CHAPTER 3
TRAFFIC AND CLIMATE

Traffic and climate related inputs required for conducting pavement design and analysis using M-E Design software are discussed in this chapter.

3.1 Traffic

Prior to M-E Design, the number of 18,000-pound Equivalent Single Axle Loads (18-kip ESAL) represented the amount of traffic and its characteristics. However, M-E Design traffic input requirements are more detailed and can be categorized as follows, refer to **Figure 3.1 Traffic Inputs in the M-E Design Software**:

- Base year traffic information
    - Analysis period or pavement design life
    - Date newly constructed or rehabilitated pavement is opened to traffic
    - Two-way average annual daily truck traffic (AADTT)
    - Number of lanes in design direction
    - Truck direction distribution factor
    - Lane distribution factor
    - Operational speed

- Traffic adjustment factors
    - Monthly adjustment factors
    - Vehicle class distribution
    - Truck hourly distribution
    - Growth rate and type
    - Number of axles per truck
    - Axle load distribution factors

- General traffic inputs
    - Lateral wander of axle loads
    - Axle configuration
    - Wheelbase
    - Tire pressure

This section primarily deals with traffic input requirements for pavement designs using M-E Design software. The 18-kip ESALs are still required for asphalt binder selection, see **Section 6.12.3 Binder Selection** and pavement designs using the CDOT thin and ultra-thin Concrete Overlay design procedures. Refer to the *CDOT 2012 Pavement Design Manual* for information on traffic characterization using the ESAL methodology.

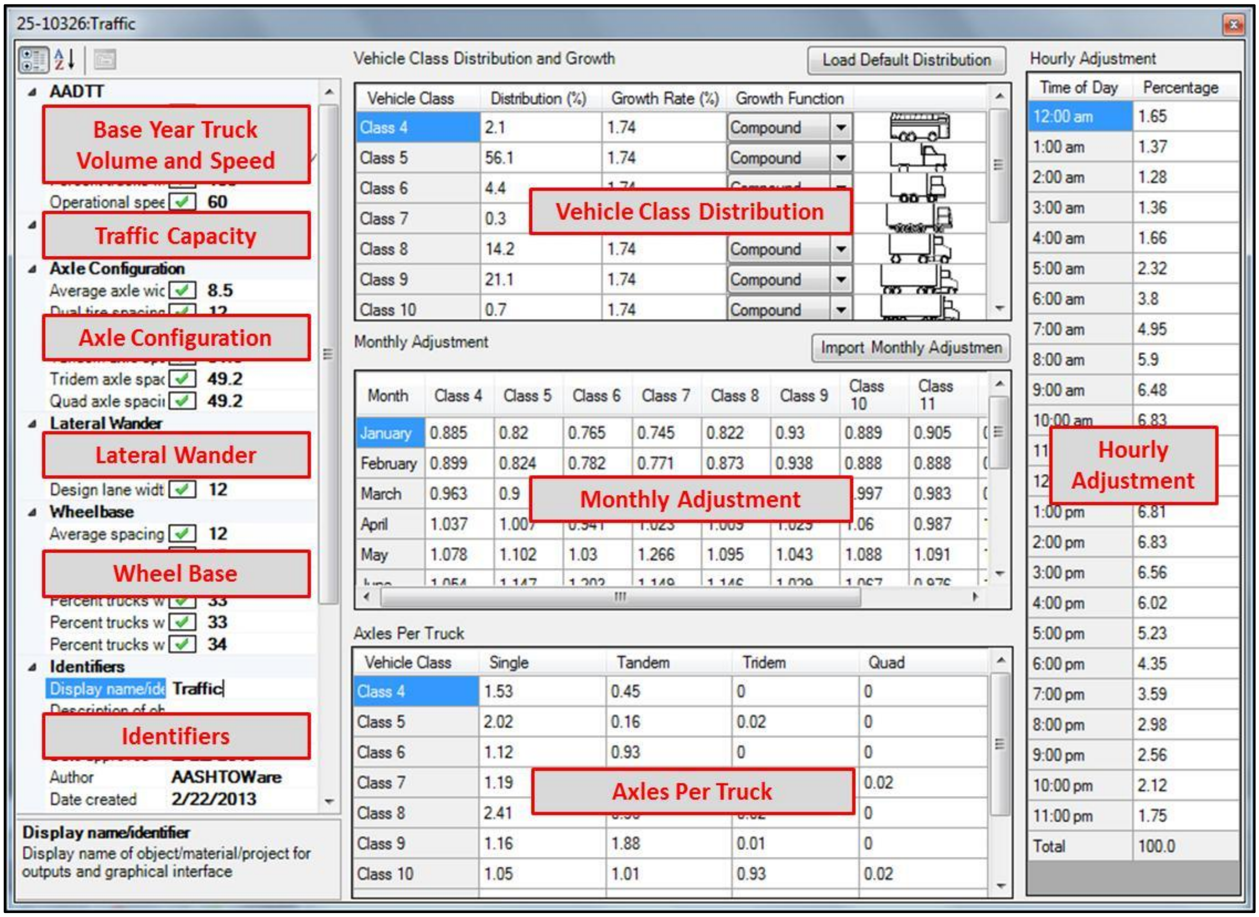


Figure 3.1 Traffic Inputs in the M-E Design Software

3.1.1 CDOT Traffic Data

The Department has various sites on the highway system where instruments have been placed in the roadway to measure axle loads as a vehicle passes over the site. These stations, called Weigh-in-Motion (WIM) sites, can provide accurate information of the existing traffic load. An estimate of growth over the design period will be needed to calculate the traffic load during the design period. The link http://dtdapps.coloradodot.info/Otis/TrafficData is used to access traffic load information.

The Division of Transportation Development (DTD) Traffic Analysis Unit supplies traffic analysis for pavement structure design. All vehicular traffic on the design roadway is projected for the design year in the categories of passenger cars, single unit trucks, and combination trucks with various axle configurations. The DTD Traffic Analysis Unit will make adjustments for directional distribution and lane distribution.

The DTD provides traffic projections of Average Annual Daily Traffic (AADT) and ESALs. The designer must request 10, 20, and 30-year traffic projections for flexible pavements and 20 and 30-year traffic projections for rigid pavements from the Traffic Section of DTD. Requests for traffic projections should be coordinated with the appropriate personnel of DTD. The pavement designer can help ensure accurate traffic projections are provided by documenting local conditions and planned economic development that may affect future traffic loads and volumes. The DTD should be notified of special traffic situations when traffic data are requested. Some special situations may include:

- A street that is or will be a major arterial route for city buses.
- A roadway that will carry truck traffic to and from heavily used distribution or freight centers.
- A highway that will experience an increase in traffic from a connection to a major, high-traffic area.
- A highway that will be constructed in the near future.
- A roadway that will experience a decrease in traffic due to the future opening of a parallel roadway facility.

3.1.2 Traffic Inputs Hierarchy

The M-E Design methodology defines three levels of traffic data inputs based on how well the pavement designer can estimate future truck traffic for the roadway being designed. **Table 3.1 Hierarchy of Traffic Inputs** presents the hierarchy description of traffic inputs and common data sources. Refer to **Table 2.8 Selection of Input Hierarchical Level** for selection of an appropriate hierarchical level for traffic inputs. **Table 3.2 Recommendations of Traffic Inputs at Each Hierarchical Level** presents the traffic input requirements of the M-E Design method and the recommendations for obtaining these inputs at each hierarchical input level.

Table 3.1 Hierarchy of Traffic Inputs

Input Hierarchy	Description
Level 1	Site-specific traffic data determined from site-specific measurements of weigh-in-motion data • Volume counts • Traffic adjustment factors • Axle load distribution
Level 2	Site-specific traffic volume counts • CDOT averages of traffic adjustment factors and axle load data • Derived averages from CDOT weigh-in-motion • Automatic vehicle classification historical data
Level 3	Site-specific traffic volume counts and national averages of traffic adjustment factors and axle load data (M-E Design software defaults)

Table 3.2 Recommendations of Traffic Inputs at Each Hierarchical Level

Input	Level 1	Level 2	Level 3
AADT	Use project specific historical traffic volume data **Section 3.1.3 Volume Counts**		
Traffic Growth Rate Distribution Factor	Use project specific historical traffic volume data **Section 3.1.5 Growth Factors for Trucks**		
Lane and Directional Distribution Factor	Use project specific values	**Section 3.1.4 Lane and Directional Distributions**	
Vehicle Class Distribution	Use project specific values	Use CDOT averages **Table 3.5 Level 2 Vehicle Class Distribution Factors**	Use M-E Design software defaults
Monthly Adjustment Factor	Use project specific values	Use CDOT averages **Table 3.7 Level 2 Monthly Adjustment Factors**	
Hourly Distribution Factor	Use project specific values	Use CDOT averages **Table 3.8 Hourly Distribution Factors**	
Axle Load Distribution	Use project specific values	Use CDOT averages **Section 3.1.10 Axle Load Distribution**	
Operational Speed	Use posted or design speed (Levels 1 and 2 not available)		
Number of Axles Per Truck	Use project specific values	Use CDOT averages **Table 3.6 Level 2 Number of Axles Per Truck**	
Lateral Traffic Wander	Use M-E Design software defaults (Levels 1 and 2 not available) **Section 3.1.12 Lateral Wander of Axle Load**		
Axle Configuration	Use M-E Design software defaults (Levels 1 and 2 not available) **Section 3.1.13 Axle Configuration and Wheelbase**		
Wheelbase	Use project specific values	Use national defaults **Section 3.1.13 Axle Configuration and Wheelbase**	
Tire Pressure	Use M-E Design software defaults (Levels 1 and 2 not available) **Section 3.1.14 Tire Pressure**		

3.1.3 Volume Counts

M-E Design characterizes traffic volume as the Annual Average Daily Truck Traffic (AADTT) (see **Figure 3.2 M-E Design Software Screenshot of AADTT**). AADTT is a product of Annual Average Daily Traffic (AADT) and percent trucks (FHWA vehicle Classes 4 through 13). Project specific AADTT for the base year is required for pavement design/analysis of all hierarchical input levels. CDOT reports both AADT and AADTT, thus historical AADT and/or AADTT estimates for a specific project segment can be accessed from the link: http://dtdapps.coloradodot.info/Otis/TrafficData.

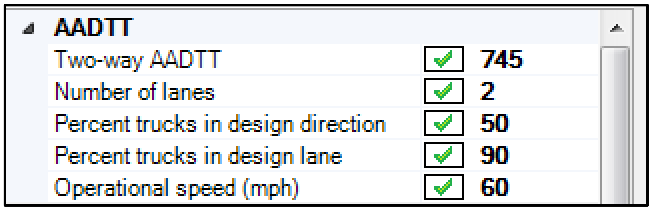


Figure 3.2 M-E Design Software Screenshot of AADT

3.1.4 Lane and Directional Distributions

The most heavily used lane is referred to as the design lane. Generally, the outside lanes are the design lanes. Traffic analysis determines a percent of all trucks traveling on the facility for the design lanes. This is also referred to as a lane distribution factor.

The percent of trucks in the design direction is applied to the two directional AADT to account for any differences to truck volumes by the direction. The percent trucks in the design direction is referred to as the directional distribution factor. Generally, the directional distribution factor is a 50/50 percent split. If the number of lanes and volumes are not the same for each direction, it may be appropriate to design a different pavement structure for each direction of travel.

CDOT uses a design lane factor to account for the lane and directional distribution which are combined into one factor, the design lane factor. **Table 3.3 Design Lane Factor** shows the relationship of the design lane factor versus the lane and directional distributions. **Figure 3.2 M-E Design Software Screenshot of AADTT** presents the M-E Design software screenshot of lane and directional distribution factors.

Table 3.3 Design Lane Factor

Type of Facility	Number of Lanes in Design Direction	Design Lane Factor	Percent of Total Trucks in the Design Lane (Outside Lane)	Directional Split (Design Direction/ Non-design Direction)
One Way	1	1.00	100	NA
2-Lanes	1	0.60	100	60/40
4-Lanes	2	0.45	90	50/50
6-Lanes	3	0.309	60	50/50
8-Lanes	4	0.25	50	50/50

Note: The *Highway Capacity Manual*, 2000 (Exhibit 12-13) recommends using a default value for directional split of 60/40 on a two-lane highway may it be rural or urban (3).

3.1.5 Growth Factors for Trucks

The number of vehicles using a pavement tends to increase with time. A simple growth rate assumes the AADT is increased by the same amount each year. A compound growth rate assumes the AADT percent growth rate for any given year is applied to the volume during the preceding year. CDOT a the compound growth rate. Use equation **Eq. 3-1** or **Table 3.4 Growth Rate Determined Using OTIS 20-Year Growth Factor**.

$$\mathbf{T_f = (1+r)^{\mathit{n}}} \qquad \textbf{Eq. 3-1}$$

Where:

T_f = growth factor
r = rate if growth expressed as a fraction
n = number of years

The CDOT traffic analysis unit may be consulted to estimate the increase in truck traffic over time (using the M-E Design approach). The M-E Design software has the capability to use different growth rates for different truck classes, but assumes the growth rate remains the same throughout the analysis period, see **Figure 3.3 M-E Design Software Screenshot of Growth Rate**. Additionally, the estimated traffic volumes to be used in the pavement design can be subjected to roadway capacity limits. Project specific growth rates are required for pavement design/analysis for all hierarchical input levels. An estimate of truck volume growth over the design period can be accessed from the link http://dtdapps.coloradodot.info/Otis/TrafficData.

Vehicle Class Distribution and Growth | Load Default Distribution

Vehicle Class	Distribution (%)	Growth Rate (%)	Growth Function	
Class 4	2.1	1.74	Compound	
Class 5	56.1	1.74	Compound	
Class 6	4.4	1.74	Compound	
Class 7	0.3	1.74	Compound	
Class 8	14.2	1.74	Compound	
Class 9	21.1	1.74	Compound	
Class 10	0.7	1.74	Compound	
Class 11	0.7	1.74	Compound	
Class 12	0.2	1.74	Compound	
Class 13	0.2	1.74	Compound	
Total	100			

Figure 3.3 M-E Design Software Screenshot of Growth Rate

Table 3.4 Growth Rate Determined Using OTIS 20-Year Growth Factor

20 Year Growth Factor (OTIS)	r (%)	20 Year Growth Factor (OTIS)	r (%)
1.00	0.000	2.30	4.256
1.05	0.245	2.35	4.364
1.10	0.478	2.40	4.475
1.15	0.703	2.45	4.584
1.20	0.916	2.50	4.690
1.25	1.122	2.55	4.793
1.30	1.320	2.60	4.894
1.35	1.512	2.65	4.995
1.40	1.697	2.70	5.092
1.45	1.877	2.75	5.179
1.50	2.048	2.80	5.283
1.55	2.196	2.85	5.377
1.60	2.378	2.90	5.464
1.65	2.535	2.95	5.559
1.70	2.689	3.00	5.647
1.75	2.840	3.05	5.834
1.80	2.983	3.10	5.820
1.85	3.123	3.15	5.905
1.90	3.261	3.20	5.988
1.95	3.393	3.25	6.070
2.00	3.526	3.30	6.149
2.05	3.655	3.35	6.232
2.10	3.784	3.40	6.310
2.15	3.902	3.45	6.386
2.20	4.021	3.50	6.465
2.25	4.139		

3.1.6 Vehicle Classification

M-E Design requires a vehicle class distribution which represents the percentage of each truck class (Classes 4 through 13) within the truck traffic distribution as part of the AADTT for the base year. The sum of the percent AADTT of all truck classes should equal 100. This normalized distribution is determined from an analysis of AVC data and represents data collected over multiple years. CDOT uses a classification scheme of categorizing vehicles into three bins. These vehicle classifications types are (1):

- Passenger vehicles: Classes 1-3 are 0-20 feet
- Single unit trucks: Classes 4-7 are 20-40 feet
- Combination trucks: Classes 8-13 and greater than 40 feet long

These bins are further broken down into 13 classes. The 13 classification scheme follows FHWA vehicle type classification. For some situations, a fourth bin containing all unclassified vehicles is used. Additional classes, Class 14 and 15, may also be included in the fourth bin. CDOT vehicle classes are presented in **Figure 2.3 Functional Classification Map**. FHWA vehicle classes with definitions are presented as follows (2). **Note:** The M-E Design method does not include vehicle Classes 1 to 3 (i.e. light weight vehicles) and Classes 14 and 15 (i.e. unclassified vehicles).

Class 1: Motorcycles: All two or three-wheeled motorized vehicles. Typical vehicles in this category have saddle type seats and are steered by handlebars rather than steering wheels. This category includes motorcycles, motor scooters, mopeds, motor-powered bicycles, and three-wheel motorcycles. This vehicle type may be reported at the option of the State.

Class 2: Passenger Cars: All sedans, coupes, and station wagons manufactured primarily for the purpose of carrying passengers, including 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. Because automatic vehicle classifiers have difficulty distinguishing Class 3 from Class 2, these two classes may be combined into Class 2.

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 a truck and should be appropriately classified.

Class 5: Two-Axle, Six-Tire, Single-Unit Trucks: All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., with 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., with 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 Fewer Axle Single-Trailer Trucks: All vehicles with four or fewer 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 fewer Axle Multi-Trailer Trucks: All vehicles with five or fewer 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.

Note: In reporting information on trucks the following criteria should be used:

- Truck tractor units traveling without a trailer will be considered single-unit trucks.
- A truck tractor unit pulling other such units in a "saddle mount" configuration will be considered one single-unit truck and defined only by the axles on the pulling unit.
- Vehicles are defined by the number of axles in contact with the road, therefore, "floating" axles are counted only when in the down position.
- The term "trailer" includes both semi and full trailers.

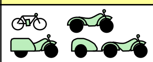
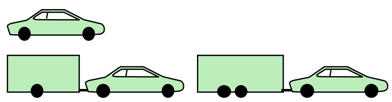
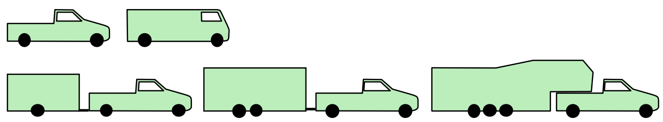
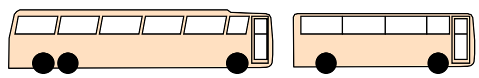
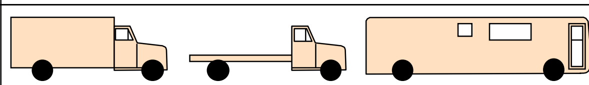
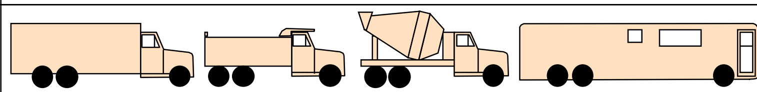
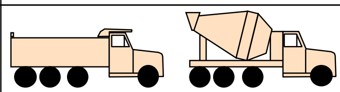
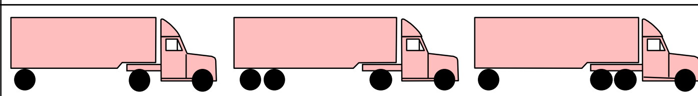
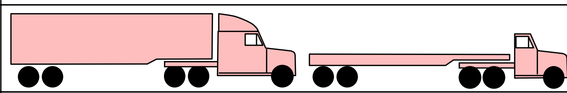
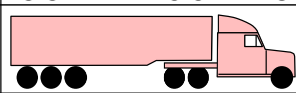
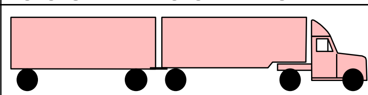
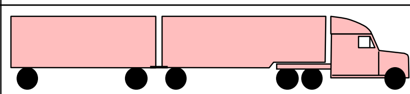
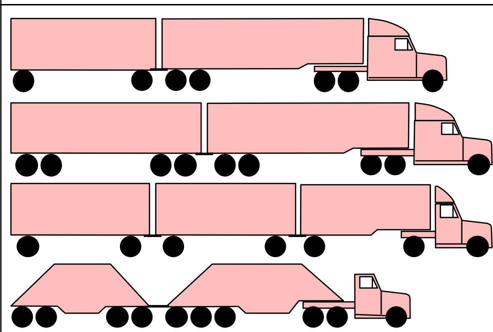
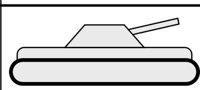
	Class	Schema	Description
Light-weight Vehicles	1		all motorcycles plus two wheel axles
	2		all cars plus one/two axle trailers
	3		all pickups and vans single/dual wheels plus one/two/three axle trailers
Single Unit Vehicles	4		buses single/dual wheels
	5		two axle, single unit single/dual wheels
	6		three axle, single unit
	7		four axle, single unit
Combination Unit Vehicles	8		four or less axles, single trailers
	9		five axles, single trailers
	10		six or more axles, single trailers
	11		five or less axles, multi-trailers
	12		six axles, multi-trailers
	13		seven or more axles, multi-trailers
Unclassified Vehicles	14		Unclassifiable vehicle
	15		Not used

Figure 3.4 CDOT Vehicle Classifications

For M-E Design, the vehicle class distribution inputs can be defined at three hierarchical input levels. See **Figure 3.5 M-E Design Software Screenshot of Vehicle Class Distribution**. The three input levels are described in the following sections.

3.1.6.1 Level 1 Vehicle Class Inputs

Level 1 inputs are the actual measured site data (over 24-hours) and must be used for highways with heavy seasonal and atypical traffic. This data can be obtained from the CDOT DTD.

3.1.6.2 Level 2 Vehicle Class Inputs

Level 2 inputs are the regional average values determined from traffic analyses of data from various WIM and AVC sites in Colorado. The traffic data analyses indicated three vehicle class distribution clusters defined according to location and highway functional class. The descriptions of vehicle class clusters are presented as follows, refer to **Table 3.5 Class 5 and Class 9 Distribution per Cluster Type):**

- **Cluster 1**: This distribution had one large primary peak for Class 5 vehicles with percentage ranging from 40 to 75. There was a secondary peak for Class 8 and 9 trucks with percentage ranging from 10 to 30 percent. The main highway functional class was 4-lane rural principal arterials (non-interstate, US highways and state routes), and a few sections of urban freeways.

- **Cluster 2**: This distribution had two distinct peaks for Class 5 and 9 vehicles. The percentage of Class 5 ranged from 5 to 35 and the percentage of Class 9 ranged from 40 to 80. The main highway functional class was 4-lane rural principal arterial, interstate, and highways.

- **Cluster 3**: This distribution had two distinct peaks for Class 5 and 9 vehicles with percentages of each class ranging from 15 to 50, with Class 9 trucks having a slightly higher percentage than other truck types. The main highway functional classes were 2-lane rural principal arterials (other), 2-lane rural major collectors, and 4-lane urban principal arterials.

Table 3.5 Class 5 and Class 9 Distribution Per Cluster Type

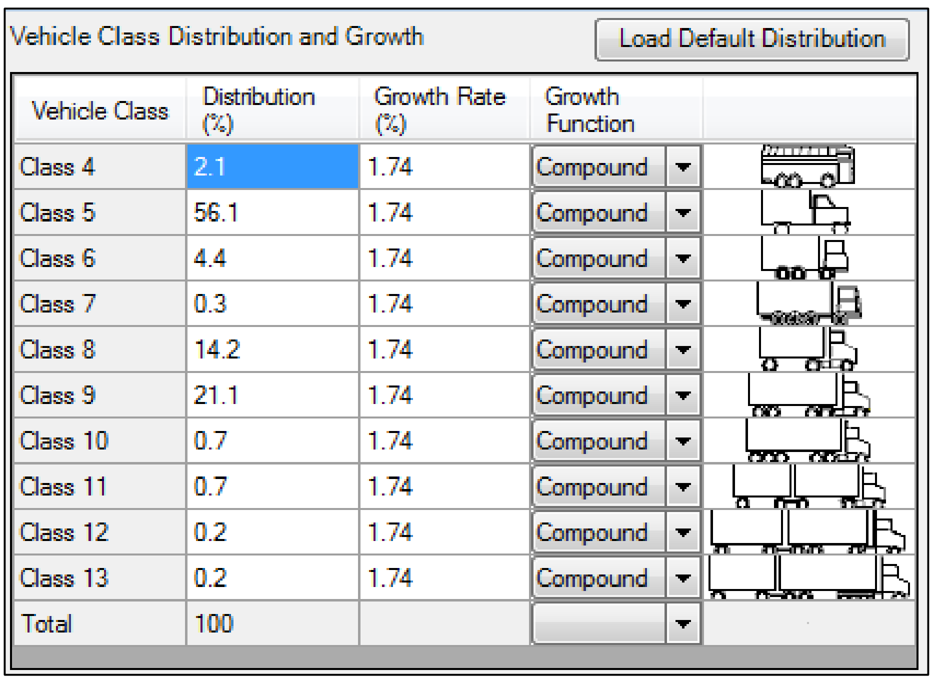
Cluster	Class 5 Distribution (%)	Class 9 Distribution (%)	Most Common Highway Functional Class
Cluster 1	40-75	10-30	• 4-lane rural principal arterial (non-interstate) • A few urban freeways
Cluster 2	5-35	40-80	• 4-lane rural principal arterial (other) • Interstate highways
Cluster 3	15-50	15-50	• 2-lane rural principal arterial (other) • 2-lane rural major collector • 4-lane urban principal arterial

As a minimum, selection of the appropriate cluster type must be based on project location as shown in **Table 3.6 Level 2 Vehicle Class Distribution Factors** and **Figure 3.6 Vehicle Class Distribution Factors for CDOT Clusters**. Designers must choose the default vehicle class distribution for the cluster that most closely describes the design traffic stream for the roadway under design.

3.1.6.3 Level 3 Vehicle Class Inputs

For situations, where CDOT clusters are not suitable and Level 1 data is not available, designers may use an appropriate default Truck Traffic Class (TTC) group in the M-E Design software. TTC factors were developed using traffic data from over a 100 WIM and AVC sites located nationwide. The data was obtained from FHWA LTPP program data.

Designers may select the most appropriate from seventeen TTC groups that best describe the truck traffic mix of a given project. **Figure 3.7 Truck Traffic Classification Groups** presents a screenshot of the seventeen TTC groups and their descriptions in the M-E Design software.


Vehicle Class Distribution and Growth
Load Default Distribution

Vehicle Class	Distribution (%)	Growth Rate (%)	Growth Function
Class 4	2.1	1.74	Compound
Class 5	56.1	1.74	Compound
Class 6	4.4	1.74	Compound
Class 7	0.3	1.74	Compound
Class 8	14.2	1.74	Compound
Class 9	21.1	1.74	Compound
Class 10	0.7	1.74	Compound
Class 11	0.7	1.74	Compound
Class 12	0.2	1.74	Compound
Class 13	0.2	1.74	Compound
Total	100		

Figure 3.5 M-E Design Software Screenshot of Vehicle Class Distribution

Table 3.6 Level 2 CDOT Vehicle Class Distribution Factors

Vehicle Class	Cluster 1 (Predominately Class 5)	Cluster 2 (Predominately Class 9)	Cluster 3 (Predominately Class 5 and 9)
	4-Lane Rural Principal Arterial (Non-Interstate)	4-Lane Rural Principal Arterial (Interstates and Highways)	2-Lane Rural Principal Arterial (other) 2-Lane Rural Major Collector 4-Lane Urban Principal Arterial
4	2.1	2.7	5.1
5	56.1	19.3	32.3
6	4.4	4.5	18
7	0.3	0.3	0.3
8	14.2	4.6	4.9
9	21.1	61.9	36.8
10	0.7	1.6	1.2
11	0.7	2.7	0.7
12	0.2	1.3	0.5
13	0.2	1.1	0.2

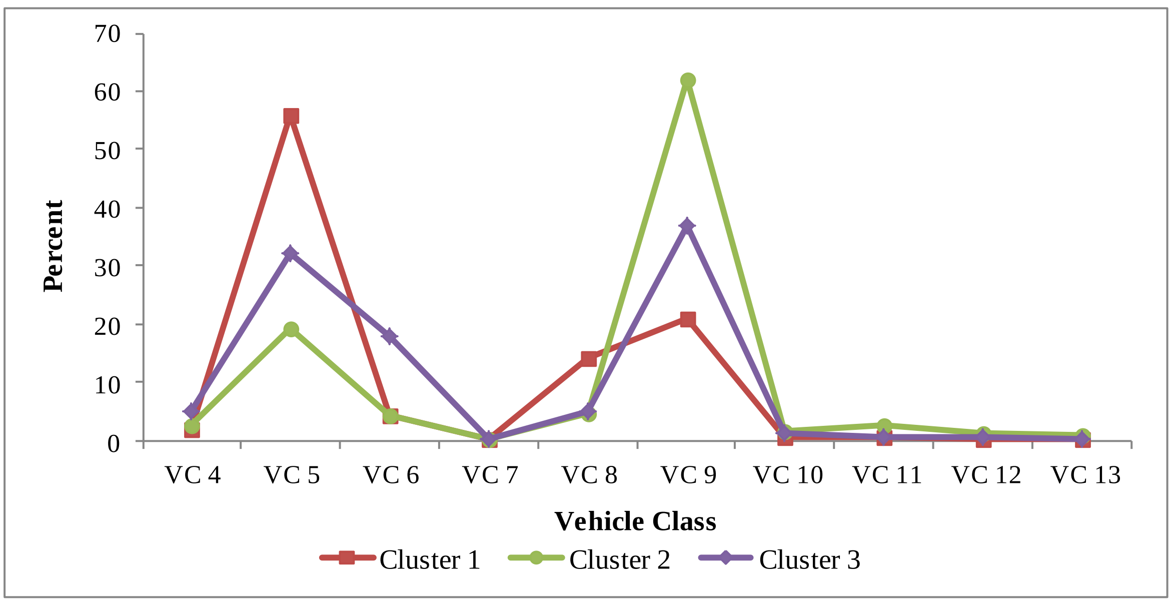
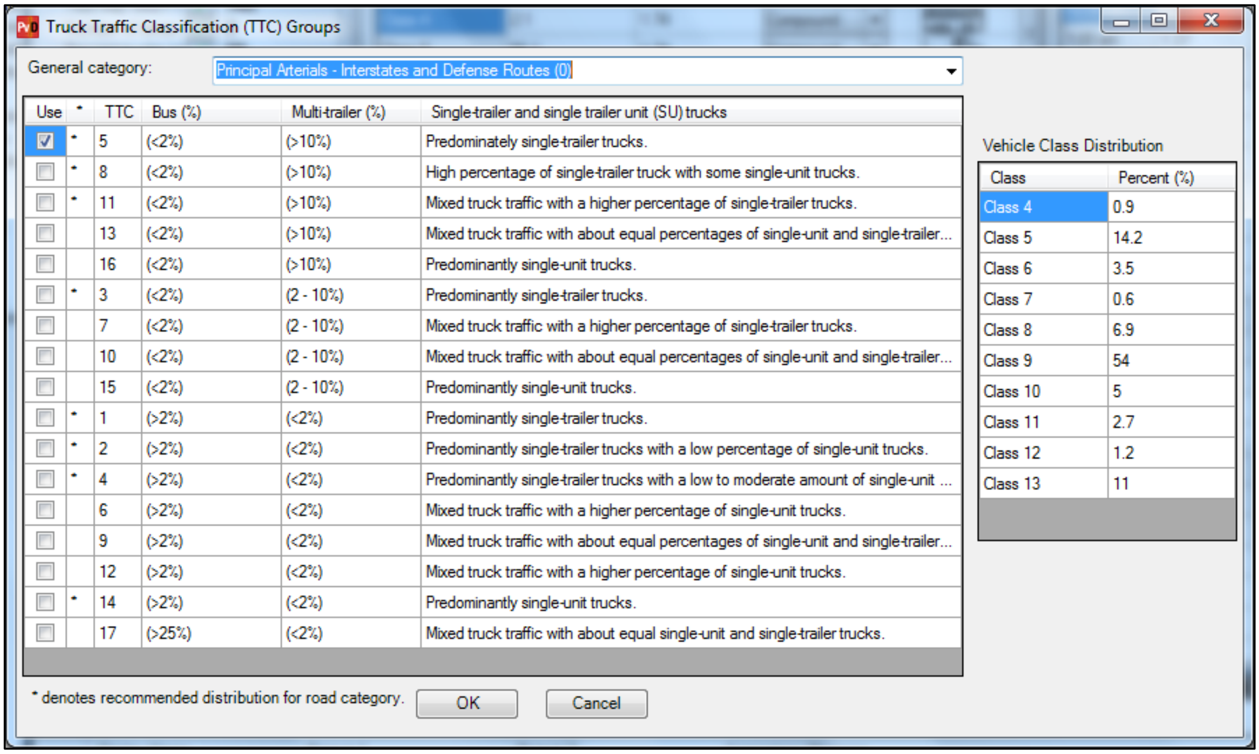


Figure 3.6 Vehicle Class Distribution Factors for CDOT Clusters



Truck Traffic Classification (TTC) Groups

General category: Principal Arterials - Interstates and Defense Routes (0)

Use	*	TTC	Bus (%)	Multi-trailer (%)	Single-trailer and single trailer unit (SU) trucks
☑	*	5	(<2%)	(>10%)	Predominately single-trailer trucks.
☐	*	8	(<2%)	(>10%)	High percentage of single-trailer truck with some single-unit trucks.
☐	*	11	(<2%)	(>10%)	Mixed truck traffic with a higher percentage of single-trailer trucks.
☐		13	(<2%)	(>10%)	Mixed truck traffic with about equal percentages of single-unit and single-trailer...
☐		16	(<2%)	(>10%)	Predominantly single-unit trucks.
☐	*	3	(<2%)	(2 - 10%)	Predominantly single-trailer trucks.
☐		7	(<2%)	(2 - 10%)	Mixed truck traffic with a higher percentage of single-trailer trucks.
☐		10	(<2%)	(2 - 10%)	Mixed truck traffic with about equal percentages of single-unit and single-trailer...
☐		15	(<2%)	(2 - 10%)	Predominantly single-unit trucks.
☐	*	1	(>2%)	(<2%)	Predominantly single-trailer trucks.
☐	*	2	(>2%)	(<2%)	Predominantly single-trailer trucks with a low percentage of single-unit trucks.
☐	*	4	(>2%)	(<2%)	Predominantly single-trailer trucks with a low to moderate amount of single-unit ...
☐		6	(>2%)	(<2%)	Mixed truck traffic with a higher percentage of single-unit trucks.
☐		9	(>2%)	(<2%)	Mixed truck traffic with about equal percentages of single-unit and single-trailer...
☐		12	(>2%)	(<2%)	Mixed truck traffic with a higher percentage of single-unit trucks.
☐	*	14	(>2%)	(<2%)	Predominantly single-unit trucks.
☐		17	(>25%)	(<2%)	Mixed truck traffic with about equal single-unit and single-trailer trucks.

Vehicle Class Distribution

Class	Percent (%)
Class 4	0.9
Class 5	14.2
Class 6	3.5
Class 7	0.6
Class 8	6.9
Class 9	54
Class 10	5
Class 11	2.7
Class 12	1.2
Class 13	11

* denotes recommended distribution for road category.

OK Cancel

Figure 3.7 Truck Traffic Classification Groups

3.1.7 Number of Axles per Truck

This input represents the average number of axles for each truck class (FHWA vehicle Class 4 to 13) and each axle type (single, tandem, tridem, and quad). For the M-E Design, the number of axles per truck can be defined at three hierarchical input levels. **Figure 3.8 M-E Design Screenshot of Number of Axles Per Truck** presents the M-E Design software screenshot for the number of axles per truck. Three input levels are described in the following sections.

3.1.7.1 Level 1 Number of Axles Per Truck

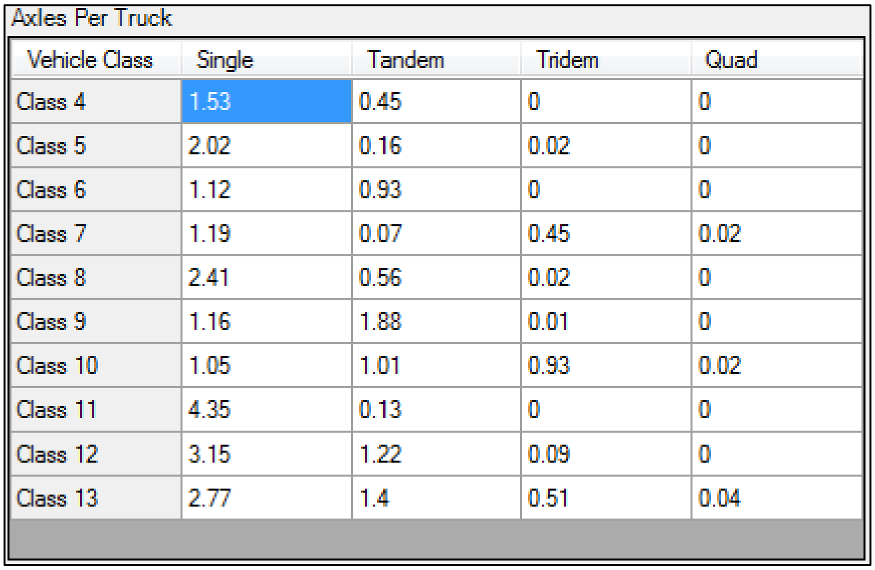
Level 1 inputs are the actual measured site data and must be used for highways with heavy seasonal and atypical traffic. This data can be obtained from the CDOT DTD.

3.1.7.2 Level 2 Number of Axles Per Truck

Level 2 inputs are the statewide average values determined from traffic analyses of data from various WIM and AVC sites in Colorado. Refer to **Table 3.7 Level 2 Number of Axles Per Truck** for CDOT statewide averages.

3.1.7.3 Level 3 Number of Axles Per Truck

Level 3 inputs are the M-E Design software defaults. This level is not recommended.



Axles Per Truck

Vehicle Class	Single	Tandem	Tridem	Quad
Class 4	1.53	0.45	0	0
Class 5	2.02	0.16	0.02	0
Class 6	1.12	0.93	0	0
Class 7	1.19	0.07	0.45	0.02
Class 8	2.41	0.56	0.02	0
Class 9	1.16	1.88	0.01	0
Class 10	1.05	1.01	0.93	0.02
Class 11	4.35	0.13	0	0
Class 12	3.15	1.22	0.09	0
Class 13	2.77	1.4	0.51	0.04

Figure 3.8 M-E Design Screenshot of Number of Axles Per Truck

Table 3.7 Level 2 Number of Axles Per Truck

Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
4	1.53	0.45	0.00	0.00
5	2.02	0.16	0.02	0.00
6	1.12	0.94	0.00	0.00
7	1.19	0.07	0.45	0.02
8	2.41	0.56	0.02	0.00
9	1.16	1.90	0.01	0.00
10	1.15	1.01	0.93	0.02
11	4.35	0.29	0.02	0.00
12	3.27	1.22	0.09	0.00
13	2.77	1.40	0.51	0.04

3.1.8 Monthly Adjustment Factors (Trucks)

Truck traffic monthly adjustment factors represent the proportion of the annual truck traffic for a given truck class that occurs in a specific month. The sum of monthly factors for all months for each vehicle class must equal 12. These monthly distribution factors may be determined from WIM, AVC, or manual truck traffic counts. Axle data shall come from CDOT's data base.

For the M-E Design, the monthly adjustment factors can be defined at three hierarchical input levels, see **Figure 3.9 M-E Design Screenshot of Monthly Adjustment Factors**. The input levels are described in the following sections.

3.1.8.1 Level 1 Monthly Adjustment Factors

Level 1 inputs are the actual measured site data and must be used for highways with heavy seasonal and atypical traffic. This data can be obtained from the CDOT DTD.

3.1.8.2 Level 2 Monthly Adjustment Factors

Level 2 inputs are the statewide average values determined from traffic analyses of data from various WIM and AVC sites in Colorado. Refer to **Table 3.8 Level 2 Monthly Adjustment Factors** for Level 2 averages. The axle data and clusters shall come from CDOT's data base.

3.1.8.3 Level 3 Monthly Adjustment Factors

Level 3 inputs are the M-E Design software defaults. This level is not recommended for use on CDOT projects

Table 3.8 Level 2 Monthly Adjustment Factors

Month	Vehicle/Truck Class									
	4	5	6	7	8	9	10	11	12	13
Jan	0.885	0.820	0.765	0.745	0.822	0.930	0.889	0.905	0.918	0.862
Feb	0.899	0.824	0.782	0.771	0.873	0.938	0.888	0.888	0.976	0.830
Mar	0.963	0.900	0.843	1.066	0.993	0.990	0.997	0.983	0.919	0.925
Apr	1.037	1.007	0.941	1.023	1.009	1.029	1.060	0.987	1.031	1.050
May	1.078	1.102	1.030	1.266	1.095	1.043	1.088	1.091	1.123	0.999
Jun	1.054	1.147	1.203	1.149	1.146	1.029	1.067	0.976	1.083	1.035
Jul	1.103	1.209	1.467	1.279	1.175	0.995	1.090	1.057	1.082	1.255
Aug	1.117	1.158	1.275	1.034	1.148	1.049	1.089	1.101	1.055	0.968
Sep	1.064	1.114	1.116	1.032	1.050	1.041	1.066	1.070	0.976	1.081
Oct	1.029	1.011	0.966	0.979	0.985	1.043	1.017	1.031	0.944	1.103
Nov	0.912	0.906	0.857	0.862	0.879	1.004	0.951	0.998	1.001	1.031
Dec	0.859	0.802	0.755	0.794	0.825	0.909	0.798	0.913	0.892	0.861

Monthly Adjustment | Import Monthly Adjustmen

Month	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13
January	0.885	0.82	0.765	0.745	0.822	0.93	0.889	0.905	0.918	0.862
February	0.899	0.824	0.782	0.771	0.873	0.938	0.888	0.888	0.976	0.83
March	0.963	0.9	0.843	1.066	0.993	0.99	0.997	0.983	0.919	0.925
April	1.037	1.007	0.941	1.023	1.009	1.029	1.06	0.987	1.031	1.05
May	1.078	1.102	1.03	1.266	1.095	1.043	1.088	1.091	1.123	0.999
June	1.054	1.147	1.203	1.149	1.146	1.029	1.067	0.976	1.083	1.035
July	1.103	1.209	1.467	1.279	1.175	0.995	1.09	1.057	1.082	1.255
August	1.117	1.158	1.275	1.034	1.148	1.049	1.089	1.101	1.055	0.968
Septem...	1.064	1.114	1.116	1.032	1.05	1.041	1.066	1.07	0.976	1.081
October	1.029	1.011	0.966	0.979	0.985	1.043	1.017	1.031	0.944	1.103
Novem...	0.912	0.906	0.857	0.862	0.879	1.004	0.951	0.998	1.001	1.031
Decem...	0.859	0.802	0.755	0.794	0.825	0.909	0.798	0.913	0.892	0.861

Figure 3.9 M-E Design Screenshot of Monthly Adjustment Factors

3.1.9 Hourly Distribution Factors (Trucks)

The hourly distribution factors represent the percentage of the total truck traffic within each hour of the day and are required for the analysis of only rigid pavements. Site-specific hourly distribution factors may be estimated from WIM, AVC, or manual truck traffic counts.

For the M-E Design, the hourly distribution factors can be defined at three hierarchical input levels. The three input levels are described in the following sections.

3.1.9.1 Level 1 Hourly Distribution Factors

Level 1 inputs are the actual measured site data and must be used for highways with heavy seasonal and atypical traffic. This data can be obtained from the CDOT DTD.

3.1.9.2 Level 2 Hourly Distribution Factors

Level 2 inputs are the statewide average values determined from traffic analyses of data from various WIM and AVC sites in Colorado. Refer to **Table 3.9 Hourly Distribution Factor**s and **Figure 3.10 Level 2 hourly Distribution Factors for Level 2 Averages**. The axle data and clusters shall come from CDOT's database.

3.1.9.3 Level 3 Hourly Distribution Factors

Level 3 inputs are the M-E Design software defaults. This level is not recommended.

Table 3.9 Hourly Distribution Factors

Time Period	Distribution, percent	Time Period	Distribution, percent
12:00 a.m. - 1:00 a.m.	1.65	12:00 p.m. - 1:00 p.m.	6.75
1:00 a.m. - 2:00 a.m.	1.37	1:00 p.m. - 2:00 p.m.	6.81
2:00 a.m. - 3:00 a.m.	1.28	2:00 p.m. - 3:00 p.m.	6.83
3:00 a.m. - 4:00 a.m.	1.36	3:00 p.m. - 4:00 p.m.	6.56
4:00 a.m. - 5:00 a.m.	1.66	4:00 p.m. - 5:00 p.m.	6.02
5:00 a.m. - 6:00 a.m.	2.32	5:00 p.m. - 6:00 p.m.	5.23
6:00 a.m. - 7:00 a.m.	3.80	6:00 p.m. - 7:00 p.m.	4.35
7:00 a.m. - 8:00 a.m.	4.95	7:00 p.m. - 8:00 p.m.	3.59
8:00 a.m. - 9:00 a.m.	5.90	8:00 p.m. - 9:00 p.m.	2.98
9:00 a.m. - 10:00 a.m.	6.48	9:00 p.m. - 10:00 p.m.	2.56
10:00 a.m. – 11:00 a.m.	6.83	10:00 p.m. - 11:00 p.m.	2.12
11:00 a.m. – 12:00 p.m.	6.85	11:00 p.m. - 12:00 a.m.	1.75

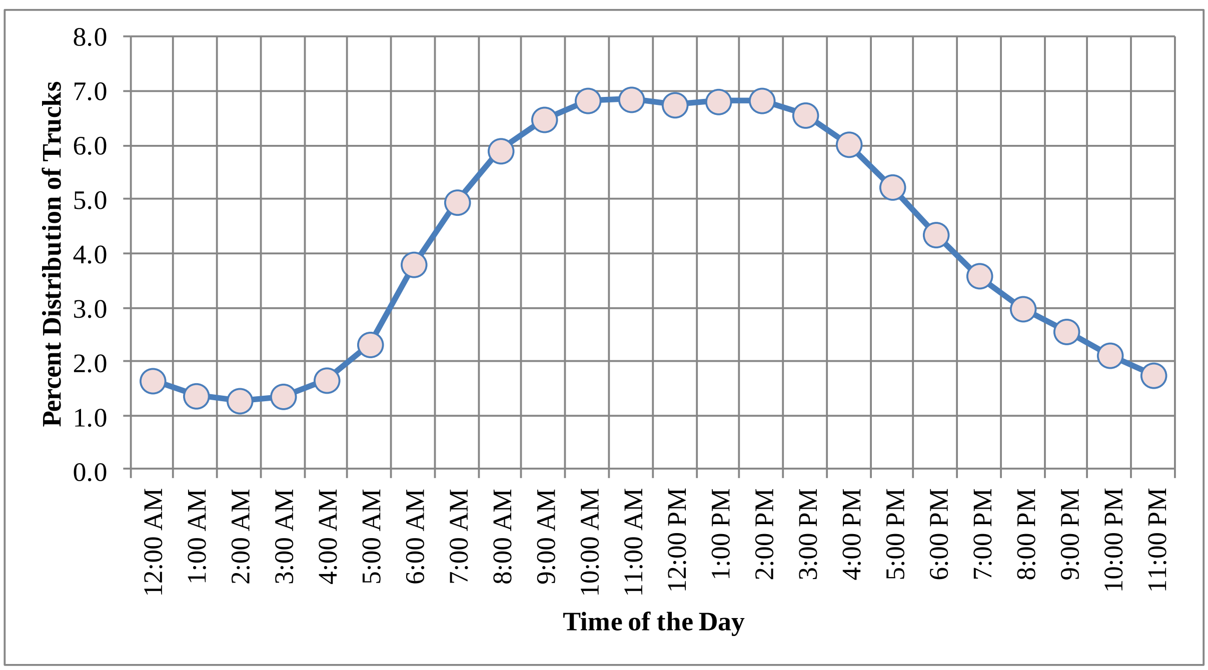


Figure 3.10 Level 2 Hourly Distribution Factors

3.1.10 Axle Load Distribution

The axle load distribution factors represent the percentage of the total axle applications within each load interval for a specific axle type (single, tandem, tridem, and quad) and vehicle class (Classes 4 through 13). A definition of load intervals for each axle type is provided below:

- **Single Axles:** 3,000 lb to 40,000 lb at 1,000-lb intervals
- **Tandem Axles**: 6,000 lb to 80,000 lb at 2,000-lb intervals
- **Tridem and Quad Axles**: 12,000 lb to 102,000 lb at 3,000-lb intervals. Developing site-specific axle load distribution factors involves the processing of a massive amount of WIM data. The processing should be completed external to the M-E Design software using traffic loading analysis software.

For M-E Design, the axle load distribution factors can be defined at three hierarchial input levels. See **Figure 3.11 Single Axle Distribution in the M-E Design Software** for a screenshot of axle load distribution factors in the M-E Design software. The input levels are described in the following sections.

3.1.10.1 Level 1 Axle Load Distribution Factors

Level 1 inputs are the actual measured site data and must be used for highways with unique traffic characteristics and heavy haul routes (i.e. mining, lumber, and agricultural routes). This data can be obtained from the CDOT DTD.

3.1.10.2 Level 2 Axle Load Distribution Factors

Level 2 inputs are the statewide average values determined from traffic analyses of data from various WIM and AVC sites in Colorado. **Table 3.10 Level 2 Axle Load Distribution Factors (Percentages)** through **Table 3.13 Level 2 Quad Axle Load Distribution Factors (Percentages),** presents the CDOT averages of axle load distribution factors for single, tandem, tridem and quad axles for each truck class, respectively. The axle data and clusters shall come from CDOT's data base.

Figure 3.12 CDOT Averages of Single Axle Load Distribution (Classes 5 and 9 only) presents the load distributions of single axles for vehicle Classes 5 and 9. **Figure 3.13 CDOT Averages of Tandem Axle Load Distribution (Classes 5 and 9 only)** presents the load distributions of tandem axles for vehicle Classes 5 and 9. Electronic versions of the Level 2 axle load distributions factors can be obtained from the CDOT Pavement Design office.

3.1.10.3 Level 3 Axle Load Distribution Factors

Level 3 inputs are the M-E Design software defaults. This level is not recommended for use on CDOT projects.

25-10326:Single

Month	Class	Total	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000	13000	140
January	4	99.97	0.28	0.73	1.77	5.18	8.12	12.73	10.08	11.45	9.11	9.81	6.59	7.11
January	5	100.01	3.69	9.71	14.2	17.72	12.56	11.97	7.19	6.2	3.63	3.19	1.71	1.93
January	6	100.02	2.73	2.86	3.85	4.77	4.61	7.48	9.46	14.63	11.36	10.35	5.42	5.76
January	7	100.01	3.78	3.45	2.25	2.75	3.07	3.85	3.32	6.38	7.33	8.54	6.63	6.61
January	8	100.01	7.61	6.63	7.1	8.63	8.44	11.24	9.57	10.41	6.57	5.67	3.15	3.56
January	9	100.02	1.42	2.5	2.93	3.43	3.39	5.89	9.34	18.41	17.14	14.29	5.72	4.49
January	10	99.99	0.92	1.23	1.93	3.3	3.66	6.43	9.17	16.61	15.03	13.75	6.74	6.86
January	11	100.02	1.69	2.17	3.87	6.46	6.14	7.89	8.72	12.31	9.15	8.6	5.12	6.85
January	12	99.98	2.2	3.48	5.08	7.98	7.27	10.22	11.02	14	9.32	8.24	4.47	5
January	13	100.01	3.13	3.18	3.4	6.19	5.25	7.45	7.88	9.91	7.39	8.07	5.02	7.52
February	4	99.99	0.23	0.81	1.74	5.33	8.49	12.67	10.35	11.55	9.15	9.72	6.51	7.1
February	5	100.02	3.98	10.45	15.97	19.7	13.19	11.09	6.08	5.2	2.96	2.58	1.39	1.6
February	6	100.01	2.73	2.85	3.84	4.81	5.06	7.94	9.89	14.79	11.42	10.11	5.22	5.35
February	7	100.03	4.9	1.93	2.27	1.32	4.43	3.99	2.65	4.74	8.66	9.29	7.32	8.44
February	8	99.97	7.33	6.45	7.07	8.51	8.59	11.42	9.48	10.35	6.54	5.62	3.22	3.59
February	9	100	1.47	2.53	2.94	3.44	3.43	6.13	9.36	18.27	16.86	14.31	5.79	4.65
February	10	100	0.97	1.18	1.98	3.36	3.84	6.83	9.38	16.42	14.83	14.36	7.49	6.52
February	11	100.01	0.95	2.18	3.59	6.29	5.7	7.97	8.71	12.13	8.99	8.68	5.57	7.37
February	12	99.99	1.56	2.55	4.06	9.1	7.09	9.61	11.67	12.98	9.67	8.91	4.65	6.85
February	13	99.97	3	3.05	3.24	5.78	4.5	8.1	9.66	9.37	7.94	7.68	5.86	8.8
March	4	100	0.27	0.74	1.61	5.05	7.8	12.35	10.28	11.6	9.29	9.89	6.47	7.27
March	5	100	4.73	10.98	15.79	19.04	12.61	10.96	6.15	5.26	3.02	2.66	1.44	1.63

Figure 3.11 Single Axle Distribution in the M-E Design Software

Table 3.10 Level 2 Single Axle Load Distribution Factors (Percentages)

Mean Axle Load (lbs.)	Vehicle/Truck Class									
	4	5	6	7	8	9	10	11	12	13
3,000	0.24	4.71	2.19	3.49	8.44	1.39	0.76	1.85	1.51	2.59
4,000	0.78	11.26	2.75	3.13	7.28	2.51	1.41	2.11	2.97	3.03
5,000	1.77	16.33	3.98	2.56	7.40	3.00	2.30	3.59	4.66	3.27
6,000	5.24	18.85	5.03	2.64	8.36	3.54	3.49	6.44	8.65	5.20
7,000	8.19	12.49	4.79	2.86	8.10	3.41	3.73	6.09	7.66	4.89
8,000	12.87	10.93	7.67	3.92	10.75	5.87	6.41	8.41	10.14	7.37
9,000	10.32	6.13	9.77	3.87	9.17	9.19	9.18	9.19	11.54	8.06
10,000	11.46	5.22	15.52	5.65	10.06	18.64	17.04	12.53	14.27	10.20
11,000	9.21	2.97	12.24	6.04	6.37	17.62	15.60	9.05	9.77	8.25
12,000	9.87	2.56	10.78	7.46	5.59	14.63	14.47	8.87	8.93	8.60
13,000	6.45	1.39	5.47	6.33	3.07	5.65	7.00	5.49	4.75	5.97
14,000	7.05	1.62	5.52	8.39	3.56	4.26	6.33	6.88	5.34	8.08
15,000	4.78	1.15	3.54	7.22	2.55	2.32	3.63	5.22	3.41	6.20
16,000	2.68	0.69	2.06	5.82	1.55	1.50	1.92	3.20	1.74	3.64
17,000	2.53	0.79	2.15	7.44	1.76	1.64	1.80	3.50	1.70	3.88
18,000	1.56	0.52	1.42	4.57	1.18	1.23	1.05	2.15	0.76	2.19
19,000	1.35	0.51	1.28	4.82	1.15	1.11	0.80	1.84	0.63	1.96
20,000	0.83	0.33	0.79	3.63	0.73	0.68	0.54	1.01	0.35	1.20
21,000	0.76	0.32	0.67	2.78	0.65	0.51	0.51	0.82	0.26	0.94
22,000	0.47	0.21	0.42	1.79	0.38	0.30	0.31	0.40	0.20	0.58
23,000	0.41	0.22	0.36	1.46	0.34	0.23	0.26	0.29	0.18	0.51
24,000	0.23	0.15	0.23	0.76	0.20	0.16	0.22	0.26	0.09	0.42
25,000	0.20	0.16	0.21	0.62	0.19	0.14	0.20	0.14	0.08	0.45
26,000	0.13	0.12	0.15	0.53	0.13	0.09	0.14	0.08	0.05	0.47
27,000	0.11	0.08	0.13	0.60	0.12	0.08	0.13	0.08	0.07	0.29
28,000	0.06	0.03	0.08	0.33	0.07	0.05	0.08	0.06	0.04	0.12
29,000	0.07	0.03	0.08	0.31	0.07	0.04	0.08	0.06	0.04	0.17
30,000	0.06	0.02	0.06	0.30	0.05	0.03	0.06	0.05	0.03	0.10
31,000	0.03	0.02	0.04	0.09	0.04	0.02	0.04	0.03	0.01	0.07
32,000	0.03	0.02	0.04	0.16	0.04	0.02	0.04	0.03	0.01	0.08
33,000	0.02	0.01	0.03	0.11	0.03	0.01	0.03	0.02	0.01	0.06
34,000	0.02	0.01	0.03	0.05	0.03	0.01	0.05	0.02	0.00	0.09
35,000	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.00	0.03
36,000	0.01	0.01	0.02	0.01	0.02	0.01	0.03	0.01	0.01	0.05
37,000	0.01	0.00	0.02	0.04	0.02	0.00	0.01	0.01	0.00	0.03
38,000	0.01	0.01	0.02	0.02	0.02	0.00	0.01	0.02	0.00	0.05
39,000	0.00	0.00	0.01	0.01	0.01	0.00	0.02	0.00	0.00	0.03
40,000	0.00	0.00	0.01	0.03	0.02	0.00	0.01	0.00	0.00	0.02
41,000	0.14	0.14	0.42	0.16	0.45	0.09	0.31	0.18	0.11	0.89

Table 3.11 Level 2 Tandem Axle Load Distribution Factors (Percentages)

Mean Axle Load, lbs.	Vehicle/Truck Class									
	4	5	6	7	8	9	10	11	12	13
6,000	0.41	38.29	2.94	12.80	18.36	3.21	0.90	4.34	2.19	3.22
8,000	1.51	24.51	7.75	2.15	9.01	5.20	1.57	1.62	3.19	3.76
10,000	2.68	16.41	12.42	3.45	9.79	7.57	3.08	3.78	4.89	5.06
12,000	4.17	8.75	12.11	3.65	10.51	8.61	5.30	6.50	9.15	7.11
14,000	4.46	4.66	9.72	3.15	10.15	8.29	7.08	13.11	10.75	8.50
16,000	4.82	2.61	7.83	0.70	8.39	7.24	8.17	8.03	11.61	8.73
18,000	6.53	1.60	6.30	2.20	6.65	6.08	8.73	8.03	12.58	8.04
20,000	8.19	1.03	5.26	0.65	5.50	5.21	8.66	8.31	12.86	7.51
22,000	9.39	0.71	4.49	3.40	4.33	4.74	8.02	9.39	10.78	7.33
24,000	10.04	0.49	3.86	4.00	3.33	4.50	7.08	9.00	8.14	6.27
26,000	9.41	0.31	3.47	6.15	2.41	4.53	6.35	8.10	5.33	5.05
28,000	8.81	0.21	3.20	2.10	1.83	4.77	6.00	6.46	3.37	4.19
30,000	8.53	0.14	3.32	4.35	1.60	5.41	5.67	4.88	2.06	4.46
32,000	6.48	0.08	2.94	3.15	1.19	5.40	4.73	2.95	0.97	3.34
34,000	4.95	0.05	2.71	5.85	1.08	5.48	4.21	2.16	0.55	2.91
36,000	3.51	0.03	2.48	5.85	0.97	4.66	3.51	1.02	0.33	2.83
38,000	2.10	0.02	2.15	7.55	0.88	3.28	2.54	0.61	0.34	2.16
40,000	1.29	0.02	1.74	6.05	0.74	2.01	1.99	0.44	0.27	2.17
42,000	0.78	0.01	1.39	4.00	0.60	1.20	1.64	0.32	0.15	1.34
44,000	0.52	0.01	1.05	2.50	0.50	0.77	1.10	0.19	0.09	0.83
46,000	0.37	0.01	0.75	3.85	0.39	0.52	0.81	0.09	0.04	0.84
48,000	0.26	0.00	0.52	1.20	0.30	0.36	0.70	0.09	0.12	0.93
50,000	0.19	0.00	0.37	1.60	0.23	0.26	0.53	0.08	0.03	0.62
52,000	0.13	0.02	0.34	4.15	0.19	0.19	0.37	0.05	0.02	0.87
54,000	0.11	0.01	0.24	1.15	0.15	0.14	0.26	0.04	0.02	0.31
56,000	0.08	0.01	0.18	1.40	0.13	0.10	0.20	0.05	0.04	0.28
58,000	0.05	0.00	0.12	0.15	0.11	0.07	0.16	0.03	0.01	0.23
60,000	0.04	0.00	0.08	1.00	0.08	0.05	0.15	0.03	0.02	0.15
62,000	0.03	0.00	0.06	0.75	0.07	0.04	0.11	0.07	0.01	0.12
64,000	0.02	0.00	0.05	0.60	0.05	0.03	0.07	0.02	0.00	0.22
66,000	0.01	0.00	0.03	0.00	0.05	0.02	0.05	0.01	0.00	0.09
68,000	0.01	0.00	0.03	0.00	0.03	0.02	0.10	0.01	0.00	0.11
70,000	0.01	0.00	0.01	0.00	0.03	0.01	0.03	0.01	0.00	0.04
72,000	0.00	0.00	0.02	0.40	0.02	0.01	0.03	0.01	0.00	0.05
74,000	0.01	0.00	0.01	0.00	0.03	0.01	0.01	0.01	0.00	0.05
76,000	0.00	0.00	0.01	0.00	0.02	0.00	0.02	0.01	0.00	0.03
78,000	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.02
80,000	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.02
82,000	0.05	0.00	0.05	0.00	0.23	0.04	0.06	0.16	0.05	0.25

Table 3.12 Level 2 Tridem Axle Load Distribution Factors (Percentages)

Mean Axle Load, lbs.	Vehicle/Truck Class									
	4	5	6	7	8	9	10	11	12	13
12,000	0.00	65.36	0.00	4.82	11.33	38.87	15.53	0.00	19.21	3.20
15,000	0.00	17.43	0.00	3.96	7.69	11.93	10.88	0.00	6.55	4.21
18,000	0.00	8.73	0.00	3.78	9.59	8.99	9.05	0.00	6.99	4.87
21,000	0.00	4.26	0.00	6.28	9.32	5.50	7.23	0.00	14.85	3.31
24,000	0.00	1.65	0.00	3.79	7.83	3.82	6.03	0.00	3.22	2.59
27,000	0.00	0.98	0.00	5.04	7.42	3.24	6.05	0.00	0.63	3.11
30,000	0.00	0.48	0.00	4.84	7.77	2.90	5.79	0.00	3.41	3.75
33,000	0.00	0.24	0.00	5.82	5.88	2.90	5.78	0.00	6.59	4.29
36,000	0.00	0.34	0.00	8.30	5.45	2.93	6.49	0.00	6.02	5.24
39,000	0.00	0.12	0.00	8.19	4.74	2.65	5.87	0.00	5.54	6.88
42,000	0.00	0.11	0.00	9.17	4.17	2.76	5.58	0.00	6.16	7.31
45,000	0.00	0.06	0.00	8.36	3.60	2.52	4.06	0.00	2.33	6.91
48,000	0.00	0.06	0.00	7.35	3.02	2.14	2.71	0.00	5.15	6.34
51,000	0.00	0.06	0.00	4.93	2.75	2.12	2.23	0.00	4.50	6.75
54,000	0.00	0.03	0.00	3.28	1.49	1.67	1.68	0.00	2.97	7.60
57,000	0.00	0.04	0.00	3.77	1.64	1.46	1.36	0.00	2.37	5.84
60,000	0.00	0.01	0.00	1.22	1.32	0.98	1.05	0.00	0.00	5.41
63,000	0.00	0.01	0.00	2.88	0.62	0.60	0.69	0.00	3.23	4.18
66,000	0.00	0.00	0.00	0.86	0.47	0.46	0.53	0.00	0.10	2.55
69,000	0.00	0.00	0.00	0.55	0.49	0.35	0.40	0.00	0.16	1.56
72,000	0.00	0.00	0.00	0.50	0.36	0.25	0.26	0.00	0.00	1.08
75,000	0.00	0.00	0.00	0.46	0.38	0.21	0.22	0.00	0.00	0.78
78,000	0.00	0.00	0.00	0.43	0.57	0.15	0.13	0.00	0.00	0.57
81,000	0.00	0.00	0.00	0.25	0.36	0.13	0.10	0.00	0.00	0.43
84,000	0.00	0.01	0.00	0.42	0.24	0.08	0.08	0.00	0.00	0.34
87,000	0.00	0.00	0.00	0.09	0.12	0.07	0.05	0.00	0.00	0.33
90,000	0.00	0.00	0.00	0.53	0.24	0.06	0.03	0.00	0.00	0.22
93,000	0.00	0.00	0.00	0.01	0.09	0.04	0.02	0.00	0.00	0.11
96,000	0.00	0.00	0.00	0.02	0.09	0.03	0.02	0.00	0.00	0.03
99,000	0.00	0.00	0.00	0.01	0.03	0.01	0.01	0.00	0.00	0.04
102,000	0.00	0.01	0.00	0.10	0.90	0.17	0.06	0.00	0.00	0.18

Table 3.13 Level 2 Quad Axle Load Distribution Factors (Percentages)

Mean Axle Load, lbs.	Vehicle/Truck Class									
	4	5	6	7	8	9	10	11	12	13
12,000	0.00	0.00	0.00	0.00	0.00	41.50	39.41	0.00	0.00	13.63
15,000	0.00	0.00	0.00	3.73	0.00	0.00	6.08	0.00	0.00	3.04
18,000	0.00	0.00	0.00	0.00	0.00	0.00	5.50	0.00	0.00	4.15
21,000	0.00	0.00	0.00	16.67	0.00	0.15	16.55	0.00	0.00	4.46
24,000	0.00	0.00	0.00	0.17	0.00	0.00	0.60	0.00	0.00	19.83
27,000	0.00	0.00	0.00	0.00	0.00	0.00	1.10	0.00	0.00	1.99
30,000	0.00	0.00	0.00	0.00	0.00	0.00	0.78	0.00	47.75	1.84
33,000	0.00	0.00	0.00	0.00	0.00	8.35	1.16	0.00	14.70	5.11
36,000	0.00	0.00	0.00	0.00	0.00	50.00	2.23	0.00	19.35	1.89
39,000	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	13.80	4.63
42,000	0.00	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.00	5.71
45,000	0.00	0.00	0.00	0.00	0.00	0.00	3.04	0.00	0.00	1.21
48,000	0.00	0.00	0.00	15.00	0.00	0.00	2.14	0.00	1.90	3.81
51,000	0.00	0.00	0.00	0.00	0.00	0.00	1.34	0.00	0.00	3.76
54,000	0.00	0.00	0.00	0.00	0.00	0.00	1.39	0.00	0.00	4.01
57,000	0.00	0.00	0.00	0.00	0.00	0.00	1.95	0.00	2.45	1.80
60,000	0.00	0.00	0.00	33.33	0.00	0.00	5.33	0.00	0.00	3.31
63,000	0.00	0.00	0.00	0.00	0.00	0.00	2.20	0.00	0.00	2.49
66,000	0.00	0.00	0.00	14.47	0.00	0.00	3.08	0.00	0.00	3.46
69,000	0.00	0.00	0.00	16.67	0.00	0.00	0.88	0.00	0.00	2.80
72,000	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	1.38
75,000	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	2.04
78,000	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.45
81,000	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.28
84,000	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	1.60
87,000	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03
90,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71
93,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
96,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
99,000	0.00	0.00	0.00	0.00	0.00	0.00	1.61	0.00	0.00	0.00
102,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56

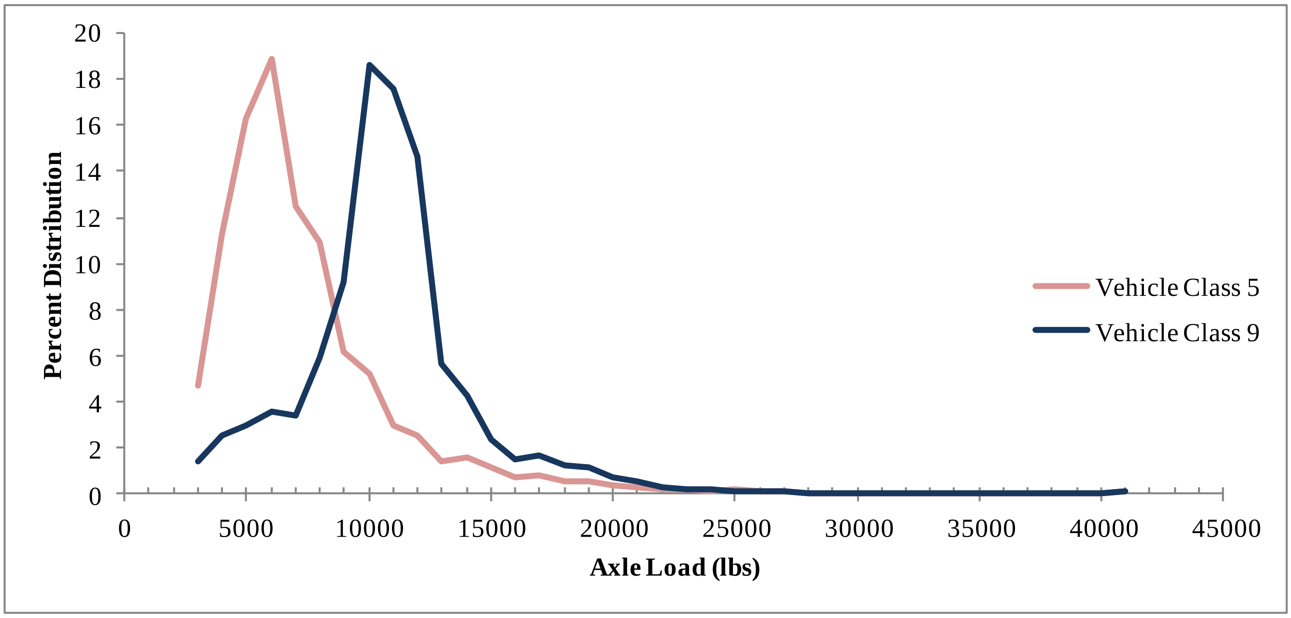


Figure 3.12 CDOT Averages of Single Axle Load Distribution (Classes 5 and 9 only)

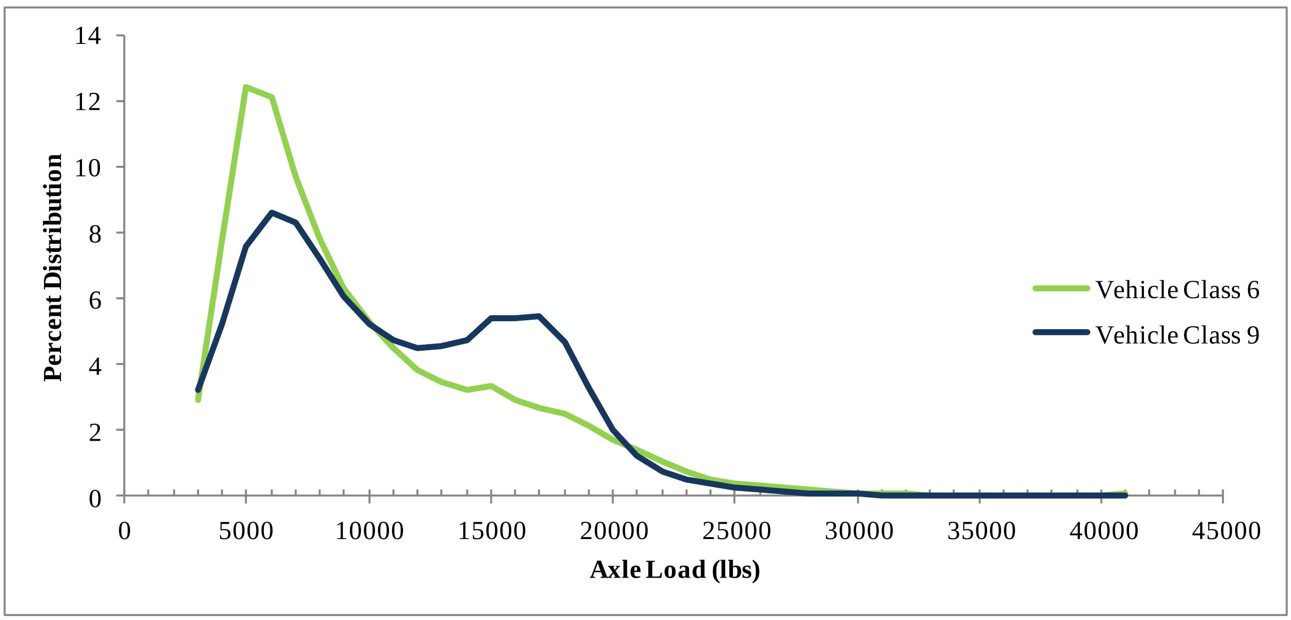


Figure 3.13 CDOT Averages of Tandem Axle Load Distribution (Classes 5 and 9 only)

3.1.11 Vehicle Operational Speed (Trucks)

The vehicle operational speed of trucks or the average travel speed generally depends on many factors, including the roadway facility type (interstate or otherwise), terrain, percentage of trucks in the traffic stream, and so on. Truck speed has a significant impact on the HMA dynamic modulus (E*) and the predicted performance. Lower speeds resulting higher incremental damage, i.e. more fatigue cracking or deeper ruts or faulting. The posted truck speed limit is suggested unless local site conditions, such as a steep upgrade or bus stop, require a lower speed.

3.1.11.1 Lateral Wander of Axle Loads

The inputs required for characterizing lateral wander (see **Figure 3.14 M-E Design Software Screenshot of Traffic Lateral Wander** include the following:

- **Mean Wheel Location:** This is the distance from the outer edge of the wheel to the pavement marking (see **Figure 3.15 Schematic of Mean Wheel Location**). The M-E Design software provides a default value of 18 inches which is recommended unless a measure value is available.

- **Traffic Wander Standard Deviation:** This is the standard deviation of the lateral traffic wander. The wander is used to predict distress and performance by determining the number of axle load applications over a specified point. For standard lane widths, a standard deviation value of 10 inches is suggested unless a measured value is available. A lower or higher lateral wander value is suggested for narrower or wider lanes, respectively.

- **Design Lane Width:** This is the distance between the lane markings on either side of the design lane (see **Figure 3.16 Schematic of Design Lane Width**).

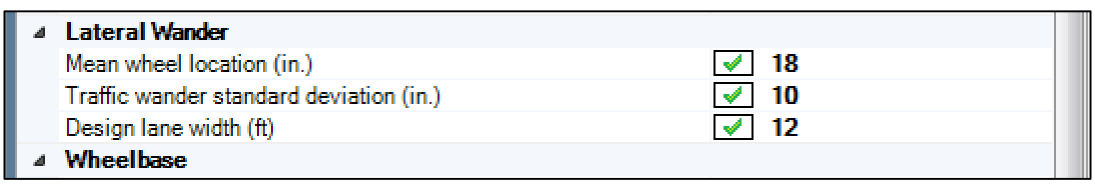


Figure 3.14 M-E Design Software Screenshot of Traffic Lateral Wander

Figure 3.15 Schematic of Mean Wheel Location

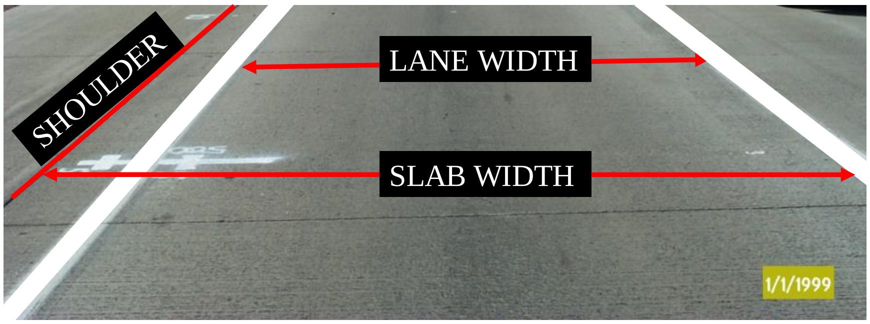


Figure 3.16 Schematic of Design Lane Width

3.1.12   Axle Configuration and Wheelbase

The inputs needed to describe the configurations of the typical tire and axle loads (see **Figure 3.17 Axle Configuration and Wheelbase in the M-E Design Software** and **Figure 3.18 Schematic of Axle Configuration and Wheel Base**) include:

- **Average Axle Width:** This input is the distance between two outside edges of an axle. The recommended value of axle width for trucks is 8.5 feet.

- **Dual Tire Spacing:** This input is the distance between centers of a dual tire. The recommended value of dual tire spacing for trucks is 12 inches.

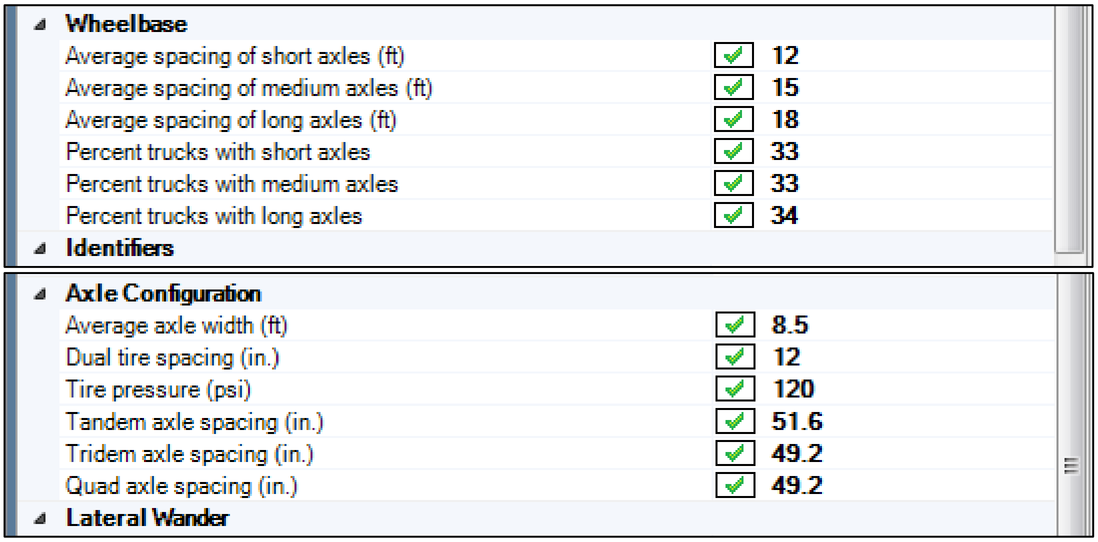


Figure 3.17 Axle Configuration and Wheelbase in the M-E Design Software

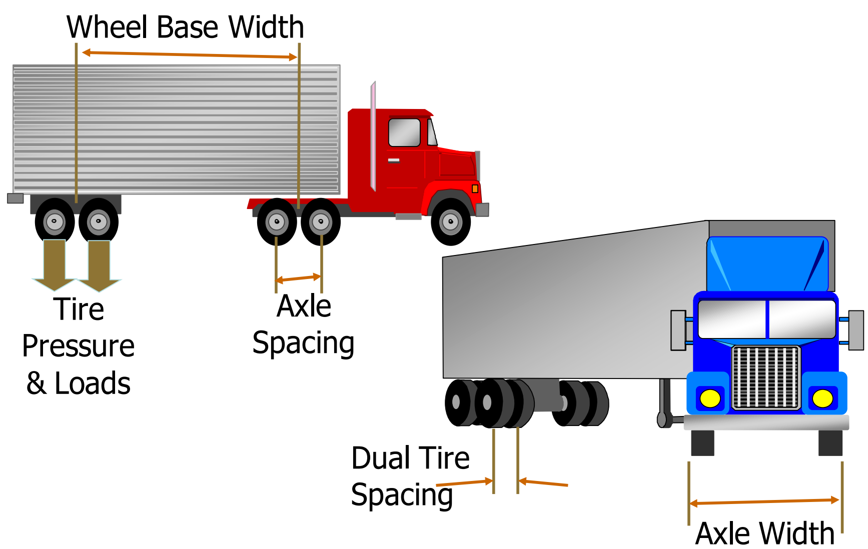


Figure 3.18 Schematic of Axle Configuration and Wheelbase

- **Axle Spacing:** This input is the distance between the two consecutive axles of a tandem, tridem, or quad truck. It is used in determining the number of load applications for JPCP top-down cracking. The spacing of the axles is recorded in the WIM database. These values have been found to be relatively constant for the standard truck classes. The following values are suggested for use unless the predominant truck class has different axle spacing.

    - Tandem axle spacing: 51.6 inches
    - Tridem axle spacing: 49.2 inches
    - Quad axle spacing: 49.2 inches

- **Wheelbase:** This input is the distance between the centers of the front and rear axles. It is used in determining the number of load applications for JPCP top-down cracking. The wheelbase is recorded in the WIM database. The following national averages are suggested for use, unless site-specific wheelbase values are available.
    - Trucks with short spacing (10-13.5 feet): 17.5%
    - Trucks with medium spacing (13.5 to 16.5 feet): 21.6%
    - Trucks with long spacing (16.5 to 20.0 feet): 60.9%

3.1.13 Tire Pressure

Tire pressure may vary with the tire type. A constant value of hot inflation tire pressure representing the average operating conditions should be used. The hot inflation pressure is typically about 10 to 15 percent greater than the cold inflation pressure. A hot inflation tire pressure value of 120 psi is suggested for use unless a special loading condition is simulated.

3.1.14 Traffic Files in Electronic Format for the M-E Design Software

Designers can create their own traffic input files in electronic formats by directly inputting the data using the traffic input interface of the M-E Design software. This is not recommended for most of the required inputs with exceptions for simple inputs such as AADTT, growth rate, etc.

For more complex input types such as the axle load distribution or axles per truck, the designers can add Level 1 and 2 inputs in electronic format from the CDOT DTD. Level 3 input data can be retrieved directly from the M-E Design software.

3.2 Climate

Climate data for the M-E Design software is obtained from weather stations located throughout the state. Information from these stations (temperature, precipitation, wind speed, percent sunshine, and relative humidity) are used to predict the temperature and moisture profiles within the pavement structure. In addition, the M-E Design software requires the depth to groundwater table (GWT) as an input. **Note:** The GWT depth value entered in the M-E Design software is the depth below the final pavement surface.

For critical designs, the GWT data can be obtained from Colorado Division of Water Resources database, United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, or project-specific soil borings. For non-critical designs, one should guestimate the GWT depth based on designer’s experience.

3.2.1 Creating Project Specific Climate Input Files

The M-E Design software will identify the six closest weather stations for a given project location based on its geographic coordinates. Designers can select one or more weather stations based on the proximity to the project location. A single weather station can be selected when the project is within reasonable proximity, or up to six surrounding weather stations can be selected and combined into a virtual weather station. The software does this automatically after selection by the user. Proximity is defined in terms of both distance and elevation. The recommendations for selecting climatic inputs are presented in **Table 3.14 Recommendations for Climatic Inputs**. A screenshot of the climate tab from the M-E Design software is presented in **Figure 3.19 Climate Tab in the M-E Design Software**.

Climate data is currently available for 42 weather stations in Colorado, see **Figure 3.20 Location of Colorado Weather Stations**. Weather stations located near the border of neighboring states (Utah, Wyoming, Nebraska, New Mexico, Oklahoma, Kansas and Arizona) can be used. **Table 3.14 Geographic Coordinates and Data Availability of Colorado Weather Stations** presents the geographic coordinates of Colorado Weather stations, including start and end dates of available hourly weather records.

Table 3.14 Recommendations for Climatic Inputs

Climate Inputs	Recommendations
Weather Station ≤ 50 Miles	Import specific weather station
Weather Station >50 Miles	Create a virtual weather station that includes two or more surrounding weather stations
Depth of Water Table (feet)	Actual depth may be found in County Soil Reports[1], project geotechnical reports, or an estimate based on the area. The depth of the water table typically ranges from 3 to 100 feet.
Note: [1] The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database. Another available resource for estimating depth of water table for a project site is the Colorado Division of Water Resources database and geologic well logs available online at http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/geo/.	

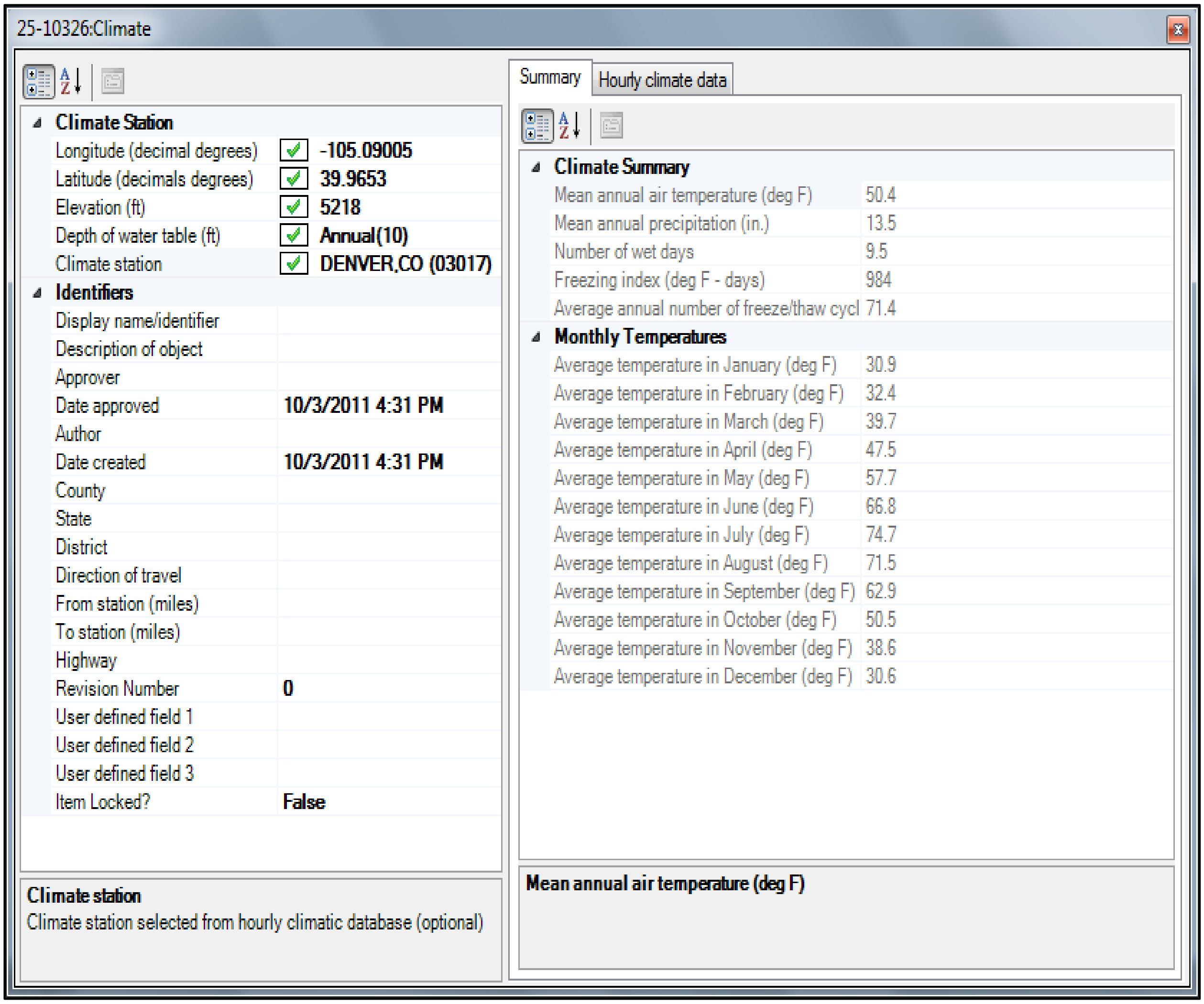


Figure 3.19 Climate Tab in the M-E Design Software

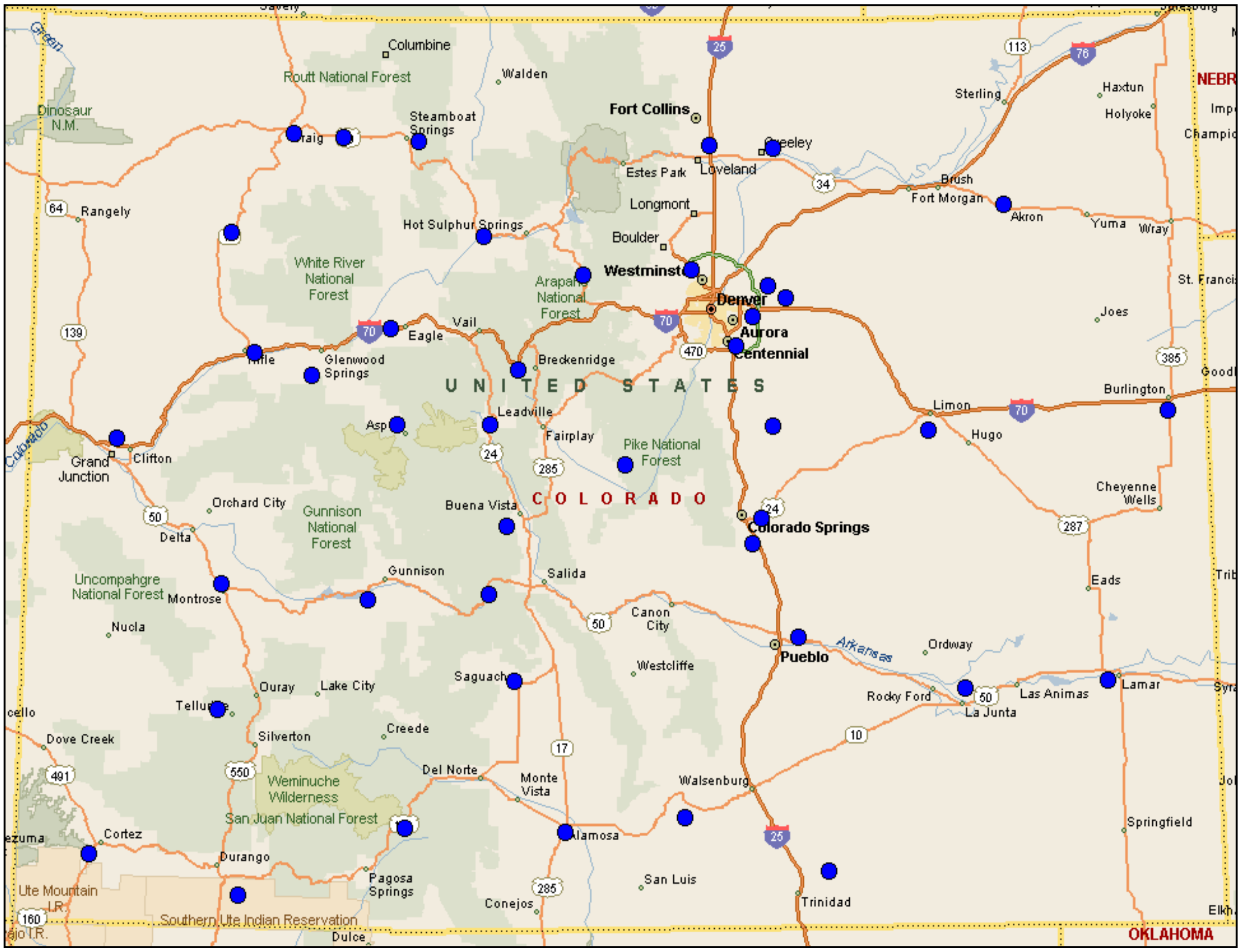


Figure 3.20 Location of Colorado Weather Stations

Table 3.15 Geographic Coordinates and Data Availability of Colorado Weather Stations

Station Number	Station	Latitude	Longitude	Elevation	Start Date	End Date	Years of Data
24015	Akron/Washington County	40.172	-103.232	4621	6/1/1973	3/31/2010	36.9
23061	Alamosa Muni(AWOS)	37.436	-105.866	7540.9	1/1/1973	3/31/2010	37.3
93073	Aspen Pitkin County SAR	39.223	-106.868	7742	1/1/1973	3/31/2010	37.3
03065	Broomfield/Jefferson County	39.909	-105.117	5669.9	9/1/1984	3/31/2010	25.6
23036	Buckley Air Force Base	39.702	-104.752	5662	1/1/2000	3/31/2010	10.3
03026	Burlington	39.245	-102.284	4216.8	2/1/1999	3/31/2010	11.2
93067	Centennial Airport	39.57	-104.849	5828	10/1/1983	3/31/2010	26.5
93037	Colorado Springs Municipal AP	38.812	-104.711	6169.9	1/1/1973	3/31/2010	37.3
03038	Copper Mountain Resort	39.467	-106.15	12074	8/1/2004	3/31/2010	5.7
93069	Cortez/Montezuma County	37.303	-108.628	5914	1/1/1973	3/31/2010	37.3
12341	Cottonwood Pass	38.783	-106.217	9826	7/1/2005	3/31/2010	4.8
24046	Craig-Moffat	40.495	-107.521	6192.8	9/1/1996	3/31/2010	13.6
03017	Denver International Airport	39.833	-104.658	5431	1/1/1995	3/31/2010	15.3
12342	Denver Nexrad	39.783	-104.55	5606.9	5/1/2006	3/31/2010	3.9
93005	Durango/La Plata Airport	37.143	-107.76	6685	1/1/1973	3/31/2010	37.3
23063	Eagle County Airport	39.643	-106.918	6535	1/1/1973	3/31/2010	37.3
03040	Elbert County Airport	39.217	-104.633	7060	6/1/2004	3/31/2010	5.8
94015	Fort Carson/Butts	38.7	-104.767	5869.4	1/1/1969	3/31/2010	41.3
94062	Fort Collins Airport	40.452	-105.001	5016	5/1/1986	3/31/2010	23.9
23066	Grand Junction Airport	39.134	-108.538	4838.8	1/1/1973	3/31/2010	37.3
24051	Greeley/Weld County Airport	40.436	-104.618	4648.9	8/1/1991	3/31/2010	18.7
93007	Gunnison County Airport	38.452	-107.034	7673.8	4/1/1976	3/31/2010	34.0
94025	Hayden/Yampa (AWOS)	40.481	-107.217	6602	1/1/1973	5/31/2010	37.4
94076	Kremmling Airport	40.054	-106.368	7411	6/1/2004	3/31/2010	5.8
23067	La Junta Muni Airport	38.051	-103.527	4214.8	1/1/1961	3/31/2010	49.3
03042	La Veta Pass	37.5	-105.167	10216.7	7/1/2004	3/31/2010	5.8
03013	Lamar Muni Airport	38.07	-102.688	3070	1/1/1980	3/31/2010	30.3
93009	Leadville/Lake County Airport	39.228	-106.316	9926.7	7/1/1987	3/31/2010	22.8
93010	Limon Muni Airport	39.189	-103.716	5365.1	1/1/2004	3/31/2010	6.2
94050	Meeker	40.049	-107.885	6390	12/1/1978	3/31/2010	31.4
93013	Montrose Regional Airport	38.505	-107.898	5758.8	1/1/1973	3/31/2010	37.3
12343	Mount Werner/Steamboat	40.467	-106.767	10633.1	4/1/2005	5/31/2010	5.2
03039	Pagosa Springs	37.45	-106.8	11790.9	6/1/2004	3/31/2010	5.8
93058	Pueblo Airport	38.29	-104.498	4720.1	6/1/1954	3/31/2010	55.9
03016	Rifle/Garfield Airport	39.526	-107.726	5543.9	7/1/1987	3/31/2010	22.8
03069	Saguache Muni Airport	38.097	-106.169	7826	10/1/2004	3/31/2010	5.5
03041	Salida/Monarch Pass	38.483	-106.317	12030.7	6/1/2004	3/31/2010	5.8
12344	Sunlight Mtn Glenwood Springs	39.433	-107.383	10603.5	6/1/2005	3/31/2010	4.8
03011	Telluride Regional Airport	37.954	-107.901	9078	12/1/2000	3/31/2010	9.3
23070	Trinidad/Animas County AP	37.259	-104.341	5743	1/1/1973	3/31/2010	37.3
12345	Wilkerson Pass	39.05	-105.517	11279.4	6/1/2005	3/31/2010	4.8
12346	Winter Park Resort	39.883	-105.767	9091.1	5/1/1986	6/30/1993	7.2

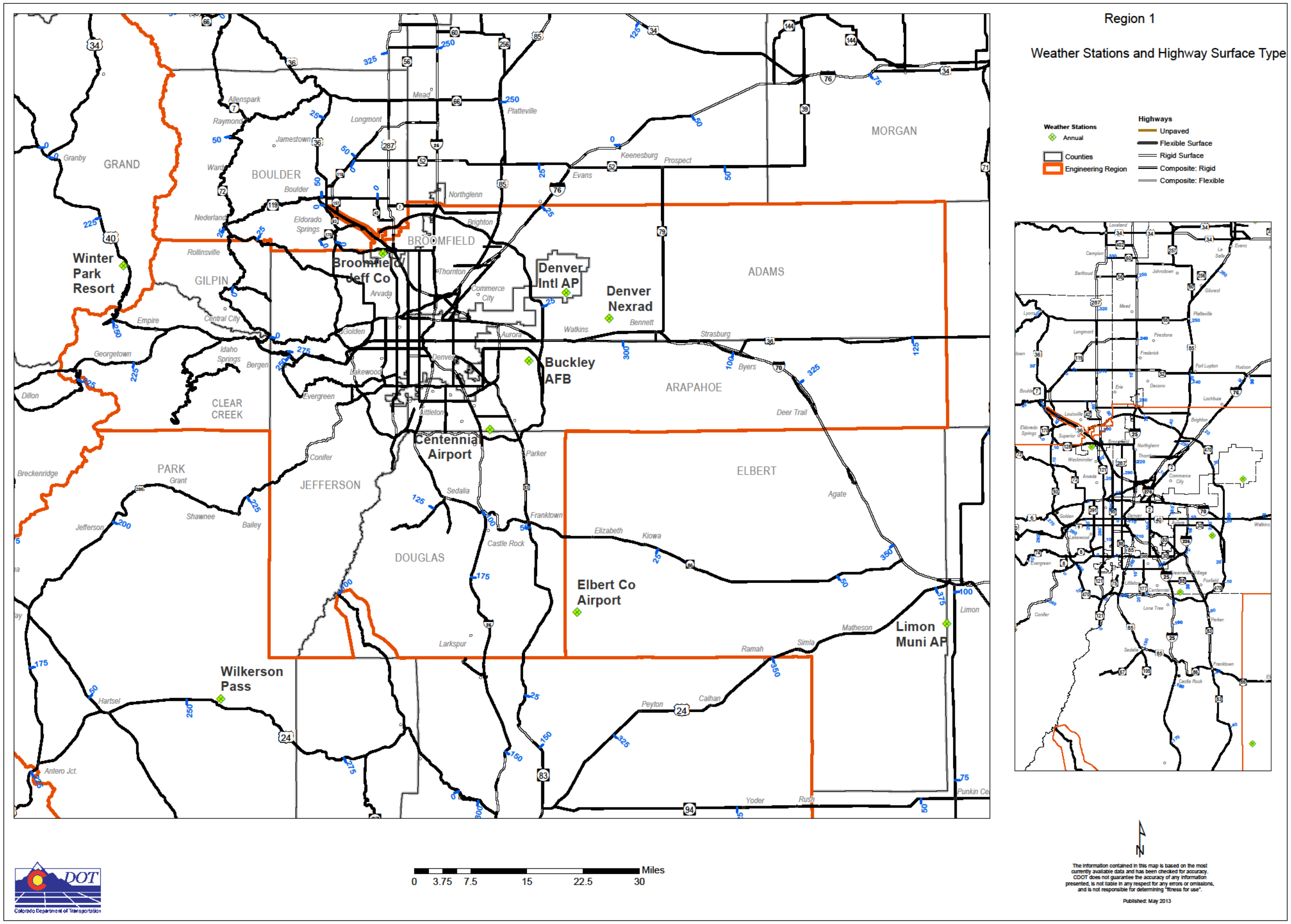


Figure 3.21 Region 1 Weather Stations and Highway Surface Type Map

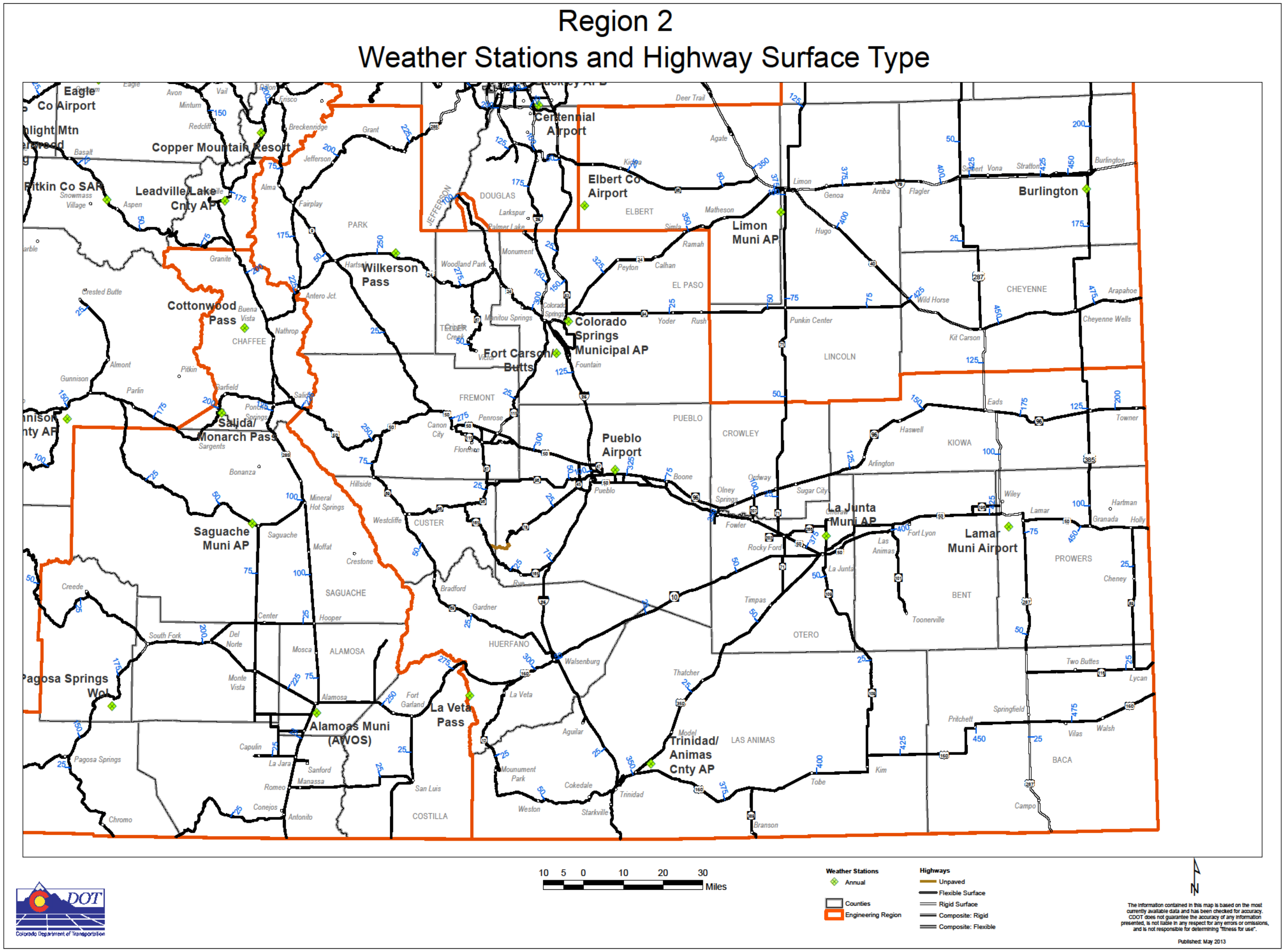


Figure 3.22 Region 2 Weather Stations and Highway Surface Type Map

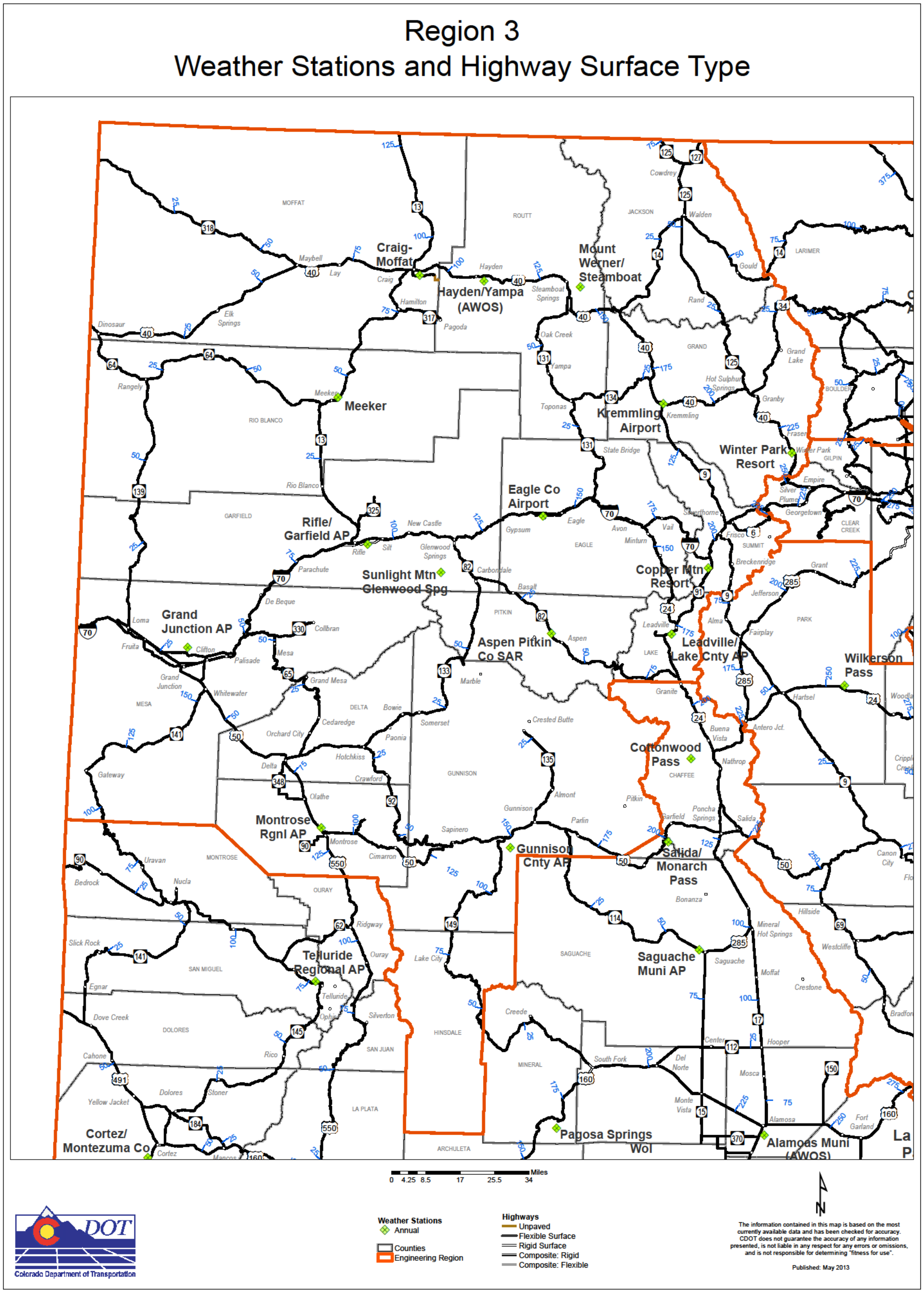


Figure 3.23 Region 3 Weather Stations and Highway Surface Type Map

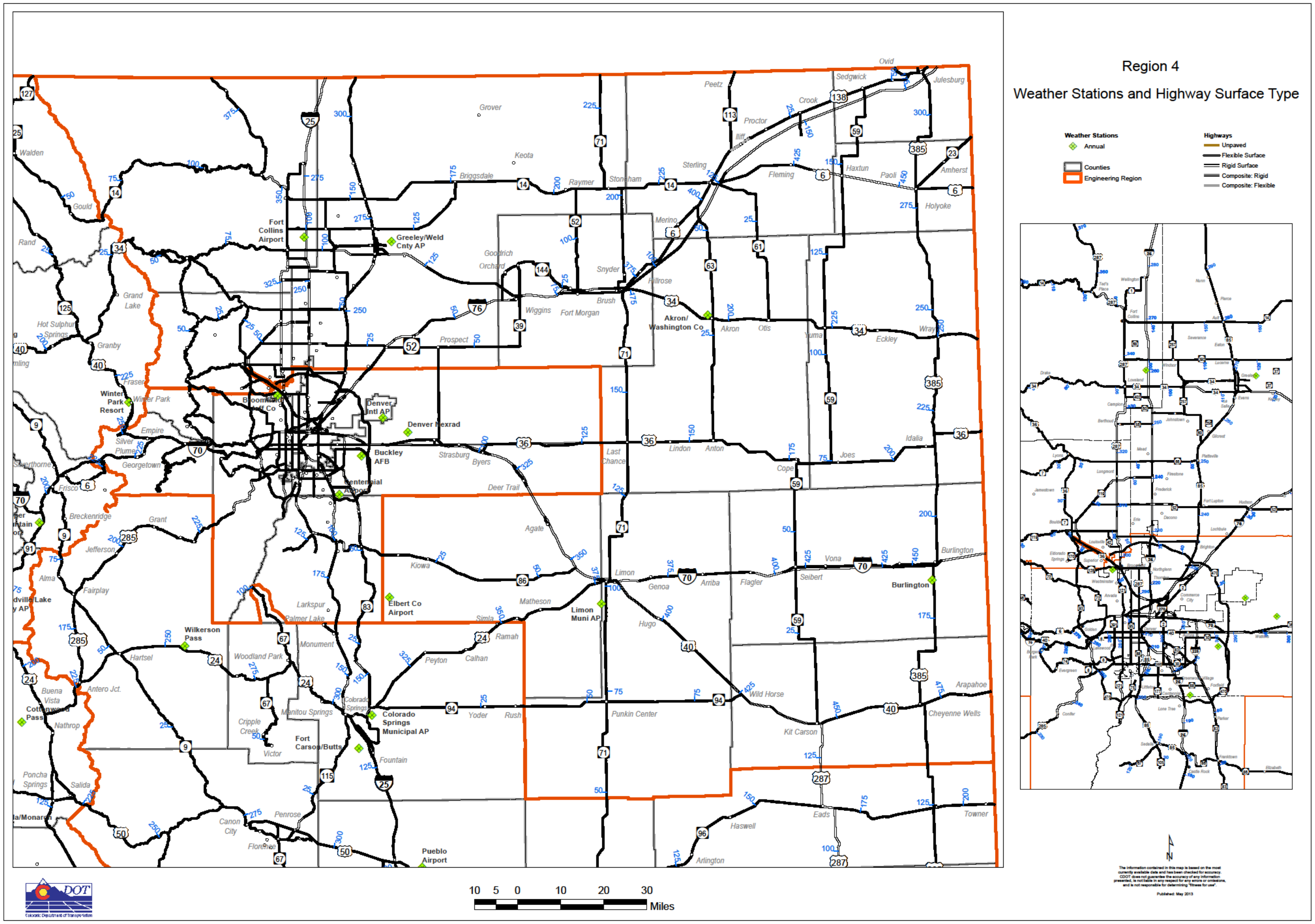


Figure 3.24 Region 4 Weather Stations and Highway Surface Type Map

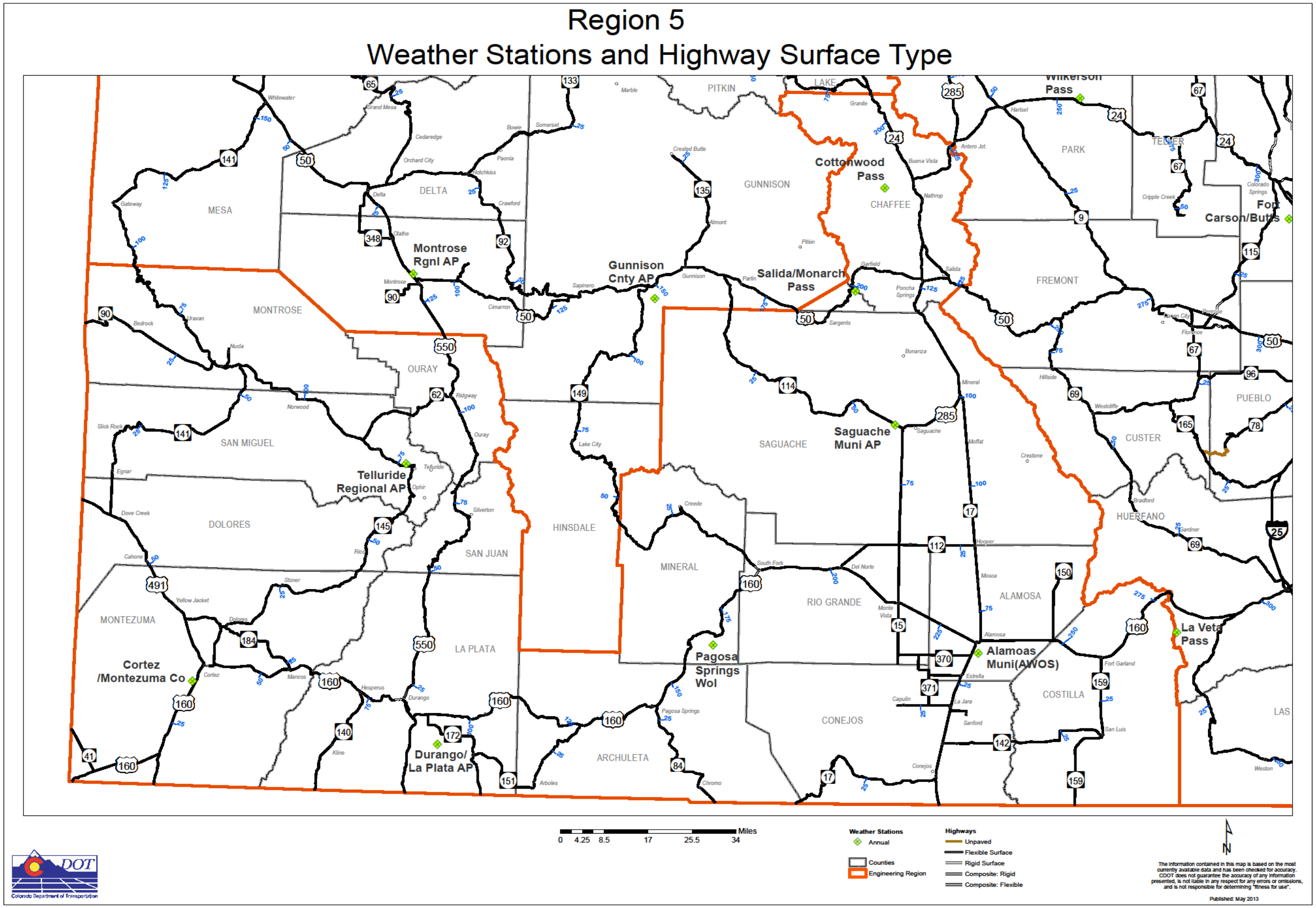


Figure 3.25 Region 5 Weather Stations and Highway Surface Type Map

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