing by." (Tony, morning shift)

"After looking at traffic for so long, it was almost hypnotic. It was kind of scary." (Brian, evening shift)

Despite these concerns, most said that it had been a very easy shift. This methodology offers generous breaks between the counts. It should be noted that it was the only time these opinions were expressed about the 40/20 methodology. At other locations, the 40/20 methodology was universally preferred to the 15/24 methodology, based on ease of counting.

Colfax E/O I-70 - 15/24 & 40/20; US-6 E/O Colfax - 15/24 & 40/20; Colfax E/O US-6 – 15/24

By now, the technicians were familiar with both methodologies – the 15/24 methodology was easier if a break occurred halfway through. Counting three locations within an hour using the 15/24 methodology proved too much at least a few times. Drive time was the primary issue, as heavy traffic would impact the schedule, and any sudden need for a bathroom break. The 40/20 methodology, on the other hand, was described as a pleasant experience, almost too little work.

"Very little to do. I could almost have brought a book." (Brian, night shift, 40/20)

"No problems. After the morning rush, it was easy." (Phil, morning shift, 40/20)

"The third site was difficult to get to in time, and there were absolutely no margins for error." (Michael, evening shift, 15/24)

Havana S/O Parker - 15/24 & 40/20; Havana N/O Parker - 15/24 & 40/20; Parker E/O Havana – 15/24

Very similar to the Colfax location, except the issue of getting to the third site for the 15/24 team was not due to the distance between the sites, but due to the traffic. The Havana/Parker intersection gets completely jammed during rush hour, and more often than not, the technicians could just not make it from one site to the next in time.

A case of miscommunication forced us to extend the count, after the first shift was found counting the traffic in a different spot than where the video camera was focused. The difference was small, but in between was an exit that was generating more traffic than expected.

"I don't think I could keep track of both directions at once, but one (direction), no problem." (Tony, morning shift, 15/24)

"The traffic was backing up heavily, but as long as you made a mental note of what car you counted last, you could get right back at it when they started moving again." (Gary, morning shift, 15/24)

"The time passes fast as long as I have someone to talk to." (Brian, evening shift, 40/20)

Hwy 58 W/O MacIntyre; US-6 E/O Hwy 58, 40/20

The only difference from our previous count time at this location was that one technician was scheduled during the night shift, and as expected it proved no problem at all. Compared to other locations, Golden was by far the easiest. Asking how the traffic was, I just got smiles or laughs back.

"Too much downtime." (Chuck, morning shift)

"Easiest count yet." (Neil, evening shift)

Summary

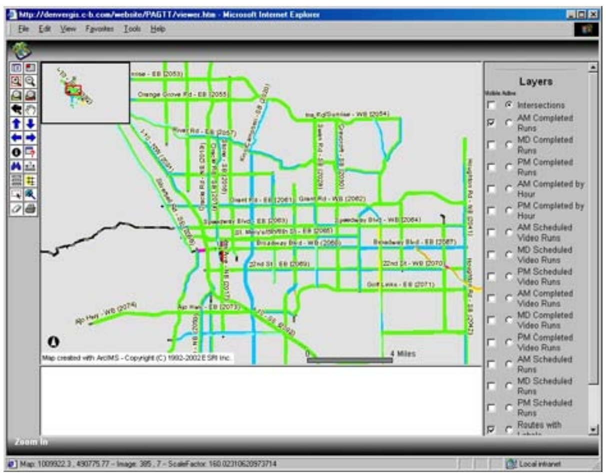
The statistical result from the two methodologies aside, the technicians expressed a definite preference for the 40/20 methodology. At the same time, no strong objections were expressed in regards to the 15/24 methodology.

From a supervisory point of view, the 15/24 methodology has its advantages, as one shift ends at the same time as the next starts, allowing a smooth and quick hand over. Meanwhile the 40/20 methodology has long gaps between the end of one interval and the start of the next, which means a lot of down time for the technicians (and sometimes supervisors). Finding efficient ways to use the time is overall a challenge with the 40/20 methodology.

APPENDIX G – STUDY PROPOSAL

INTRODUCTION

Carter & Burgess, Inc. has assembled an experienced team to meet the needs of the Validation of Urban Vehicle Classification Sampling Methodology Project as outlined by the Colorado Department of Transportation (CDOT) Division of Transportation Development (DTD). For this project we draw upon resources from Carter & Burgess, Traffic Research & Analysis, Inc. (TRA) and Dr. Bruce Janson of the University of Colorado at Denver. Descriptions of our team members follow:



Carter & Burgess will be the prime contractor for this project and will be performing project management, data analysis and documentation. Carter & Burgess has grown to be recognized as a national leader in planning, engineering, architecture, construction management and related services. Founded in 1939, the firm offers clients some of the most skilled traffic engineers and transportation planners in the country, as well as project management skills that emphasize responsiveness, quality control, timeliness, and cost-efficiency. More than doubling in size over the last three years, Carter & Burgess has nearly 2,400 employees in 37 offices across the country. As a full-service engineering, architecture, and planning firm, Carter & Burgess can respond to virtually any client need. We are proud of our reputation for meeting aggressive project schedules and our ability to assemble multidisciplinary project teams to provide our clients specialized attention and service.

This project will be staffed with personnel from our Denver-based **Management Systems Unit**. This unit supports projects throughout the nation dealing with statistical analysis, database development, geographic information systems and custom application development.

Traffic Research & Analysis, Inc. (TRA) will perform all data collection for this project. TRA was established in 1988 to provide traffic counting and data collection services. In addition to vehicle classification studies, TRA's data collection capabilities include machine counts, travel time studies, vehicle occupancy counts, origin/destination surveys, road and signage inventory, saturation flow studies, vehicle speed studies, turning movement counts, pedestrian surveys, GPS data collection, ATR maintenance, GIS mapping, vehicle queuing studies and delay studies. TRA’s primary focus is customer service and satisfaction.

TRA has enhanced services such as supplying GPS coordinates with traffic counts, GIS mapping utilizing ESRI ArcView 3.2, videotaping and/or photographing of a study area, diagramming of lane geometry, sign/striping and land use. Over the years, TRA has implemented numerous procedures to ensure accuracy in the collection of traffic data including performing biannual field-testing on all counting equipment, conducting field checks during installation and the count period and running a series of validity checks on all data once retrieved from the field.

TRA has been involved in hundreds of state and local government transportation studies and has collected thousands of traffic counts throughout the Western States - from Montana to Mississippi and Washington D.C. to Hawaii. TRA is currently certified as a Disadvantaged Business Enterprise (DBE) with the Departments of Transportation in Arizona, California, Colorado, Delaware, Idaho, Montana, Nevada, Oregon, South Dakota and Wyoming.

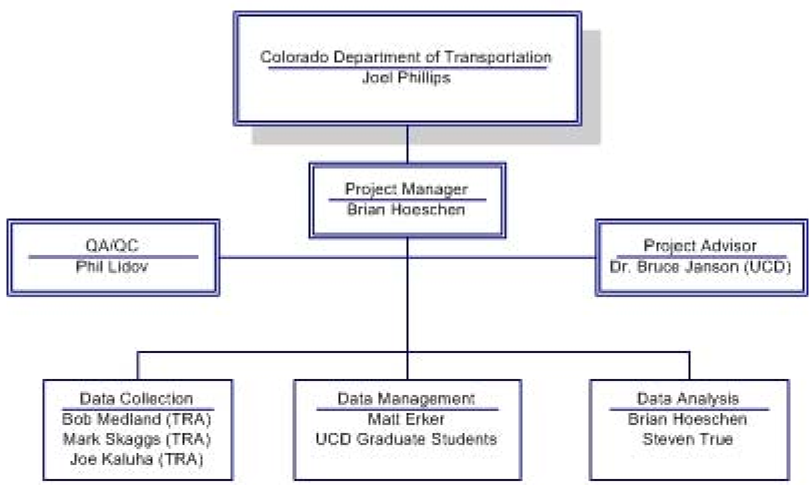
Dr. Bruce Janson of the University of Colorado at Denver, Civil Engineering Department will provide expert guidance on study design and data analysis. In addition, Dr. Janson will coordinate students who will be performing vehicle classifications from the video that will be collected as part of this project.

Dr. Janson is a Professor of Civil Engineering at the University of Colorado at Denver where he has been on the faculty since 1990. Dr. Janson conducts research on many topics concerning transportation engineering, planning, and management. His primary research focuses are:

- statistical analyses of traffic flow and traffic accident data
- effects of alternative roadway design and traffic control on accident rates
- highway and intersection capacity analyses
- network modelling and simulation of regional traffic flows and delays
- travel demand forecasting

Dr. Janson is a member of the Transportation Research Board (TRB), the American Society of Civil Engineers (ASCE), the Insititute of Transportation Engineers (ITE), and the Institute of Operations Research and Management Science (INFORMS). He has authored over 40 articles in journals and proceedings on transportation topics, and over a dozen technical reports. He has made numerous conference presentations at TRB, ASCE, and INFORMS meetings.

PROJECT TEAM



The Carter & Burgess Team is comprised of professionals with specific expertise in all of the technical disciplines required to successfully perform this project, including traffic data collection, data management, and statistical analysis. Our proposed organization is shown to the right. The following paragraphs describe the role of project team members and summarize their qualifications. Complete resumes are included in Appendix A.

Project Manager

Our Project Manager, **Mr. Brian Hoeschen**, will be responsible for project management, and will be the single point of contact. As Project Manager, Mr. Hoeschen will serve as an overall coordinator to ensure the goals of the project are met on a day-to-day basis. His knowledge of traffic engineering, database management and traffic analysis will be key to the success of this project. He maintains a sound working relationship with all members of the project team, and will be available throughout the project duration.

Mr. Hoeschen is a transportation engineer with six years of experience in research, traffic operations and programming. He has been involved in large data collection projects for the last six years such as travel speed and congestion management studies utilizing global positioning systems (GPS) and geographic information systems (GIS) linear databases. He is proficient in many different software applications relating to statistical analysis, data collection, data management, traffic analysis, and travel forecasting. He has hands-on experience in all tasks required for this project.

Project Advisor

Dr. Bruce Janson of the Civil Engineering Department of the University of Colorado at Denver will provide expert guidance on study design and data analysis. Dr. Janson will design the study, identify the statistical analysis to be performed, and assist with assessing the results. Dr. Janson's qualifications are summarized above and his complete resume is included in Appendix A.

Quality Assurance/Quality Control

Mr. Phil Lidov will act as the QA/QC Officer for this project. It will be Mr. Lidov's responsibility to ensure the study meets the project objectives by reviewing project deliverables, checking calculations, and providing technical review of the study results and guidebook.

Mr. Lidov has worked for more than 11 years as a developer of GIS databases and applications as well as other specialized information systems. At Carter & Burgess, Mr. Lidov leads an applications oriented group of GIS professionals who focus on methods for using GIS technology in the everyday activities of both the staff and clients of the Denver office. This program helps project staff to define a GIS approach to work done for all of its clients so that the projects benefit from the many advantages of GIS, including: improved data management and data access, spatial analysis, and easy report production through data summaries and maps. This group also consults with clients in order to bring them the applications and training necessary to implement this same approach in their own offices.

Data Collection

Mr. Robert Medland, Vice President of TRA will oversee the data collection required for this study. Mr. Medland will be assisted by Mr. Mark Skaggs the Colorado Regional Manager, Mr. Joe Kaluha, and other TRA staff members.

Data Management

Mr. Matt Erker will coordinate Data Management for this project, including designing the database structure, implementing the database structure, loading data and providing CDOT with the relational database in a fully documented format. Mr. Erker will also work with Dr. Bruce Janson and his graduate students to coordinate the reduction of the video data that will be collected for the project.

Mr. Erker manages the Management Systems Unit for Carter & Burgess. Mr. Erker specializes in developing computer-based solutions to engineering-related problems. In addition to his experience in statistical analyses, database management, geographic information systems (GIS) and engineering, he has more than 10 years of experience in nearly every aspect of the software development life cycle. This experience includes strategic planning, requirements and needs analysis, project management, programming, architectural design, object and data modeling, documentation, and training. Mr. Erker excels in drawing upon his broad base of experience to develop practical computer applications that work and integrate into GIS, databases, and web-based applications.

Data Analysis

Mr. Brian Hoeschen will lead data analysis for this project, including performing the statistical tests on the data, compiling the results, and preparing the summary. Mr. Hoeschen's qualifications are described above.

Mr. Steven True will support Mr. Hoeschen in performing the data analysis. Mr. True has worked for six years as a developer of GIS databases and applications as well as other types of specialized information systems in the telecommunications and real estate markets. He has developed GIS systems, based on statistical analyses, to address specific business needs of many Fortune 1000 companies, such as truck or materials routing and facilities management.

Mr. True is an integral part of the Carter & Burgess Management Systems Unit, developing applications and databases that emphasize Internet mapping applications for transportation, infrastructure and environmental projects. He works with the technical project teams and clients to define an approach and application that will improve data access, facilitate spatial analysis and provide user-friendly reports through data summaries and maps, statistical analysis & modeling.

PROJECT UNDERSTANDING

The Mobility Analysis Section (MAS) of the CDOT Division of Transportation Development (DTD) wishes to determine whether the cluster count method developed by CDOT is statistically reliable for vehicle classification on urban roadways with average daily traffic volumes exceeding

15,000 vehicles per day. Specifically, CDOT needs to assess whether or not the percentages of vehicles in the 13 FHWA vehicle categories estimated by the cluster count method differ significantly from expected percentages obtained by manual counts or electronic devices.

Since vehicle classification is expensive to perform by manual observation over long periods of time, a statistically reliable method of estimating vehicle type percentages on urban roadways using a less time consuming method is desirable. There are electronic methods of estimating vehicle classifications; using tube counters, automated traffic recorders (ATR), and image processing. The tube counters are quite dangerous for workers to install on high volume roads that are typically found in urban areas. ATRs are relatively expensive and permanent systems that can evaluate traffic at a few locations but their cost generally prohibits extensive use. Image processing techniques are also very expensive and depend heavily on camera angle to provide accurate results.

The cluster counting method, developed by CDOT, uses a series of short, manual counts taken at different sites within a small geographic area. A count is taken at four different times of day (2 peak hours and 2 off-peak hours) at each site of a cluster. The counting team moves between the sites of a cluster, located in fairly close proximity to one another, throughout the day. A count is ended at a given site after 200 vehicles per through lane are observed or after 45 minutes, whichever comes first. CDOT currently has 426 sites in the cluster counting program.

The results from this project will assess if the cluster count method is a statistically valid method of estimating vehicle classifications on various urban roadways. If so, the cluster counting method will become a standard method of classification data collection for FHWA on the roadway facilities validated in this study.

WORK PLAN

The Carter & Burgess team recognizes six tasks required to successfully complete this project. The following work plan describes how the Carter & Burgess team will approach each task to accomplish the project objectives. In addition to the project kickoff meeting and wrap-up meeting that are described below, four additional meetings will occur throughout the project to update CDOT on the progress.

Task 1 –Study Design

The objective of this task will be to discuss, agree on and document the study methodology prior to performing any field data collection. To accomplish this objective, we propose performing the subtasks described in detail below.

Carter & Burgess will organize and attend a project kickoff meeting with CDOT within a week of receiving the notice to proceed. During this meeting we will establish relationships among the project participants, identify appropriate lines of communication, and discuss required billing and status reporting procedures.

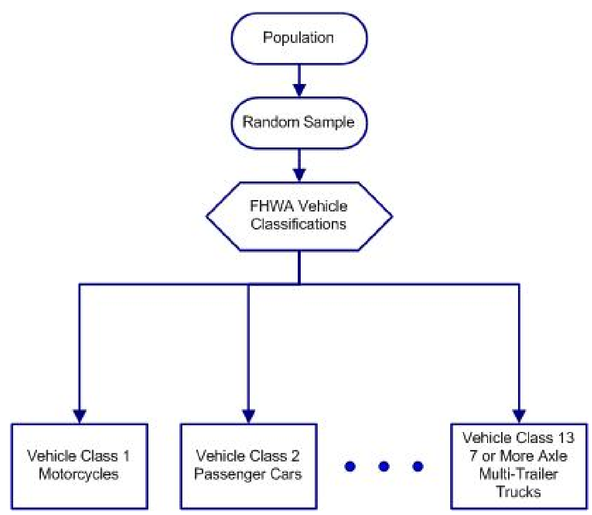
During this kickoff meeting we will also discuss the methodology of the statistical analysis and data collection. We will confirm the facility types (e.g., urban arterial, urban expressway, etc.) and volume categories that CDOT wishes to evaluate the cluster counting methodology. With help from CDOT, we will identify potential test sites for data collection, procedures for collecting the cluster counts, and the best method for collecting 24-hour classification data at each site. We will also discuss how to best use any existing data that CDOT has at each site.

Carter & Burgess will then prepare a Study Design Document that outlines the data collection sites, data collection procedures, methods for processing the data, and the procedures for the statistical analysis. In addition, the Study Design Document will describe the quality control procedures that will be used throughout the project to ensure defensible project results. Carter & Burgess will provide the Study Design Document to CDOT for their review and comment. The document will be revised to address CDOT's comments and a final version will be produced.

In preparing this proposal, the Carter & Burgess team has developed a study design that we believe meets the objectives of this project. Although this study design will be finalized as part of Task 1, we have included a preliminary study design below to demonstrate our approach to this project and to support our estimated schedule and cost.

Preliminary Study Design

Carter & Burgess will perform statistical analyses to verify the validity of the cluster count vehicle classification method. Vehicle classification data is considered categorical data based on a random traffic sample (cluster count) of a 24-hour period. The Pearson Chi-square is the best test for significance of the relationship between this random sample and the 24-hour data. This measure is based on the fact that we can compute the expected frequencies of vehicle classification in a two-way table (number of vehicles by vehicle class). The value of the Chi-square and its significance level depends on the overall number of observations (ADT), the number of vehicle classifications, and the difference between the observed cluster counts and 24-hour counts in each vehicle class.



To ensure validity, the Chi-square test requires random selection of the sample and that that the 24-hours count is not less than 5 vehicles for any vehicle class. The reason for this is that the Chi-square test tests the underlying probabilities in each vehicle class; and when the 24-hour class frequencies fall below 5, those probabilities cannot be estimated with sufficient precision. If the 24-hour count for any vehicle class is less than 5, those vehicle classes will be grouped with adjacent or similar vehicle classes until the count is at least 5. The same groupings will be made for the corresponding cluster count to calculate the chi-square statistic for each comparison. The formula for the chi-square statistic follows:

$$X^2 = \sum_{i=1}^{k} \frac{(x_i - e_i)}{e_i}$$

Where:

k = number of vehicle classes
x = observed frequency in a vehicle class (from cluster count)
e = expected frequency in a vehicle class (from 24-count)

The larger the chi-square statistic, the greater the discrepancy between the two data sets. A p-value, or statistical significance, is obtained by comparing the chi-square statistic with a chi-square distribution with k-1 degrees of freedom. The p-values that result from comparing the 24-hour count data to the cluster count data will be summarized to assess the validity of the cluster count method.

Even though the number of sites sampled does not affect the validity of the chi-square test for any given location, it does, address the question of whether the cluster counting method is reliable for different roadway facilities or volumes. To address this concern, it's recommended that at least three sites be sampled on two separate days for each of the following facility/ADT classes:

Urban Arterial with Low Volumes (15,000 > ADT < 30,000)
Urban Arterial with High Volumes (> 30,000 ADT)
Urban Expressway (High Volume)
Urban Freeway (High Volume)

Under this sampling plan, Carter & Burgess will collect 24-hour data and concurrent cluster counts resulting in twenty-four full-day comparisons and six comparisons per facility/ADT class. Each cluster count and 24-hour count can be verified by comparing the corresponding data on a different day. If the classification data shows a discrepancy at the same site for different days, another cluster count and 24-hour count will be performed and the outlying data will be discarded.

New vehicle classification data will be collected on Tuesdays, Wednesdays, or Thursdays to avoid potential end of week variations. Cluster count data will be collected at all sites using the current CDOT methodology during the following time periods:

Period Name	Time Period
AM Peak	6:30-8:30 AM
AM Off Peak	9:30-12:00 PM
PM Off Peak	1:00-3:30 PM
PM Peak	4:00-6:00 PM

Carter & Burgess proposes to utilize three different methods to collect the 24-hour data. First, urban freeway sites will be chosen near an existing CDOT automated traffic recorders (ATR). Digital video will be collected at these sites for two different hours of the day and reduced to manual classification counts to verify the ATR data. Carter & Burgess will coordinate with CDOT to obtain the ATR data for the same days as the cluster counts and video data. Second, 24-hour digital video will be collected for urban arterials with high volumes and urban expressways and reduced to manual classification counts. Third, MetroCount portable classification tubes will be used on the urban arterials with low volumes at cluster count sites where significant queuing does not occur. These 24-hour tube counts will be verified with two different hours of manual counts obtained from concurrent video recordings. Any historical vehicle classification data that has already been collected by CDOT will also be incorporated into the study as additional comparisons.

Possible sites will be discussed with CDOT and Carter & Burgess will then visit each potential test site and decide whether or not to include it in this study and the data collection methods that will be employed at that location.

Task 2 – Data Collection

The objective of this task is to collect the data according to the study design that was developed in Task 1. The data collection methodology will be refined and finalized during the Study Design process and data collection will not begin until the Study Design as been approved by CDOT. As described above, Carter & Burgess expects to collect vehicle classification data using the cluster count method, ATR data from existing CDOT ATR installations, digital video that will be reduced to provide 24-hour manual counts and MetroCount classification tubes.

TRA will provide the bulk of the data collection effort as they have with Carter & Burgess for other projects. TRA has a Denver office with technicians familiar with the area. Familiarity with the roadway network will allow technicians to identify problems due to incidents because of their knowledge of the typical congestion levels. TRA will use technicians that have been specifically trained for the cluster count project. Simultaneous video data collected at each site will provide an initial level of quality control and will be used to verify electronic classification data that will be collected at some of the study sites.

Task 3 – Data Management/Processing

The objective of this task will be to compile the data that was collected during Task 2, as well as historical vehicle classification data used during the project, and prepare it for the statistical analyses that will be performed in Task 4. Carter & Burgess expects the data that will be compiled to include the tube count data, the ATR data, the video and the associated vehicle classification data derived from the video, and the cluster count data. To perform this task, Carter & Burgess will perform three subtasks, as described below.

First, Carter & Burgess will design a relational database structure for storing all of the different types and formats of data that are being used by the project. During this subtask, Carter & Burgess will meet with CDOT personnel to identify existing database standards that relate to this project, if any exist. This database structure will document that data by identifying the source of the data, when and where the data were collected and the data type. Carter & Burgess will prepare a memo that describes the database structure and provide it to CDOT for review and comment.

Second, Carter & Burgess will upload historical data and any data collected during this project into the relational database. Depending on the data format, this uploading may be performed through desktop database software such as Microsoft Access, a custom application written specifically for this project, or through the data uploading tools provided with the relational database software. QA/QC personnel will then check all data for inconsistencies.

Third, Carter & Burgess will provide CDOT with a copy of the relational database and associated documentation for their internal use. Carter & Burgess expects this subtask will entail writing a CD-ROM of the database information and providing that with a memo that describes the database format and content.

Task 4 – Data Analysis

The objective of this task is to perform the statistical analyses to compare the data collected using the cluster count method to the data collected using the other methods. The statistical tests that Carter & Burgess currently expects to perform are described in Task 1 – Study Design and will be finalized during the project.

Carter & Burgess proposes to perform this task through three subtasks. First, we will develop automated methods for performing the statistical tests. The volume of data collected during the project will inhibit manually performing the statistical tests thereby requiring automated procedures. Depending on the final statistical study design, this may entail using pre-packaged software such as Statistica or developing procedures within the database. In either case, Carter & Burgess will provide CDOT with documentation of the procedures in the summary report (Task 5).

Second, the statistical tests will be performed using the automated procedures that were described above. The results of the statistical tests will be stored within the relational database for later reference.

Third, if a cluster count for any facility/ADT class is found to be statistically insignificant, we will explore causes and make recommendations on how to improve the cluster count methodology. We will perform limited tests of any new methodology with video or time stamped data collected in Task 2.

Quality control during data analysis will be accomplished by recording and manipulating data electronically, automated database queries, and by spot-checking results. Results will be pulled into summary tables directly from the database so that no errors are made in transferring data to the tables and any changes in calculations will be automatically updated in the tables.

Task 5 – Documentation

Carter & Burgess will prepare a report that summarizes the study design, data collection methods and results, data management procedures, and data analysis results. This summary report will assess the validity of the cluster count method and provide recommendations to improve CDOT's methodology.

Carter & Burgess will provide CDOT with a draft version of this report for their review and comment. Once CDOT has completed their review, we will meet with CDOT personnel to discuss their comments. A final version of the summary report will be prepared that addresses CDOT's comments. CDOT will be provided with ten hardcopies of this report in addition to an electronic version.

Task 6 – Guidebook

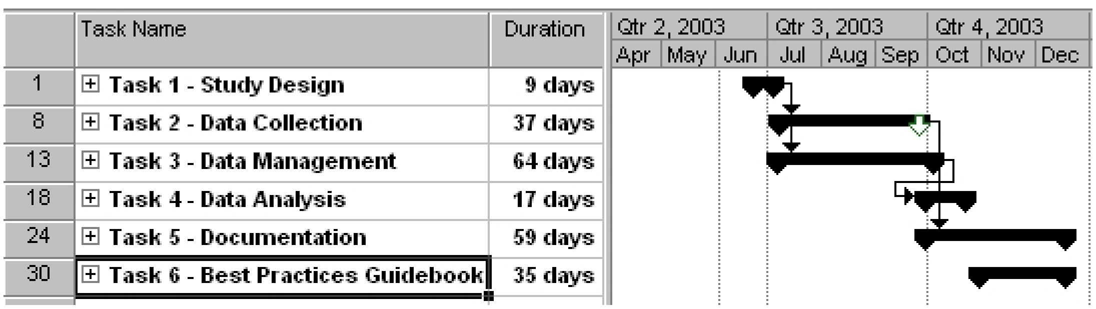
A Cluster Count Best Practices Guidebook will be produced and submitted to CDOT for their review and comment. This guidebook will contain detailed instructions for performing cluster counts in urban settings, including study design, data collection methods and data analysis techniques. Once CDOT has completed their review, Carter & Burgess will meet with CDOT staff to discuss their comments. A final version of the guidebook that addresses CDOT's comments will be produced. Carter & Burgess proposes to provide CDOT with 10 hardcopies of the guidebook as well as an electronic version.

PROJECT COST AND SCHEDULE

Our cost proposal presents costs and a schedule for each of the six tasks described above. The table below shows the expected costs for each of the tasks described in the Work Plan above.

Task	Expected Cost
Task 1 – Study Design	$10,380
Task 2 – Data Collection	$4,788
Task 3 – Data Management	$10,620
Task 4 – Data Analysis	$9,000
Task 5 – Documentation	$6,648
Task 6 – Best Practices Guidebook	$5,532
Subtotal for All Tasks	**$46,968**
Expenses	$3,000
Subconsultants	$48,295
Total Cost	**$98,263**

The figure below summarizes our proposed project schedule.



PROJECT EXPERIENCE

The Carter & Burgess Team has a long and successful track record of traffic data collection, traffic data analysis and successfully performing projects for CDOT. Descriptions of similar projects are provided below.

Denver Area Speed Study

Carter & Burgess and TRA were contracted by CDOT to conduct a speed study for purposes of updating the speeds used by the Denver Regional Council of Governments (DRCOG) regional travel demand-forecasting model. Carter & Burgess and TRA employed GPS technology to produce statistically valid estimates of speeds for different categories of roadways in the Denver metropolitan area. TRA collected a sample of roadways a mile in length, based on a plan developed by Carter Burgess and the Denver Regional Council of Governments (DRCOG) with categories of facility type (including freeway, expressway, principal and minor arterials), area type (urban, suburban, rural, and CBD), and the time of day (AM, midday, and PM peak hours). Routes were then determined by using a combination of each of the three categories. A fleet of ten vehicles performed over 3,100 one-mile sample runs for this project.

Hidalgo County Congestion Management System Report (2001 and 2002)

The purpose of this study was to identify congestion areas in one of the fastest growing regions in the nation, the Lower Rio Grande Valley. Collecting travel times on 500 centerline miles of roadway via GPS and geo-referenced digital video identified congested areas. The travel times and thus speeds were used to calculate the Congestion Index (actual speed vs. posted speed) at 2-second intervals were summarized by segment. The study results are used as factors in prioritizing needed improvements. This data, coupled with over 24,000 pictures and video of the roadway system, provide the needed reference material to prepare recommendations that are focused around problem areas.

2002 Maricopa Association of Governments Travel Speed Study

Carter & Burgess is under contract with the Maricopa Association of Governments (MAG) to conduct their 2002 Regional Travel Speed Study. The study focuses on collecting travel time data on major arterials and freeways and comparing the current travel speeds with historical data. This information will be used by MAG to identify congestion and mobility problems and target these areas for improvement and as input for calibration of the regional traffic-forecasting model. Project data collection is-built on using the ‘floating car’ method with vehicles equipped with a GPS and digital video cameras. The video is geo-referenced so that it can be accessed based on a map location. Carter & Burgess is also providing quality control procedures to ensure accurate data, coordination among the Consultant and agencies, presentation of the data in tabular and map formats and presentations to the public and MAG staff. A web-based map showing the status of the travel time runs with basic data summaries will also be available to the staff of MAG.

CDOT Portable Traffic Counting Program (1998, 1999, 2000, 2001, 2002, 2003)

Since 1998, TRA has been contracted by the Colorado Department of Transportation to collect volume and classification counts throughout the state. In 1998, TRA was awarded a contract to collect traffic counts in the western slope region of Colorado. TRA staff collected 48-hour traffic volume counts for 600 locations and 48-hour vehicle classification counts for 60 locations, encompassing hundreds of miles of roadway throughout Western Colorado. The traffic volume and classification counts were downloaded from the machines in the field weekly, and transferred electronically to the Phoenix office. Data from the Phoenix office was processed and reviewed for data validity and then delivered electronically to CDOT in Denver. TRA worked closely with CDOT to develop software compatibility and facilitate data transfers.

In 1999, TRA was awarded an annual contract for data collection and management services for the entire state. TRA's contract with CDOT was recently renewed for another year. During the contract year 2002, TRA collected approximately 3,100 traffic counts throughout the state, at locations on and off the state highway system. Types of data collected included 24-hour and 48-hour volume counts, and 48-hour vehicle classification counts. All volume counts are submitted to CDOT in FHWA Card 3 Format and classification counts are submitted in FHWA Card 4 Format.
Reference: Mike Young, Project Manager, (970) 249-5285 x 105 or Mehdi Baziar, Manager, Traffic Analysis Unit, (303) 757-9047

CDOT Cluster Counting (2003)

TRA is currently performing manual vehicle classification counts on state highways and off-system roads. Cluster Counting Methodology was developed by CDOT Division of Transportation Development as a means to collect vehicle classification data on a large number of sites, in a short time duration, using a limited amount of resources. For the current year contract, 37 Cluster Sites are counted in four nonconsecutive time periods during a given day. At every site, the count includes at least 200 vehicles for every existing thru lane, or last for a 45-minute duration, whichever occurs first. The purpose of this project is to capture an accurate picture of area traffic and compare the cluster data with other permanent counter (Automatic Traffic Recorder) classification data.
Reference: John Valerio, (303) 757-9425

HIRSYS

The Hotline Information Record System (HIRSYS) is a web-based application created to manage public contact including comments, complaints and requests for information. CDOT regions and large CDOT projects, such as T-REX, use this system to track incoming and outgoing public contact.
For example, a business owner may write a letter complaining about construction noise along a highway. The complaint is entered into HIRSYS, an appropriate person is assigned to respond to the issue and is notified automatically by e-mail. Once the issue is closed, the response and action taken are recorded in HIRSYS.

Public outreach activities, such as open house meetings and newsletter mailings, can also be entered and tracked in HIRSYS. Through the reporting feature, users can correlate between timing of public outreach activities and an increase or decrease in the number of comments or complaints.

Development of HIRSYS was a collaborative effort. Numerous meetings were conducted with CDOT personnel and public involvement specialists to gather input. Many people helped decide the type of information that should be collected and the process for dealing with incoming contact and outgoing responses.
Reference: Tara Galvez, (303) 757-9469

Congestion Mitigation and Air Quality Improvement Program

Carter & Burgess improved the state's Congestion Mitigation and Air Quality Improvement Program (CMAQ) reporting system. The CMAQ Program was authorized in 1991 through Congressional passage of the Intermodal Surface Transportation Efficiency Act (ISTEA), and subsequently reauthorized under the Transportation Equity Act of the 21st Century. ISTEA provided $6.0 billion in funding for surface transportation and other related projects that contribute to air quality improvements and reduce congestion. The main goal of the CMAQ Program is to fund transportation projects that reduce emissions in non-attainment and maintenance areas. Individual state CMAQ reporting is used to summarize the expenditure of CMAQ funds by each state in the nation that qualifies for CMAQ funds and track program effectiveness so it can be reported to the Federal Highway Administration.

Carter & Burgess re-designed the current Microsoft Excel based state reporting system to a more efficient, easy to update and secure system. The new reporting system is comprised of forms with a similar look and feel as the existing Excel application. CMAQ administrators throughout the state are provided a CD-ROM containing the forms. The reporting system is designed to walk the user through a series of questions and formulas with the end result being a printable calculation page that shows the users inputs and the calculated results.

Carter & Burgess is currently working on the second phase of the CMAQ project. During this phase, we will convert the existing HTML forms to a secure, dynamic website hosted on CDOT's web servers. The website will feature a comprehensive security model where each user's rights will be enforced to ensure data security.
Reference: Herman Stockinger, (303) 757-3063