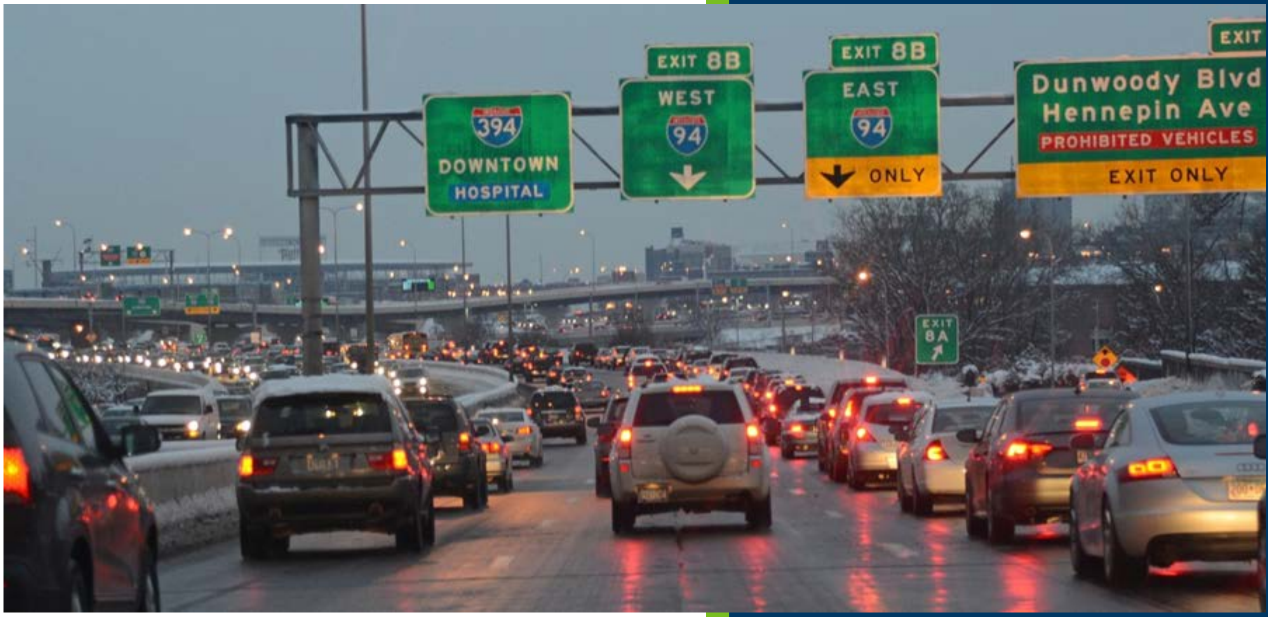
MnDOT Procedure Manual for Forecasting Traffic



Prepared by:

MnDOT Traffic Forecasting and Analysis Section

Office of Transportation System Management

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INTRODUCTION

Minnesota Department of Transportation (MnDOT) has district traffic forecasters that have been trained by the Office of Transportation System Management (OTSM) in the Transportation Data and Analysis (TDA) Section. The traffic forecasters have the responsibility of preparing project level forecasts. After their forecast is approved by TDA, it is dispersed to designers and engineers. The approved forecasts are also entered into eDOCS, which allows for storing and retrieving information. Traffic forecasts play an important role in geometric design, structural pavement design, safety analysis, environmental analysis, benefit cost analysis, and access management. Check out TDA products at http://www.dot.state.mn.us/traffic/data/index.html.

About the document

This manual is intended to be used as a guide for preparing traffic volume and equivalent single axle load (ESAL) projections. The following procedures will help standardize techniques used by traffic forecasters throughout the state. This manual was originally created in July 2002, and has been revised several times with the latest revision in May 2019.

What is Traffic Forecasting?

Traffic forecasting is the projection of traffic volumes and loads on specific roadway segments. The forecasts are derived by trending historic data and socioeconomic factors that affect future changes on particular roadways.

The most common requests for traffic forecasts are:

- Base and design year annual average daily traffic (AADT)
- Design hour volumes (DHV) with associated directional distribution (DD)
- Base year and design year heavy commercial annual average daily traffic (HCAADT)
- 20 year cumulative equivalent single axle loads (ESALs)

Overview

Traffic forecasters estimate the traffic volume and equivalent single axle load (ESALs) on Minnesota's roadway systems. An Excel spreadsheet, called the MnESAL, is used to streamline the forecasting procedure. The MnESAL has undergone several revisions since the change from the initial Lotus version. Designers and engineers use these forecasts to ensure proper geometric and structural designs. The geometric design is generally based on forecasted traffic volumes, and the structural design is based on forecasted ESALs.

1. **Traffic Volume**

The traffic volumes are estimated from historical volume data and the trending of future observations. Linear regression is used to project future traffic growth based on the slope of historic data. In Greater Minnesota, forecasts can be estimated from historical observations. In the Metro areas the Metropolitan Planning Organization (MPO) Travel Demand Models can be used to forecast the traffic volume. Under Federal transportation regulations, the travel demand model is maintained by Metropolitan Council, the MPO serving the Twin Cities seven-county metropolitan area. This model considers the impact of highway design changes and regional travel patterns. Generally, the models produced by the Met Council and other local Minnesota agencies don't produce ESALS. Instead, they may hire consultants to produce results that is verified by MnDOT's Traffic Forecasting Section.

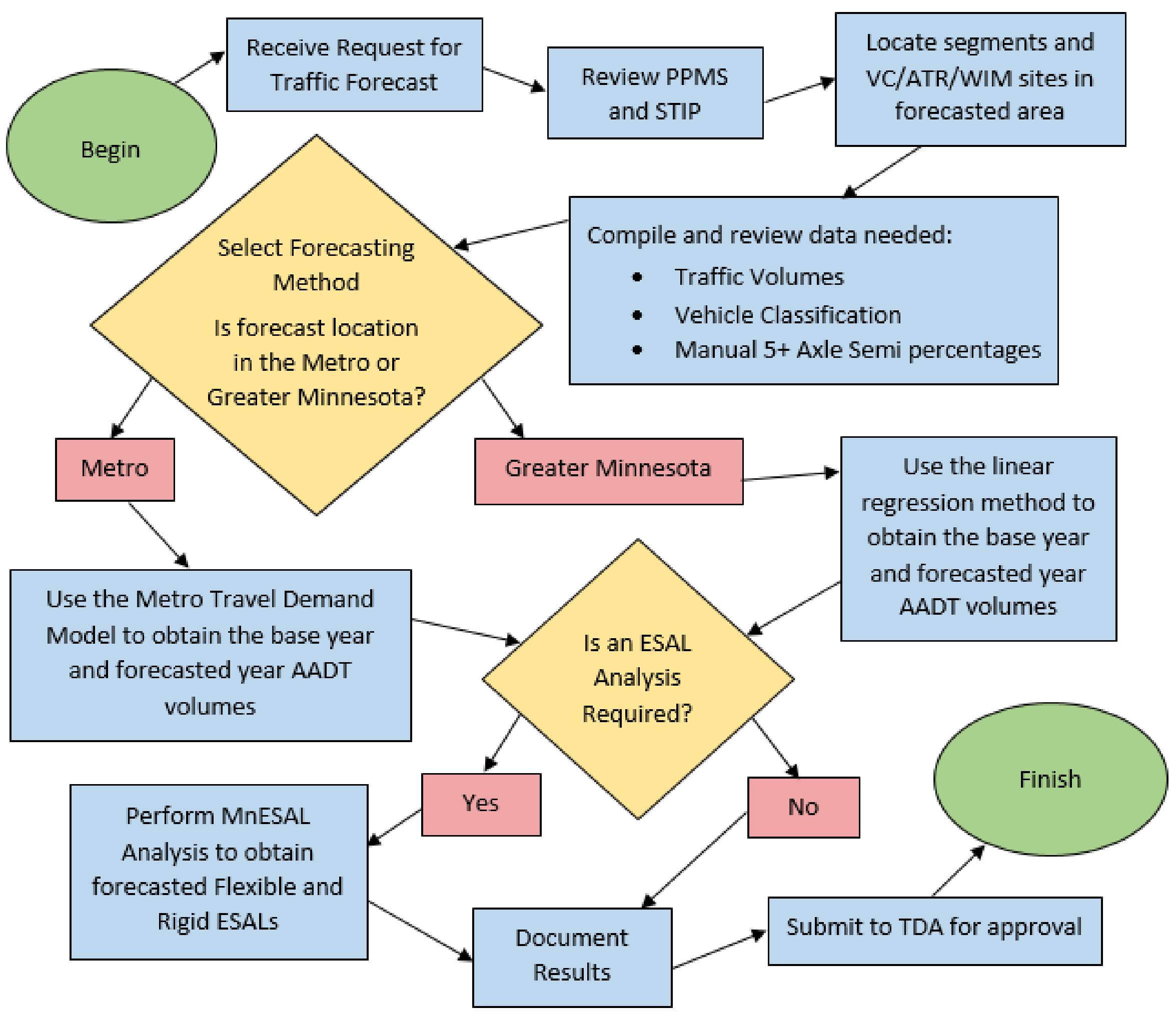
2. **Equivalent single axle load (ESAL)**

Equivalent Single Axle Loads (ESALS) are used to measure the decrease in roadway quality over time. An ESAL is defined as an 18,000 pound load on a single axle with dual tires. An ESAL should be thought of as a damage factor. It is the average damage one vehicle has on the roadway, depending on structure and quality reduction. The ESAL estimation is calculated by forecasting traffic the road is subject to over its design life, and then converted to a specific number of ESALs. A typical ESAL estimation requires:

- A traffic volume count which is used as a starting point
- A count or estimation of the number of heavy vehicles
- An estimated traffic growth rate over the design life of the pavement
- Appropriate factors to convert truck traffic into ESALs

An ESAL forecast will apply the distribution of heavy vehicles to the ESAL factors and calculate the cumulative ESAL loadings for a specific time period, typically 20 years.

TRAFFIC FORECASTING PROCESS FLOWCHART



TRAFFIC FORECASTING & ANALYSIS WEBSITE

The main webpage from MnDOT's Traffic Forecasting and Analysis Section is http://www.dot.state.mn.us/traffic/data/index.html. There are links to find data and methods for the collection of volume, vehicle classification, weight, vehicle miles traveled (VMT), and forecasts.

The most updated MnESAL excel spreadsheet, this forecasting manual, a study on the amount of historical traffic volume data to use, vehicle classification groupings for forecasting, and a tabulation of previous forecasts can all be found under data products at the bottom.

An overview of traffic forecasting and contact information for district traffic forecasters can be found under collection methods.

The Traffic Mapping Application is also on the TFA website or by clicking this link: http://mndotgis.dot.state.mn.us/tfa/Map. Traffic segments, vehicle class sites, ATR/WIM sites, AADT, and HCAADT can all be found in this application.

TRAFFIC FORECASTING PROCEDURE

- Obtain general information about the forecast
- Create a map of the forecast
- Assemble the appropriate data
- Project the AADT for base year and design year
- Calculate vehicle type percentages
- Analyze 20 year flexible and rigid ESALs
- Submit forecast to Office of Traffic Data and Analysis and they will:
    - Enter forecast into eDOCS
    - Return approved forecast to the district forecast and materials engineer

MnESAL Program

The traffic forecasting Excel spreadsheet, called the MnESAL, was developed to calculate forecasted traffic volumes and ESALs. The most updated version is available on the Traffic Forecasting and Analysis website under Forecasts at the bottom: http://www.dot.state.mn.us/traffic/data/data-products.html

The MnESAL is made up of 9 different worksheets:

1. Instructions Page
2. Title Page
3. Cover Page
4. Forecast A (Least Squared Worksheet for the A segment)
5. ESAL A (ESAL Worksheet and Report for the A segment)
6. Forecast B 1-5 (Least Squared Worksheet for B segment(s))
    - Generated on Cover Page
    - Can have up to 5 B segments in each MnESAL excel spreadsheet
7. ESAL B 1-5 (ESAL Worksheet and Report for B segment(s))
    - Generated on Cover Page
    - Can have up to 5 B segments in each MnESAL excel spreadsheet
8. VC 1-4 (Vehicle Class Count Expansion Worksheets)
    - Can have up to 4 years of Vehicle Class Data
9. VC Averages

Inputs into the MnESAL program include:

- General Project Information
- Historic traffic volumes
- Historic vehicle classification breakdowns (Up to 4 years)
- Heavy 5+ Axle Semi percentage(s)

Outputs from the MnESAL program include:

- Projected average annual daily traffic (AADT) – base and design year
- Projected heavy commercial distribution (HCAADT) – base and design year by vehicle type
- Total 20 year design-lane cumulative ESALS (flexible and rigid)
- Flexible and Rigid total ESALS for 10, 15, 20, 25, 30, and 35 years.

STEPS TO CREATE A FORECAST

Obtain General Information about the Forecast

The first step is to determine the exact limits of the project and general information from the project manager or the PPMS program listing in CHIMES: https://chimes.dot.state.mn.us/secure/login.asp

The link above will open to a home page where a User ID and password are needed. Once logged in, however, you can type in the SP number and find all of the information for the project.

General information from PPMS will be entered on the Cover Page of the MnESAL. Information needed is District, Letting Date, Program Category, Project Manager, SP Number, Route Number, Route Type, County, Beg Reference Points, End Reference Points, Miles and Project Limits (Description).

Example of a PPMS:

11/27/17 MINNESOTA DEPARTMENT OF TRANSPORTATION 2
PROJECT LIST REPORT

1 SPN: *8604-37* DIST 03 AREA RTE: 25 STATUS: Programmed ORG. LET: 12/21/18 LET DATE: 12/17/21

DESCRIPTION: **AC**MN 25, FROM 350 FEET SOUTH OF 1ST ST SOUTH TO 500 FEET NORTH OF WRIGHT CR 147 IN BUFFALO, URBAN RECONSTRUCTIION PROJECT, AC PAYBACK IN 2020)

COUNTY(S):	Wright,86	LEGISLATIVE DIST:	29B	CONG. DIST:	6
PROGRAM:	RC	COST EST CHANGE:	06/09/17	ORG COST :	
MILES:	0.55	PARCELS:		CONST COST:	$5,500,000
FUND DESIGNATORS:	STP,SM	RELLOC:		ORIG R/W EST:	$0
PRE DSN PRJ MGR:	Russell Fellbaum	STIP YR:	2022	REVISED R/W:	$0
FIN DSN PRJ MGR:		BEG RF PNT:	057+00.400	ENCUMBER R/W:	$0
DESIGN ENGINEER:		END RF PT:	057+00.948	MUNI. AGREE :	$0
CONST RES ENG:		PROCESS:	B		
BUSINESS LIAISON:		PLANS READY DATE:			
WORK TYPE:	Grade and Surface	ELEMENT ID:	119162		
MACHINE CONTROL:	Use				
JOB #S:	8604-37: P=T3A193				

Create a map of the forecasted location

Maps are a good visual of the segments and sites that are being used for the forecast.

There are two types of segments that are used to forecast:

A segments: Any segment that contains a VC, ATR, or WIM site.

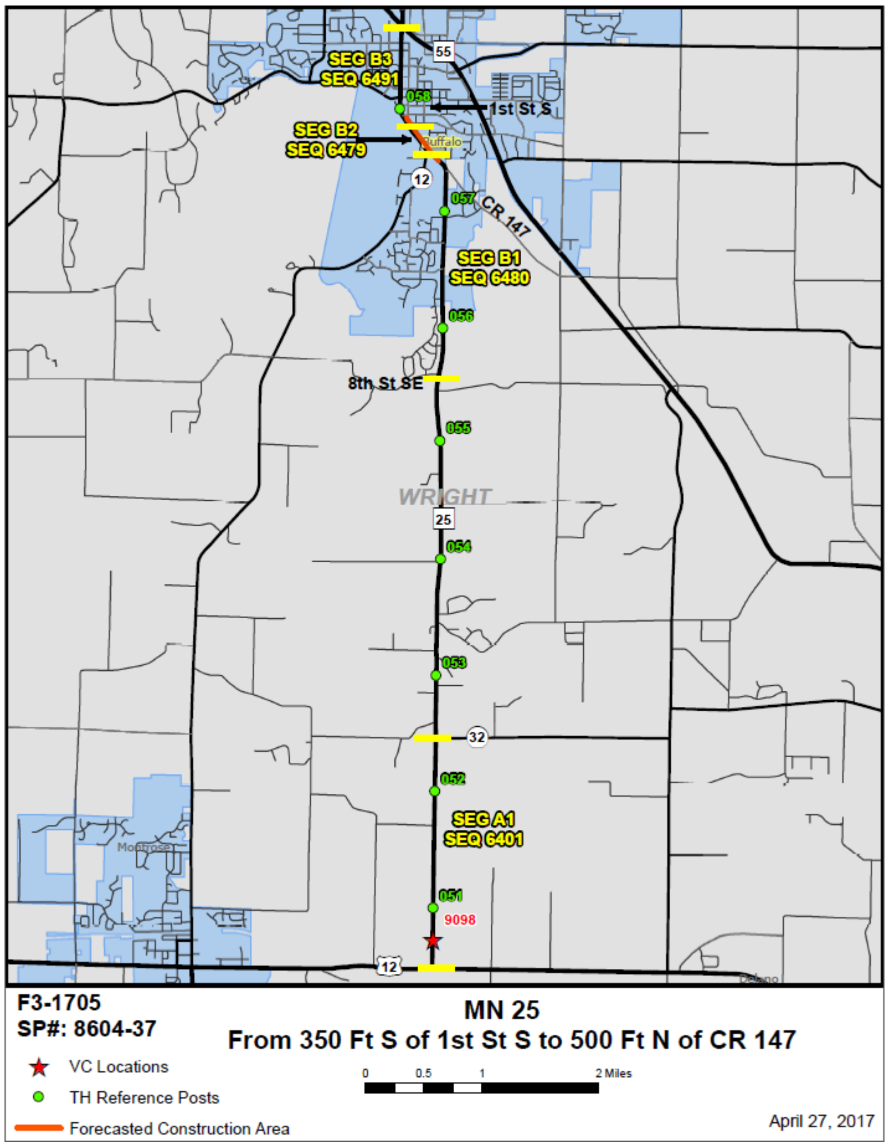
B segments: Any other segment within the forecast.

The association between A and B segments is called a Parent Child relationship. A is the Parent and B is the Child. Each forecast requires at least one A segment because that is where the vehicle class data is located. The relationship is based on distance and junction with major roadways. To determine the location of each segment and their sequence numbers, visit the Traffic Mapping Application: http://mndotgis.dot.state.mn.us/tfa/Map

The Traffic Mapping Application, GIS, Google Maps, and others can be used to create maps for forecasts.

Shown to the right is an example of a Map used for a forecast using GIS ArcMap:

In this example, there is one A segment (sequence number 6401) containing VC site 9098, and three B segments (sequence number 6480, 6479, and 6491). The forecasted construction area is shown in orange. Since the forecasted construction area does not contain a VC site, we are required to use an A segment off of the construction area. All segments that contain part of the forecasted construction area must be used. We can see that a portion of all three B segments are in the forecasted construction area. There are also segment(s) in between CSAH 32 and 8th Street SE that do not need to be forecasted because they are not part of the construction location and do not contain a VC, ATR or WIM site. (Note any VC, ATR, or WIM sites adjacent to the project, or further along the trunk highway for future reference.)



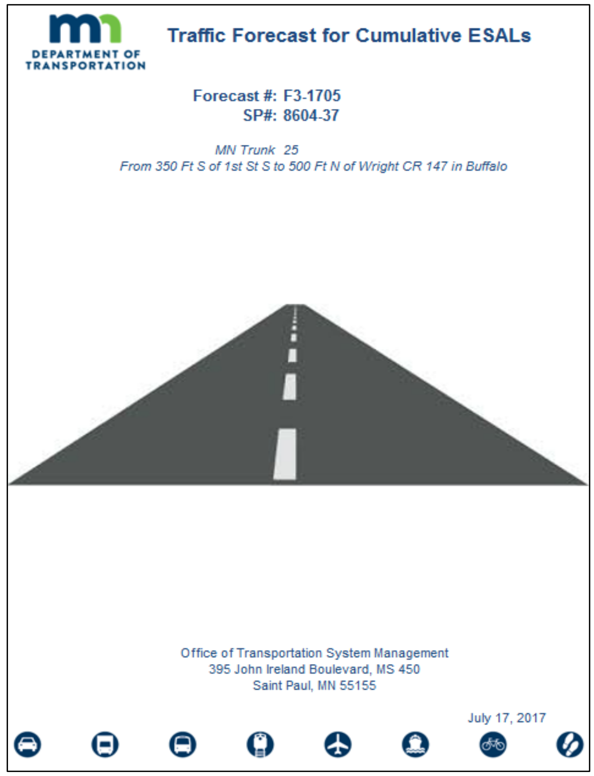
Fill out the MnESAL

At this point, PPMS and the forecast map show the information that is needed to fill out the MnESAL. The most updated MnESAL spreadsheet is on the TFA website at the bottom under forecast: http://www.dot.state.mn.us/traffic/data/data-products.html. Each MnESAL can only contain one A segment and up to five B segments. If there is more than one A segment in the forecast, you must create a new MnESAL for every additional A segment.

Note: Cells that are filled in with a light orange color indicate that information needs to be entered.

Title Sheet

General information like the forecast #, SP#, Route Name and Description will automatically transfer from the Cover Sheet.



DEPARTMENT OF TRANSPORTATION

Traffic Forecast for Cumulative ESALs

Forecast #: F3-1705
SP#: 8604-37

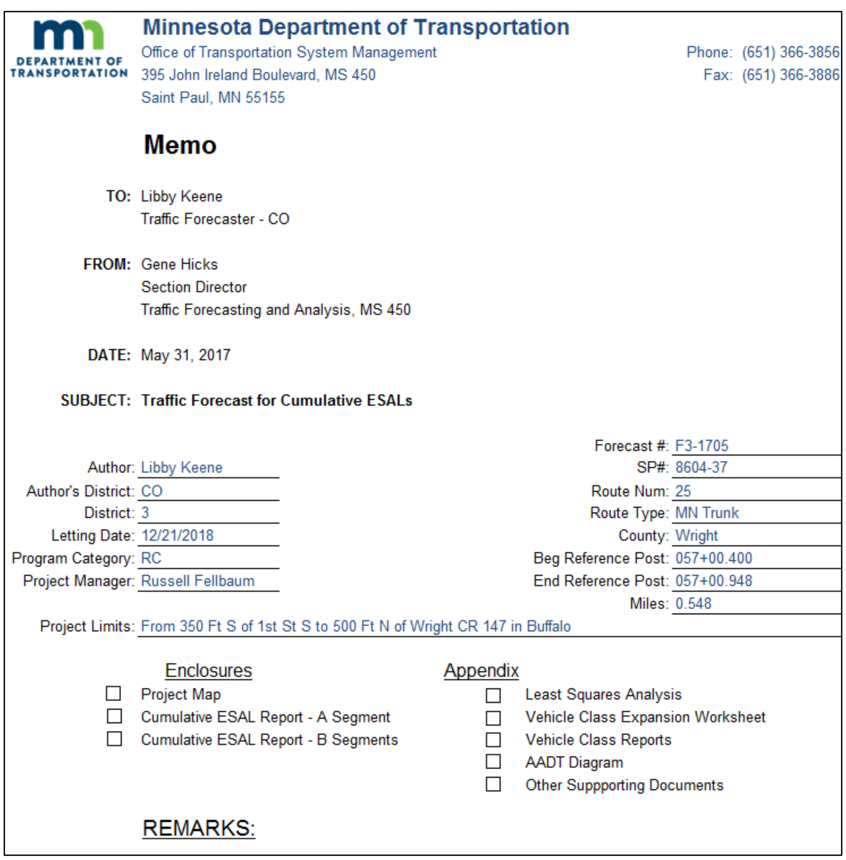
MN Trunk 25
From 350 Ft S of 1st St S to 500 Ft N of Wright CR 147 in Buffalo

Office of Transportation System Management
395 John Ireland Boulevard, MS 450
Saint Paul, MN 55155

July 17, 2017

Cover Sheet

Fill in general information about the forecast listed on the PPMS. Light orange filled cells denotes fields to be filled in. There is space for remarks at the bottom for all additional information.



DEPARTMENT OF TRANSPORTATION

Minnesota Department of Transportation
Office of Transportation System Management
395 John Ireland Boulevard, MS 450
Saint Paul, MN 55155

Phone: (651) 366-3856
Fax: (651) 366-3886

Memo

TO: Libby Keene
Traffic Forecaster - CO

FROM: Gene Hicks
Section Director
Traffic Forecasting and Analysis, MS 450

DATE: May 31, 2017

SUBJECT: **Traffic Forecast for Cumulative ESALs**

		Forecast #:	F3-1705
Author:	Libby Keene	SP#:	8604-37
Author's District:	CO	Route Num:	25
District:	3	Route Type:	MN Trunk
Letting Date:	12/21/2018	County:	Wright
Program Category:	RC	Beg Reference Post:	057+00.400
Project Manager:	Russell Fellbaum	End Reference Post:	057+00.948
		Miles:	0.548

Project Limits: From 350 Ft S of 1st St S to 500 Ft N of Wright CR 147 in Buffalo

Enclosures
- ☐ Project Map
- ☐ Cumulative ESAL Report - A Segment
- ☐ Cumulative ESAL Report - B Segments

Appendix
- ☐ Least Squares Analysis
- ☐ Vehicle Class Expansion Worksheet
- ☐ Vehicle Class Reports
- ☐ AADT Diagram
- ☐ Other Suppporting Documents

REMARKS:

Forecast A Worksheet

This worksheet is used to forecast the AADT of the base year and forecasted year. Enter information in the light orange filled cells. Once the sequence number is entered, the historical data will be listed to the right of the print area. Click copy AADT over to worksheet for the data to appear in cells A7:B22.

Linear regression projects that traffic will grow at a constant rate based on the slope of historic data (shown in the white box). Then, a county growth factor is applied to reflect socioeconomic data trends (shown in the yellow box). The county factors are updated based on vehicle miles traveled (VMT). In this example, the base year AADT is 3680 and the forecasted year AADT is 5220.

Note: The MnESAL only allows for a minimum growth rate of 0.5%.

LEAST SQUARES WORKSHEET SEGMENT A1

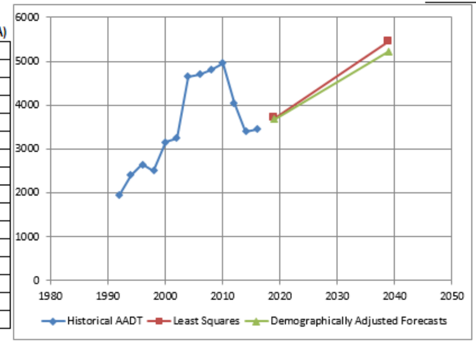
ROUTE: MN 25 SP#: 8604-37 DATE 05/31/17

LOCATION: US 12 to CSAH 32 Miles : 1.97

BASE YEAR: 2019 FORECAST YEAR: 2039 Seq # 6401

of lanes 2

YEAR	FLOW MAP AADT (SEG A)
1992	1950
1994	2400
1996	2650
1998	2500
2000	3150
2002	3250
2004	4650
2006	4700
2008	4800
2010	4950
2012	4050
2014	3400
2016	3450



LEAST SQUARES BASED FORECASTS:

Year	AADT	Calc	ADT Calc
2016	4576	-1126	3450
2019	4837		3711
2039	6579		5453

Statistics	AADT
R 2	0.45
SLOPE	87.09
INTERCEPT	-170993
N	13

Raw Least Squares Forecasts

YEAR	AADT
2016	3450
2019	3710
2039	5450

Slope Over Base Year 2.35%

Demographically Adjusted Forecasts

YEAR	AADT
2016	3450
2019	3680
2039	5220

Slope Over Base Year 2.23%

NOTE:

County Adjustment Factors were developed to Apply to Projected AADT. They are based on 1992-2007 VMT, Population, Labor Force, Household, and Employment Data.

COUNTY	COUNTY FACTOR	GROWTH PROFILE
WRIGHT	0.95	HIGH GROWTH AREA

Forecast B(s) Worksheet

The forecast worksheets for the B segment(s) are used the same as the A segment forecast worksheet (refer above).

The forecaster must complete a least squared worksheet for every segment along the project. On the cover page, there is a drop down to select the number of B segments. The system only generates one B segment at a time.

Interpolation

In the Metropolitan Area, the Travel Demand Model should be used. This model estimates the projected AADTs based on roadway and transit networks, population, land use, and employment data. MnDOT does not have a statewide Travel Demand Model, therefore, in Greater Minnesota we rely on regression analysis for forecasting traffic volumes.

To obtain the base year and future year AADT, the forecaster should interpolate between the last counted AADT and the forecasted AADT from the Travel Demand Model.

In this example, all of the segments were last counted in 2016, the Travel Demand Model produced AADT's in 2040, the base year is 2019 and the future year is 2039.

Description	Last AADT	Forecast	Interpolated	Interpolated
	2016	2040	2019	2039
A1 (SEQ 6401)	3,450	6,000	3,770	5,890
B1 (SEQ 6480)	6,500	10,000	6,940	9,850
B2 (SEQ 6479)	11,800	16,000	12,330	15,830
B3 (SEQ 6491)	12,300	15,000	12,640	14,890

Yearly Growth Rates	
Simple	Compound
3.08%	2.33%
2.24%	1.81%
1.48%	1.28%
0.91%	0.83%

The 2019 and 2039 AADTs for all of the segments should be entered in the MnESAL on the Forecast Worksheets. These values will go in the yellow box at the bottom to then be transferred to other worksheets.

VC 1-4 Worksheets

The heavy commercial traffic (HCAADT) from vehicle classification counts are determined using these worksheets. Enter the site number and the count year for the four most recent years of data. The worksheet will automatically fill in afterwards. The manual (16 hour) and tube (48 hour) counts have different formats, but the vehicle type breakdowns are the same. Note: for tube counts, motorcycles and passenger vehicles are added together.

VEHICLE CLASS COUNT EXPANSION WORKSHEET 1

SITE NUMBER: 9098 COUNTY: Wright

SITE DESCRIPTION: N OF JCT TH12

PROJECT SP#: 8604-37 YEAR OF COUNT: 2014

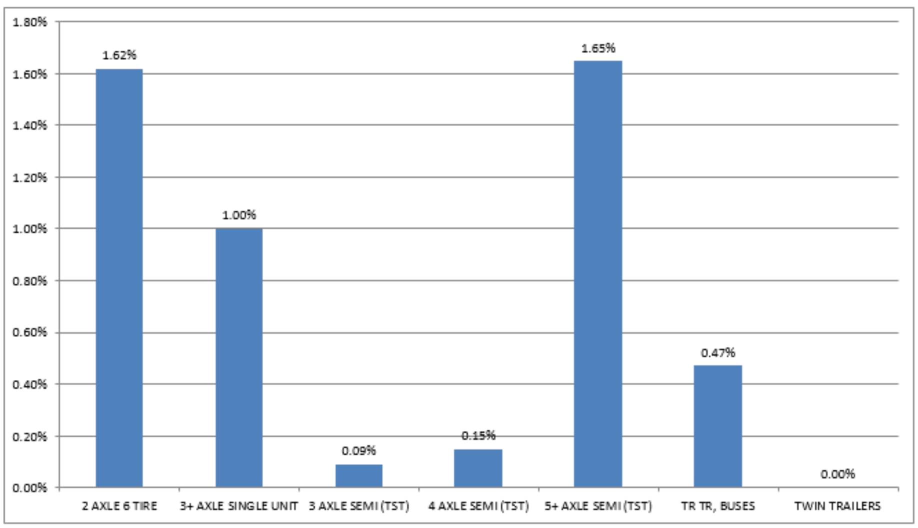
MONTH NUMBER OF COUNT: 8 CONSTRAIN AADT: 3400

16 or 24 HR 24

VEHICLE TYPE	RAW COUNT	AADT ADJ FACTOR		ADJUSTED RAW	VEH. TYPE PERCENTS		A.C.F.
CARS AND PICKUPS	3077	#N/A		3231			0.95
2 AXLE 6 TIRE	66	0.83		55	1.62%		
3+ AXLE SINGLE UNIT	51	0.66		34	1.00%		
3 AXLE SEMI (TST)	4	0.72		3	0.09%		
4 AXLE SEMI (TST)	7	0.72		5	0.15%		
5+ AXLE SEMI (TST)	72	0.78		56	1.65%		
TR TR, BUSES	24	0.68		16	0.47%		
TWIN TRAILERS	0	0.76		0	0.00%		
TOTALS ----------->	3301	-------->	1.0	3400	5.0%	(%HC)	

9098

N OF JCT TH12



The raw count data is located in the yellow cells above. The raw data is then adjusted for the month the count was taken, whether it is a tube (24 hour) count or manual (16 hour) count, and if the location is in a rural or urban area. These factors were developed by looking at continuous ATR and WIM data. Click here to learn more about the 24 hour and 16 hour adjustment factors. The AADT adjusted factors are multiplied by the raw data to get the adjusted data. The adjusted total is constrained by the AADT in the count year.

The axle correction factor (ACF), shown above on the right side of the worksheet, is the total number of vehicles divided by half of the total number of axles to account for trucks with more than two axles. Click here to learn more.

The VC 1-4 worksheets do not need to be filled out when using ATR or WIM data. Since ATR and WIM sites are counting traffic continuously, the data does not need to be adjusted.

VC Average Worksheet

This worksheet shows the average of the truck volumes and percentages. All of the data is automatically transferred from the VC 1-4 worksheets. Any columns that are not being used, may be erased.

A manual count is needed to obtain the heavy 5+ axle semi percentage. In this example, a manual count was taken in 1994 and was one of the four most recent years of data. If one or more manual count(s) were taken at the site, but were not the four most recent years of data, provide the heavy 5+ axle semi percentages(s) in cells D20, F20, H20 and J20. Only one manual count is needed but if there are multiple manual counts, the spreadsheet will take the average of the heavy 5+ axle semi percentages. If the average of the heavy 5+ axle semis percentage is greater than 30%, then the heavies will split causing the ESALs to be higher. In this example the heavy 5+ axle semis split at 32.8%. If the 5+ axle semis split, they are broken down into “Maximum” and “Other”. The max is 0.69% and the other is 1.41% in this example. Click [here](#) to learn more about manual counts.

When using an ATR or WIM site, the VC 1-4 worksheets are not used so the forecaster should enter in the four most recent years of data manually in cells C10:C17, E10:E17, G10:G17, and I10:I17. Since ATR and WIM sites do not breakdown the 5+ axle semis, the forecast should look at nearby VC sites containing manual counts. (If a VC site is used, but does not contain a manual count, nearby VC sites should also be used.) Look for manual counts on the same route as the project and in the surrounding area. The forecaster should use their best judgement on the amount and where the heavy 5+ axle semis are traveling.

It is important to compare the truck volume to other years. If there is a year that is not consistent with the others, it should be thrown out and replaced with the next most recent year. Some sites may not have four years of data and that is okay, as long as the average truck volumes are most accurate to the forecaster’s knowledge.

Vehicle Class Count Averages Worksheet

VCC Site Num: 9098
Route: MN 25
Descripton: N OF JCT TH12

		VC Count 1		VC Count 2		VC Count 3		VC Count 4			
	Type	Year	Pct	Year	Pct	Year	Pct	Year	Pct	Avg Truck Volumes	Avg Vehicle Pctages
		2014		2007		2000		1994			
	Man/Tube	Tube		Tube		Tube		Manual			
1	Cars	3231	95.03%	4479	95.30%	2764	87.75%	2244	93.50%	3180	92.89%
2	2 ASU	55	1.62%	100	2.13%	179	5.68%	64	2.67%	100	3.02%
3	3+ASU	34	1.00%	30	0.64%	41	1.30%	23	0.96%	32	0.97%
4	3ASemi	3	0.09%	3	0.06%	16	0.51%	3	0.13%	6	0.20%
5	4ASemi	5	0.15%	5	0.11%	29	0.92%	3	0.13%	11	0.32%
6	5+Asemi	56	1.65%	73	1.55%	92	2.92%	54	2.25%	69	2.09%
7	TT/BUS	16	0.47%	10	0.21%	26	0.83%	9	0.38%	15	0.47%
8	Twins	0	0.00%	0	0.00%	3	0.10%	0	0.00%	1	0.02%
Total		3400	4.97%	4700	4.70%	3150	12.25%	2400	6.50%		7.11%
Total Heavy Comm		169		221		386		156		233	100.00%
Heavy 5+ Ax Semi*									32.8%		32.76%
Axle Corr Factor			0.95		0.95		0.94		0.95		0.95

Heavy 5 Axle Semi Split	
0.69%	Max
1.41%	Others
SPLIT	

* Heavy 5+ Ax Semi = Tank, Dump, Grain, and Stake Loaded
When the Tank, Dumps, Grains and Loaded Stakes are 30% or more of the 5 axle semis, then split into max and other categories (AUTOMATICALLY DONE) ----------->
Check out tube counts prior to 1996 carefully, body types are N/A prior to 1982, don't use tube collected previous to 1990.

ESAL A Worksheet and Report

The ESAL worksheet and report will calculate values automatically from data being transferred from other worksheets.

The base year proportions are directly transferred from the average vehicle percent column of the VC Average Worksheet above.

The average heavy 5+ axle split information is also transferred to the ESAL Worksheet. In our example, the heavy 5+ axle semis split. Therefore, there is zero for 5AX+ TST. The 5+ axle semis are broken into max (0.69%) and other (1.41%). If the heavy 5+ axle semis did not split, the sum of max and other (2.10%) would indicate 5AX+ TST, and there would be a zero for max and other.

The MnESAL defaults to two-way roads. The drop down in cell C3 can be changed to one-way for roads, ramps, and roundabouts. This information along with the number of lanes is needed to calculate the design lane factor (DLF). Click here to learn more.

CUMULATIVE ESALS WORKSHEET — SEGMENT A1

SP#: 8604-37
ROUTE: MN 25 — TWO-WAY — # LANES: 2 — DATE: 05/31/17
LOCATION: US 12 to CSAH 32
VCL SITE #: 9098

	YEAR	AADT	CALC HCADT	INIT CALC 5AX TST
BASE YEAR:	2019	3680	262	77
ORECAST YEAR:	2039	5220	371	109

BASE YEAR PROPORTIONS		BASE YR. VOLUME	Additonal Trucks	FORECAST %	FUTURE VOL.
2AX-6TIRE SU	3.02%	111	0	3.02%	158
3AX+ SU	0.97%	36	0	0.97%	51
3AX TST	0.20%	7	0	0.20%	10
4AX TST	0.32%	12	0	0.32%	17
5AX+ TST	0	0	0	0	0
(5AX+ TST MAX)	0.69%	25	0	0.69%	36
(5AX+ TST OTH)	1.41%	52	0	1.41%	73
TR TR, BUSES	0.47%	17	0	0.47%	25
TWIN TRAILERS	0.02%	1	0	0.02%	1

SUMMARIES:		AADT	HCADT	HCADT %	20 YR DESIGN LANE CUMULATIVE ESAL	
2019	FORECAST:	3680	262	7.1%	|	|
2039	FORECAST:	5220	371	7.1%	*****************	*****************
					FLEXIBLE	RIGID
DESIGN LANE FACTOR:		0.5			921,000	1,354,000
					*****************	*****************

ADDITIONAL OUTPUTS:

	BASE %	FORECAST %	ESAL FACTORS FLEXIBLE	ESAL FACTORS RIGID
2AX-6TIRE SU	3.0%	3.0%	0.25	0.24
3AX+ SU	1.0%	1.0%	0.58	0.85
3AX TST	0.2%	0.2%	0.39	0.37
4AX TST	0.3%	0.3%	0.51	0.53
5AX+ TST	0.0%	0.0%	1.13	1.89
(5AX+ TST MAX)	0.7%	0.7%	2.40	4.07
(5AX+ TST OTH)	1.4%	1.4%	0.87	1.44
TR TR, BUSES	0.5%	0.5%	0.57	0.74
TWIN TRAILERS	0.0%	0.0%	2.40	2.33

Notes:

CUMULATIVE ESAL REPORT — SEGMENT A1

DATE: 05/31/17
ROUTE #: MN 25 — DISTRICT: 3 — SP#: 8604-37
FORECAST #: F3-1705 — COUNTY: Wright — MILES: 1.97
DESCRIPTION: US 12 to CSAH 32
AUTHOR: Libby Keene — AUTHOR'S DISTRICT: CO

BASE YEAR NUMBER OF LANES: 2

TRAFFIC SUMMARY TWO-WAY	BASE YEAR 2019	DESIGN YEAR 2039	GROWTH / YR (SIMPLE %)
AADT:	3680	5220	2.1%
DESIGN LANE:	1840	2610	2.1%
HCADT:	260	370	2.1%
SINGLE UNITS:	150	210	2.0%
TST'S:	96	136	2.1%
5 Ax+:	77	109	2.1%

ESAL SUMMARY ANNUAL DESIGN LANE ESAL		
FLEXIBLE:	32362	45949
RIGID:	47558	67618

CUMULATIVE DESIGN-LANE ESALS (10 TON) FOR VARIABLE TIME PERIODS — Design-lane factor: 0.5

BASE YEAR	DESIGN YEAR	TIME PERIOD	DESIGN-LANE TST'S	ESALS FLEXIBLE	ESALS RIGID
2019	2029	10 Year	58	441,000	648,000
2019	2034	15 Year	63	671,000	987,000
2019	**2039**	**20 Year**	**68**	**921,000**	**1,354,000**
2019	2044	25 Year	73	1,190,000	1,750,000
2019	2049	30 Year	78	1,477,000	2,174,000
2019	**2054**	**35 Year**	**83**	**1,784,000**	**2,625,000**

APPROVED BY: ____________________ DATE: ________

The ESAL factors for flexible and rigid are shown at the bottom of the worksheet above. Flexible is bituminous and rigid is concrete.

The 20 year cumulative equivalent single axle loads (ESALS) for this forecast is 921,000 for flexible and 1,354,000 for rigid. The 10, 15, 25, 30, and 35 year cumulative ESALs are also shown to the left on the Cumulative ESAL Report.

ESAL B(s) Worksheet and Report

The ESALs for B segment(s) are computed similar to an A segment besides Urban and Rural defaults (shown below in the light gray table) are used to obtain the base year proportions.

The % change from the A segment located on the right side of the worksheet must be between -50% and 50%. Change User Adjustment to Base/Future Yr Vol accordingly (shown in orange).

CUMULATIVE ESAL WORKSHEET — SEGMENT B1

SP#: 8604-37 — CORRESPONDS: SEGMENT A1
ROUTE: MN 25 — Two Directions — # LANES: 2 — DATE: 01/24/18
LOCATION: 8th Street SE to CSAH 12

	YEAR	AADT	AADT Difference from A Seg
BASE YEAR:	2019	7540	3910
FORECAST YEAR:	2039	9720	4570

INCREMENTAL HCADT SEGMENT BASE YEAR PROPORTIONS		User Adjustment to Base Yr Vol	Base Year Incremental Volume	Base Year Volume	User Adjustment to Future Yr Vol	Future Year Incremental Volume	Future Year Volume
2AX-6TIRE SU	1.34%	-7	52	157	0	61	210
3AX+ SU	0.38%	-3	15	46	0	18	62
3AX TST	0.06%	-1	3	10	0	3	13
4AX TST	0.12%	0	5	17	0	5	22
5AX+ TST	0.81%	-3	32	32	0	37	37
(5AX+ TST MAX)	0.00%	0	0	21	0	0	30
(5AX+ TST OTH)	0.00%	0	0	44	0	0	62
TR TR, BUSES	0.21%	-10	8	26	0	10	35
TWIN TRAILERS	-0.01%	-1	0	1	0	0	1

SUMMARIES: **URBAN**

		AADT	ADDED HCADT %	COMBINED HCADT %	20 YR DESIGN LANE CUMULATIVE ESAL	
BASE YEAR:	2019	3910	2.9%	11461.9%	|	|
FORECAST YEAR:	2039	4570	2.9%	13396.4%	**********************************	
DESIGN LANE FACTOR:		0.5			FLEXIBLE	RIGID
				SEGMENT B INCREMENT ONLY:	317,000	453,000
				SEGMENT A + SEGMENT B:	**1,129,000**	**1,633,000**

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ADDITIONAL OUTPUTS:

	BASE %	FORECAST %	ESAL FACTORS FLEXIBLE	ESAL FACTORS RIGID
2AX-6TIRE SU	1.3%	1.3%	0.25	0.24
3AX+ SU	0.4%	0.4%	0.58	0.85
3AX TST	0.1%	0.1%	0.39	0.37
4AX TST	0.1%	0.1%	0.51	0.53
5AX+ TST	0.8%	0.8%	1.13	1.89
(5AX+ TST MAX)	0.0%	0.0%	2.40	4.07
(5AX+ TST OTH)	0.0%	0.0%	0.87	1.44
TR TR, BUSES	0.2%	0.2%	0.57	0.74
TWIN TRAILERS	0.0%	0.0%	2.40	2.33

Non-print area

Urban/Rural Classification

URBAN

For reference when Adjusting Base Yr/Future Yr Truck Volumes

% change from A segment	
Base volume	future volume
49.9%	41.1%
48.3%	39.8%
36.0%	29.4%
39.1%	32.3%
48.9%	40.4%
0.0%	0.0%
0.0%	0.0%
46.5%	39.2%
-21.8%	-25.5%

VEHICLE TYPE	Urban	Rural
2AX-6TIRE SU	1.52%	3.17%
3AX+ SU	0.46%	1.64%
3AX TST	0.09%	0.28%
4AX TST	0.12%	0.50%
5AX+ TST	0.89%	3.26%
TR TR, BUSES	0.47%	1.20%
TWIN TRAILERS	0.02%	0.02%
TOTAL	*3.57%*	*10.07%*

When B segment ESALS and AADT vary significantly from each other with no trunk highway junction in between segments, then the difference may be mainly cars. In these instances, the default B segment percentages may need to be adjusted to reflect logical addition or subtraction of trucks, or to smooth out the volume of trucks between all B segments

When adjusting volumes for this reason, edit "User Adjustment to Base Yr/Future Yr Vol" columns until all items in the "% change from A segment" table are within the -50% to 50% range

The B segment(s) represent the addition or subtraction of trucks on the trunk highway system to or from other road systems. Thus, the B concept is a way to forecast traffic and ESALS along a roadway using vehicle class data from another segment.

Click here to see Urban and Rural defaults percentages by AADT range.

In this example the 20 year cumulative equivalent single axle loads (ESALS) for this forecast is 1,270,000 for flexible and 1,856,000 for rigid. Similar to the A segment, there are also 10, 15, 25, 30, and 35 year cumulative ESALs listed on the Cumulative ESAL Report (shown to the right).

Note: There are small "safety factor" built into formulas throughout the MnESAL. This is provided in case of future changes in truck regulations and changes to truck weight laws.

CUMULATIVE ESAL REPORT — SEGMENT B1 — CORRESPONDS: SEGMENT A1
DATE: 5/31/2017

ROUTE #: MN 25 — DISTRICT: 3 — SP#: 8604-37
FORECAST #: F3-1705 — COUNTY: Wright — MILES: 1.97
DESCRIPTION: 8th St SE to CR 147
AUTHOR: Libby Keene — AUTHOR'S DISTRICT: CO

BASE YEAR NUMBER OF LANES: 2

TRAFFIC SUMMARY TWO-WAY	BASE YEAR 2019	DESIGN YEAR 2039	GROWTH / YR (SIMPLE %)
AADT:	7580	9920	1.5%
DESIGN LANE:	3800	5000	1.6%
HCADT:	400	500	1.3%
SINGLE UNITS:	200	300	2.5%
TST'S:	138	186	1.8%
5 Ax+:	112	151	1.8%

ESAL SUMMARY
ANNUAL DESIGN LANE ESAL

	2019	2039
FLEXIBLE:	45833	62184
RIGID:	66911	90940

CUMULATIVE DESIGN-LANE ESALS (10 TON) FOR VARIABLE TIME PERIODS — Design-lane factor: 0.5

BASE YEAR	DESIGN YEAR	TIME PERIOD	DESIGN-LANE TST'S	ESALS FLEXIBLE	ESALS RIGID
2019	2029	10 Year	81	615,000	898,000
2019	2034	15 Year	87	931,000	1,361,000
2019	**2039**	**20 Year**	**93**	**1,270,000**	**1,856,000**
2019	2044	25 Year	99	1,632,000	2,386,000
2019	2049	30 Year	105	2,017,000	2,949,000
2019	**2054**	**35 Year**	**111**	**2,425,000**	**3,546,000**

APPROVED BY: __________________ DATE: ______

Submit forecast to the Office of Traffic Forecasting and Analysis

The forecast should be a PDF saved as: F + district number – last two digits of the current year + two digit sequential requested order

Example F2-1704: In district 2, the current year is 2017 and the forth report requested in 2017

<u>Order of report:</u>
Title Sheet
Cover Sheet
Project Location Map
ESAL A Report and Worksheet
ESAL B Reports(s) and Worksheet(s)
Appendix
Least Square Analysis
Vehicle Class Expansion Worksheet
Vehicle Class Reports
AADT Diagram
Other Supporting Documents including PPMS

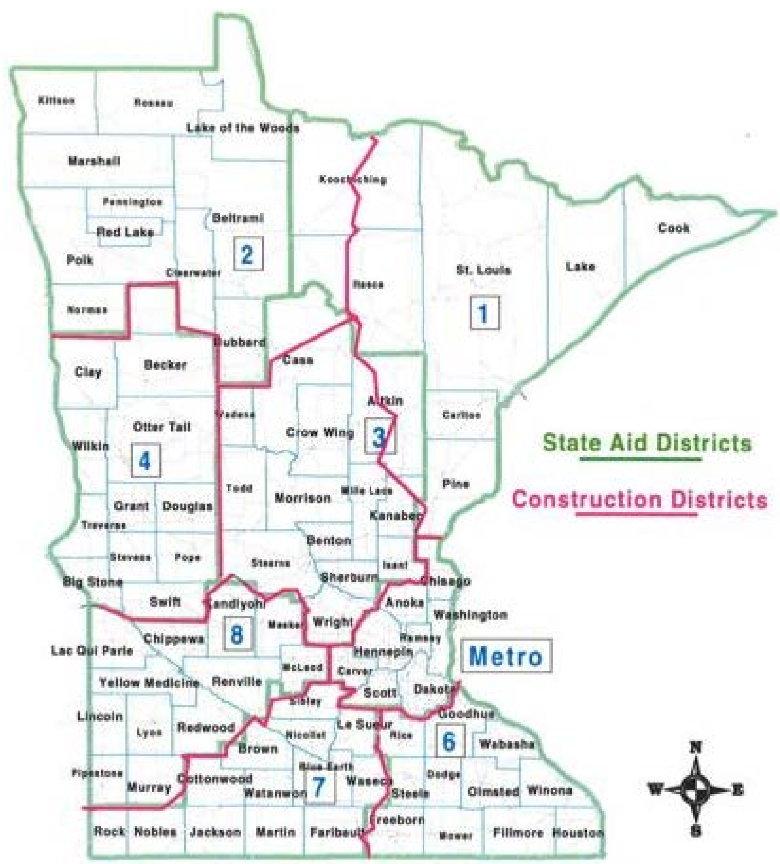
Once approved, the forecast will be entered into the statewide database (eDOCs) and returned to the district forecaster and material engineers.

A tabulation of previous forecasts is on TDA's website at the bottom under forecast: http://www.dot.state.mn.us/traffic/data/data-products.html.

Note: This manual cannot attempt to cover every situation that forecasters may encounter.

MnDOT STATE AID AND CONSTRUCTION DISTRICTS

The state is broken into state aid districts and construction districts. Forecasters follow the construction districts when performing forecasts, therefore, some forecaster's complete forecasts outside of the district they work in.



TRAFFIC DATA COLLECTION

Minnesota's traffic data collection program is designed to gain an understanding of the volume and type of heavy commercial vehicles that are utilizing Minnesota's Highway System. The Highway System consist of Interstates, US Highways, and State Truck Highways. Some data is also collected on County State Aid Highways (CSAH), County Roads (CR), and Municipal State Aid Streets (MSAS).

The Traffic Forecasting and Analysis Section rely on several data collection devices to produce forecasts. The data collected is available to our clients through our website or by our analysts if special requests are made. Some principle users are forecasters, programmers, planners, preliminary design engineers, safety engineers, and the Federal Highway Administration.

Tube Counts

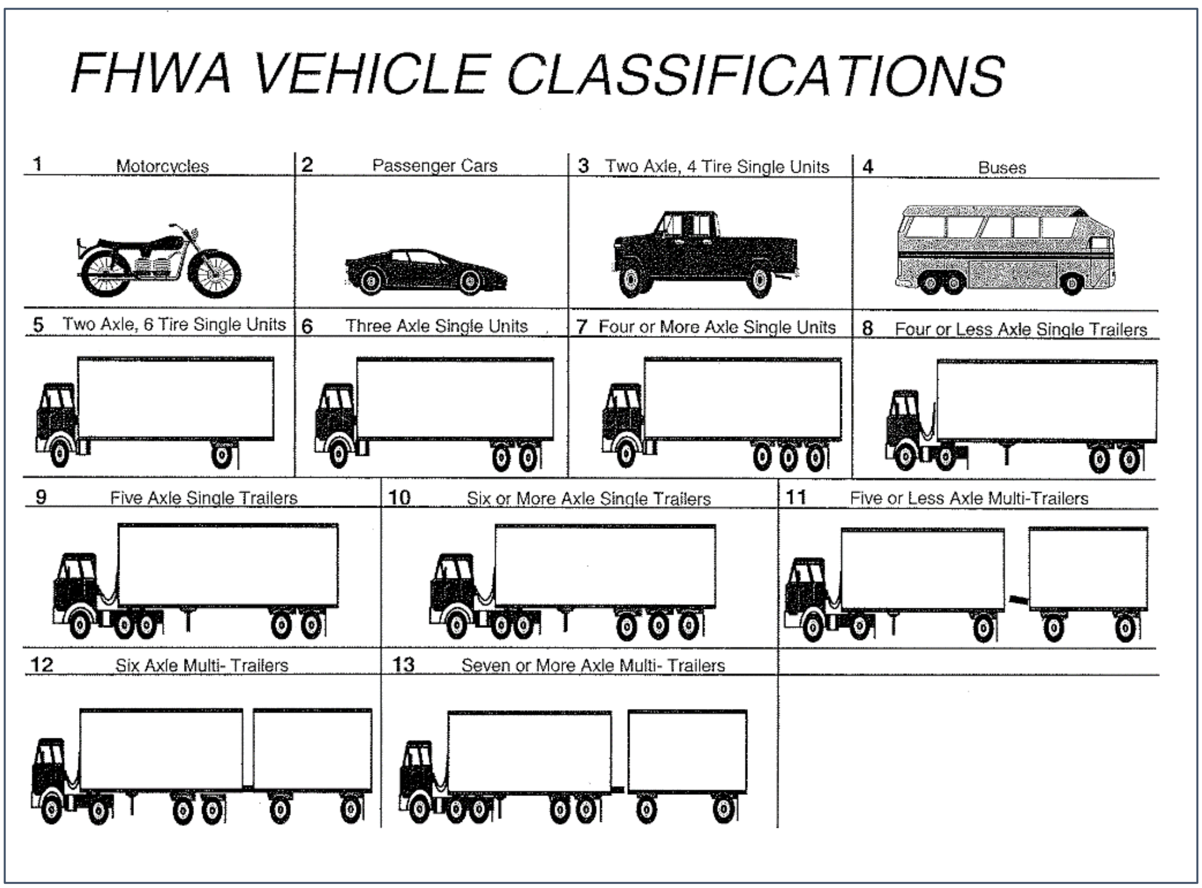
The most frequently used device is pneumatic tube counters. The pneumatic tubes are placed across the roadway surface to count axles and measure axle spacing. The tubes are supplied by the Office of Transportation Data and Analysis.

There are two types of tube counts:

- Single tube count – collects volume data
- Double tube count – collects volume and vehicle classification data

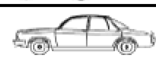
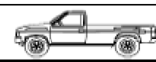
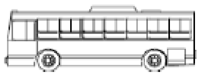
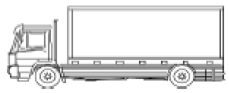
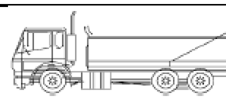
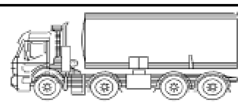
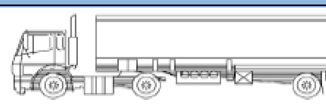
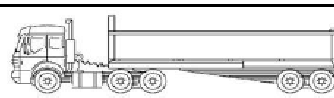
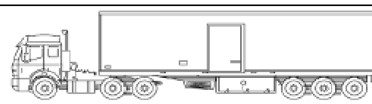
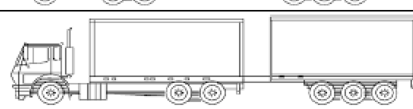
The majority of traffic data is collected by MnDOT District staff, but some Counties and Cities, especially the Metro, submit their own count data. Most traffic counting occurs on weekdays between April and October of each year. The official traffic volume maps are posted on the website the following spring. Click here to look at the Traffic Counting Schedule.

The vehicle classification data from double tube counts are developed by measuring the vehicle's axle configurations and spacing. All vehicle classifiers collect data based on the FHWA classification scheme shown below.

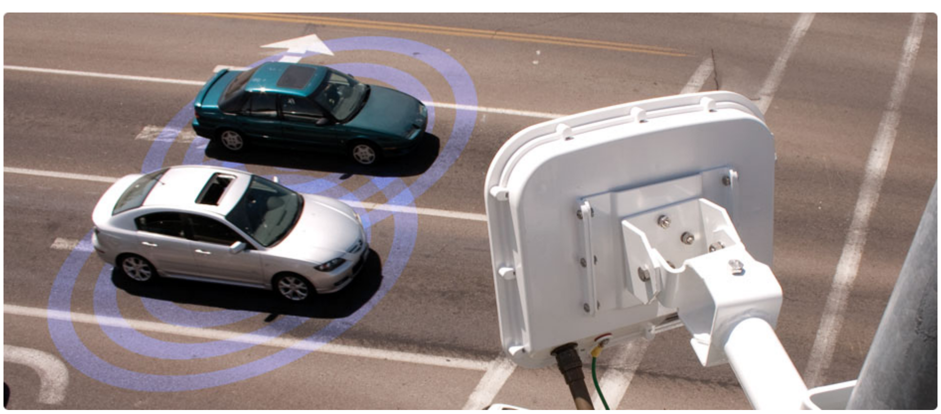


The FHWA classification data is then fit into MnDOT's 13 different classes shown below. The difference between the two classification schemes is that the FHWA scheme has truck with trailers in class 3 and buses in class 4, but MnDOT's scheme has trucks with trailers and buses together in class 4.

MnDOT VEHICLE CLASSIFICATION SCHEME

TYPE	PASSENGER VEHICLES	
1	Motorcycle	
2	Car	
3	Truck Van	
	SINGLE UNITS	
4	Bus Truck with trailer	
5	2 Axle Single Unit	
6	3 Axle Single Unit	
7	4+ Axle Single Unit	
	COMBO UNITS	
8	3 & 4 Axle Semi	
9	5 Axle Semi	
10	6+ Axle Semi	
11, 12, 13	Twin Trailer Semi	

Some locations with high traffic are unsafe for people to walk across the street to lay down tubes. If a single tube count is needed at an unsafe location, Wavetronix radar units can be used to collect volume. Wavetronix radar also counts vehicle type, but it can only separate the data into four classes, which is not useful for forecasting. Therefore, if a double tube count is needed at an unsafe location, a video camera can be set out and used to count the 13 different vehicle classes manually.



Single tube counts, double tube counts, Wavetronix radar counts and video camera counts are generally taken for a 48 hour period. Click here to see an example of double tube data.

MnDOT's 13 vehicle classes then get joined into 8 classes. The 8 vehicle classes (shown below) are used in the MnESAL for forecasting.

Vehicle Class Groupings for Forecasting

1. **Passenger Vehicles** = Motorcycles + Cars + Pickups
   [Class 1 + 2 + 3]
2. **2 Axle Single Unit** = 2AXSU
   [Class 5]
3. **3+ Axle Single Unit** = 3+AXSU + 4+AXSU
   [Class 6 + 7]
4. **3 Axle Semi** = 3&4SEMI * 0.35
   [Class 8 * 0.35]
5. **4 Axle Semi** = 3&4SEMI * 0.65
   [Class 8 * 0.35]
6. **5+ Axle Semi** = 5AXSEMI + 6+AXSEMI
   [Class 9 + 10]
7. **Heavy Truck with Trailer / Bus** = HTWT & BUS
   [Class 4]
8. **Twins** = TWINS 1 + TWINS 2 + TWINS 3
   [Class 11 + 12 + 13]

Click here to see a breakdown of the 8 Vehicle Types for Forecasting.

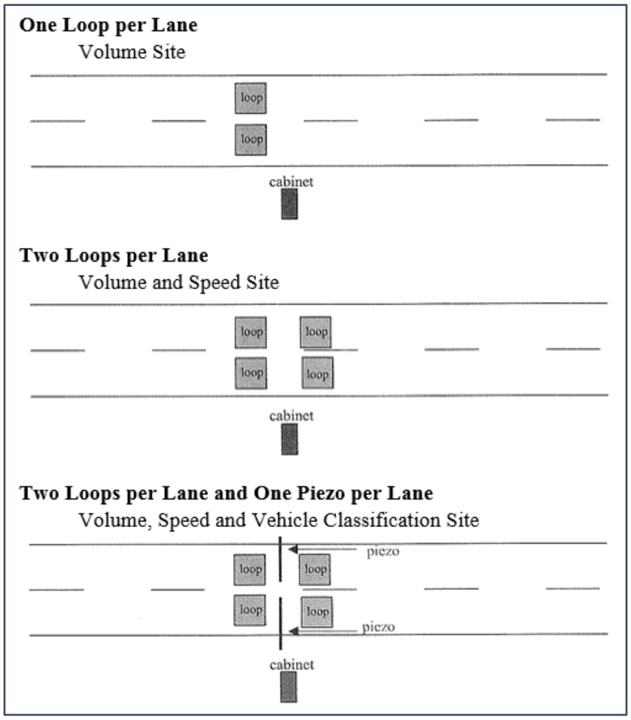
Automatic Traffic Recorder (ATR)

Automatic Traffic Recorders (ATR) are devices with magnetic loops and/or piezo sensors in the pavement that continuously collect data. ATRs come in four difference configurations:

- Single Loop per Lane – collects volume data
- Double Loops per Lane – collects volume and speed data
- Piezo ATR – collects volume, speed, and vehicle classification data
- Weigh-in-motion (WIM) – collects volume, speed, vehicle classification, and weight

These sensors are all located at sites that have a cabinet with power and phone lines.

ATR sites collect data 24 hours a day, seven days a week, and 365 days per year. They are the most valuable component of our traffic data collection system. By obtaining complete coverage, we are able to establish hourly, daily, weekly, and monthly variations of traffic flow. We are also able to develop factors that are used to adjust shorter duration counts to annual average daily traffic (AADT) and heavy commercial annual average daily traffic (HCAADT). Click here to learn more about adjustment factors.



Weigh-In-Motion (WIM)

Weigh-in-motion sites are permanent devices in the road that continually collect and store axle weight data. WIM sites have two Kistler piezo sensors and two magnetic loops. The device collects volume, speed, vehicle classification, and weight data.

WIM sites classify vehicles based on axle configuration in combination with weight on the front axle. The data also provides factors that are used to expand shorter counts. In addition, WIM sites include ESAL factors for truck types, and axle weights.

The data collected consists of axle weight, gross weight, axle spacing, vehicle length, vehicle type, speed, time, lane, and equivalent single axle load (ESALS). ESALS are calculated based on the weight of individual axles or groups of axles; not on gross weight. Processing of weight data is done by vendor software, which produces summary tables. The purpose is to produce WIM reports to calculate and update ESAL factors. Click here to learn more about ESALs.

Over time the loops and piezos used at ATR and WIM sites stop working and need to be replaced. The Office of Transportation Data & Analysis pay for the installation and maintenance of the ATR and WIM site.

Manual Counts

Manual counts are taken by someone going to a site and manually keeping record on paper or on a laptop of the vehicles passing. Manual counts collect vehicle classification data including the six different 5 axle semi types.

Most manual counts have been taken for 16 hours. Recently, they have been counted for 4 hours and then adjusted to a 16 hour count by using the monthly and seasonal factors developed from the ATR and WIM data. Then adjusted again for the missing 8 hours in a day and the effect of weekends to change the 16 hour manual count to Annual Average Daily Traffic (AADT) and Heavy Commercial Annual Average Daily Traffic (HCAADT). In general, a 16 hour volume count is about 90% of a 24 hour volume count. Click here to see more analysis on 16 hour volume count traffic behavior.

In order to obtain an accurate ESAL forecast, it is important to know the percentage of heavy 5+ axle semis because they typically do the most amount of damage to the roads. The heavy semis are tank trucks, dump trucks, grain trucks, and stake loaded trucks. Click here to see example of heavy 5+ axle semi types. Manual counts are the only counts that classify the different 5 axle trucks.

Example of obtaining the percent of heavy 5+ axle semis from a manual count:

BODY TYPE REPORT BASED ON PRELIMINARY ADJUSTED VEHICLE CLASSIFICATION COUNT 6/29/2016

SITE: 2182 **ROUTE:** TH 4 **DESCRIPTION** S OF JCT CSAH 57 (10TH AVE S) IN ST JAMES **RECORDER:** TN

COUNTY: WATONWAN **DIST:** 7

				Single Units		Semis												
								Heavies										
	Begin Hour	Date	Pass. Vehicle	2ax	3ax plus	3ax	4ax	5ax dump	5ax tank	5ax grain	5ax stlo	5ax stun	5ax other	6ax+	Bus	Heavy Truck w/Trlr	Twin Trl 5ax+	Total Vehicles
North	10:00	6/27/2016	134	7	2	0	0	0	0	9	2	1	3	2	0	3	0	163
	11:00	6/27/2016	146	3	2	0	0	1	2	5	0	0	5	1	0	3	0	168
	12:00	6/27/2016	137	3	2	0	0	0	1	8	1	0	2	0	0	0	1	155
	13:00	6/27/2016	163	3	3	0	1	0	0	6	1	0	2	1	0	2	0	182
	Directional Totals:		580	16	9	0	1	1	3	28	4	1	12	4	0	8	1	668
South	10:00	6/27/2016	122	2	6	0	0	1	1	3	1	1	3	0	0	0	0	140
	11:00	6/27/2016	92	6	1	0	1	0	1	8	3	0	2	1	0	2	0	117
	12:00	6/27/2016	107	6	2	0	0	0	1	6	3	2	4	0	0	4	0	135
	13:00	6/27/2016	167	2	2	0	2	0	4	2	2	0	2	1	0	2	0	186
	Directional Totals:		488	16	11	0	3	1	7	19	9	3	11	2	0	8	0	578
	Site Totals:		1068	32	20	0	4	2	10	47	13	4	23	6	0	16	1	1246

16 Hour Totals for Calculating ESALS by Month:	*Pass. Vehicles*	*2 Axle SU*	*3+ Axle SU*	*3 Axle Semi*	*4 Axle Semi*	*5+ Axle Semi*	*Trk Trl/Bus*	*Twins*	*Total*
	3962	102	58	0	12	300	64	1	4499

Heavy 5+ axle semis: (2+10+47+13) / (2+10+47+13+4+23+6) = 72 / 105 = 68.6% heavies

TRAFFIC MONITORING PROGRAM OVERVIEW

Methods used for collection:

1. Short Duration Counts (48 hour tube counts)
   - Volume Sites (Single Tube)
     - Collects traffic volumes
   - Vehicle Classification Sites (Double Tube)
     - Collects volume and vehicle classification

2. Automatic Traffic Recorder (ATR)
   - In-pavement sensors
   - Collects volume, vehicle classification and/or speed

3. Weigh in Motion System (WIM)
   - In-pavement sensor
   - Collects volume, vehicle classification, speed, and weight

4. Manual counts (4 hour counts)
   - Collects vehicle classification including the different 5 axle semi types

5. Regional Traffic Management Center (RTMC)
   - Annual duration vehicle counts
   - Primary purpose is traffic management
   - Data is stored, processed and converted to an AADT

The data collected is used for:

1. Annual reporting of Vehicle Miles Traveled (VMT) and AADT estimates to the Federal Highway Administration (FHWA) for use in Federal level travel analysis and determination of funds.

2. Traffic volume data is used in the formula for annual allocation of state funds for roadway maintenance and construction on the County and Municipal State Aid road system.

3. Providing information to help facilitate decision making for planners, engineers, forecasters, businesses, and the general public.

Produces AADT estimates on:

- Truck Highways (Interstates, US Highways, and MN Highways)
- County State Aid Highways (CSAH)
- County Roads
- Municipal State Aid Roads (MSAS)

RESOURCES

The Office of Transportation Data and Analysis is the source of the data needed for traffic forecasting. Each district forecasters is provided with the following resources:

- **Traffic Volume Maps –** located on the TDA website are metro, county, and municipality AADT maps: http://www.dot.state.mn.us/traffic/data/data-products.html

  Official AADT is published each spring from the previous year's data and can be viewed by going to Traffic Mapping Application on our website: http://www.dot.state.mn.us/traffic/data/tma.html

  Draft AADT can be viewed in the Traffic Mapping Application as it becomes available in the fall of the year it is counted. These values are considered DRAFT ONLY, so they have the potential of changing before the official product is released in the spring.

- **Vehicle Class site maps** – located on the TDA website: http://www.dot.state.mn.us/traffic/data/data-products.html

  All vehicle class and manual counts can be obtained by contacting the Traffic Forecast Unit. The districts collect copies of the raw vehicle class counts and store in their office.

- **ATR and WIM data** – can be found on the TDA website: http://www.dot.state.mn.us/traffic/data/data-products.html

- **Special Requests for Vehicle Class Counts** – If a forecaster knows of a particular project in their district that does not have recent data, they can request to have it counted as a special count for the upcoming summer season.

- **Previous forecasts –** eDOCS: http://edms/cyberdocs/Libraries/Default_Library/Groups/MNDOT_USERS/frameset.asp

If you have any questions, comments or would like further information please feel free to contact our office:

Christy Prentice (Volume Data): Christy.Prentice@state.mn.us

John Hackett (Vehicle Class Data): John.Hackett@state.mn.us

Ian Vaagenes (WIM and ATR Data): Ian.Vaagenes@state.mn.us

For additional resources, forecasters may want to contact the State Demographic Office, the Minnesota Department of Employment and Economic Security, Metropolitan Planning Organizations, Area Transportation Partnerships, Regional Development Commissions, and City or County Traffic Engineers. City and county engineers can provide information about land use developments, and future projects that may cause detours and changes in traffic patterns. The State Demographic Office can provide information on population, household, labor force, and income data by county and city. The Minnesota Department of Economic Security has useful information on employment by industry and region.

AXLE CORRECTION FACTORS

The axle correction factor (ACF) adjusts tube counts to correct AADT by accounting for trucks.

Axle Correction Factor

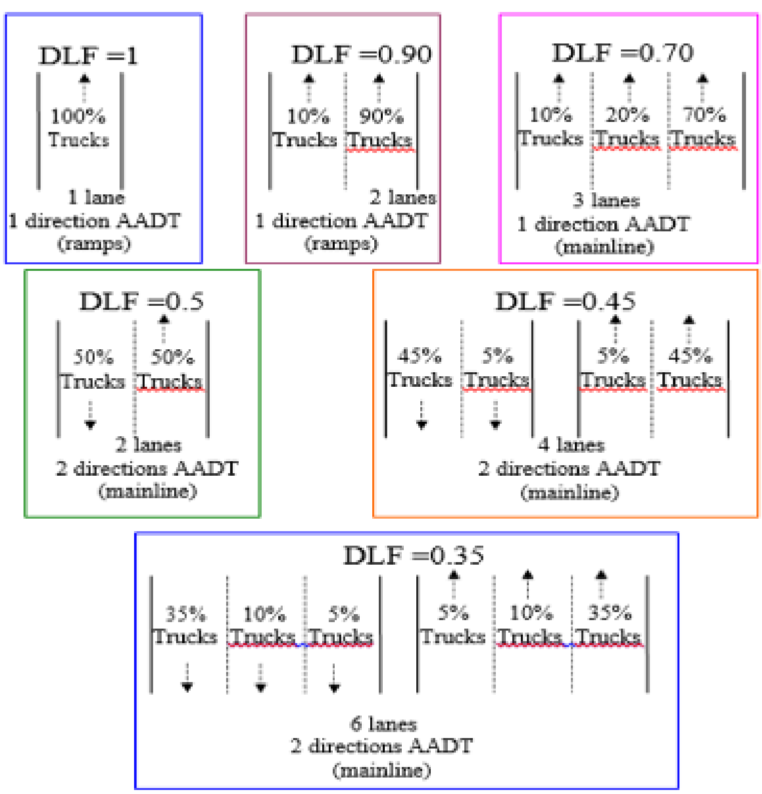
Vehicle	Total number of Vehicles		Number of Axles		Total Axles
Cars	1000	X	2	=	2000
2 AX SU	100	X	2	=	200
3+ AX SU	50	X	3	=	150
3 AX SEMI	25	X	3	=	75
4 AX SEMI	25	X	4	=	100
5+ AX SEMI	300	X	5	=	1500
TT/BUS	50	X	4	=	200
TWINS	50	X	5	=	250
Total	1600				4475

If we assume that there are 2 axles per vehicle, then 4475 / 2 = 2238 instead of 1600 vehicles. To correct this assumption, take 1600 / 2238 = 0.71. Therefore, 0.71 is the axle correction factor.

The axle correction factor is shown on the Vehicle Class Count Expansion Worksheets (VC 1-4) and the Vehicle Class Count Averages Worksheet (VC Avg) in the MnESAL.

DESIGN LANE FACTOR

Design Lane Factor (DLF) is used to estimate traffic volume and truck components on the heaviest traveled lanes for the purposes of ESAL estimation. The design lane factor is shown on the Cumulative ESAL worksheet(s). Forecasts are performed for the design lane only. For example, if we are forecasting at a 4 lane, two-way road. We assume that there will be 45% of the total vehicles in the driving lane for each direction, and 5% in the passing lane for each direction.



ADJUSTMENT FACTORS

The forecasting process assumes that the raw data taken on a typical weekday can be expanded to represent average annual daily traffic (AADT) by using adjustment factors derived from ATR and WIM data.

24 Hour Adjustment Factors

The factors are categorized into urban and rural areas. For estimating equivalent single axle loads (ESALS), the eight vehicle types need to be adjusted for the month of the year and the effects of weekend traffic. These factors are applied to the raw counts in the MnESAL to produce an estimate of AADT by vehicle type.

2013 24 Hour Seasonal Adjustment Factors for Urban Areas in MNESAL												
Body Type	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
CARS+PICKUP	1.08	1.04	1.04	0.97	0.97	0.96	0.91	0.90	0.93	0.88	0.97	1
2ASU	0.96	0.88	0.92	0.90	0.89	0.86	0.80	0.76	0.83	0.76	0.79	0.84
3+ASU	1.23	1.16	1.21	0.86	0.75	0.67	0.59	0.54	0.64	0.64	0.80	1.09
3A SEMI	1.24	1.18	1.02	0.88	0.86	0.80	0.74	0.70	0.72	0.71	0.87	1.17
4A SEMI	1.24	1.18	1.02	0.88	0.86	0.80	0.74	0.70	0.72	0.71	0.87	1.17
5+A SEMI	1.02	0.99	1.00	0.79	0.75	0.71	0.69	0.65	0.70	0.76	0.76	0.99
TT/BUS	1.51	1.31	1.19	1.03	0.92	0.82	0.76	0.71	0.74	0.77	0.94	1.07
TWINS	1.07	1.02	1.02	0.84	0.78	0.74	0.69	0.65	0.67	0.77	0.93	1.09

2013 24 Hour Seasonal Adjustment Factors for Rural Areas in MNESAL												
Body Type	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
CARS+PICKUP	1.31	1.23	1.19	1.06	0.98	0.92	0.84	0.88	0.91	0.95	1.08	1.12
2ASU	1.02	0.93	0.96	0.89	0.85	0.87	0.83	0.83	0.76	0.77	0.88	1.00
3+ASU	1.24	1.17	1.12	0.89	0.76	0.71	0.70	0.66	0.65	0.64	0.86	1.09
3A SEMI	1.25	1.15	1.11	0.97	0.84	0.77	0.72	0.72	0.72	0.83	1.07	1.25
4A SEMI	1.25	1.15	1.11	0.97	0.84	0.77	0.72	0.72	0.72	0.83	1.07	1.25
5+A SEMI	0.93	0.86	0.87	0.82	0.79	0.79	0.82	0.78	0.80	0.73	0.87	0.90
TT/BUS	1.60	1.44	1.31	0.99	0.81	0.75	0.67	0.68	0.70	0.68	0.96	1.40
TWINS	0.95	0.86	0.92	0.86	0.86	0.75	0.80	0.76	0.75	0.70	0.82	0.76

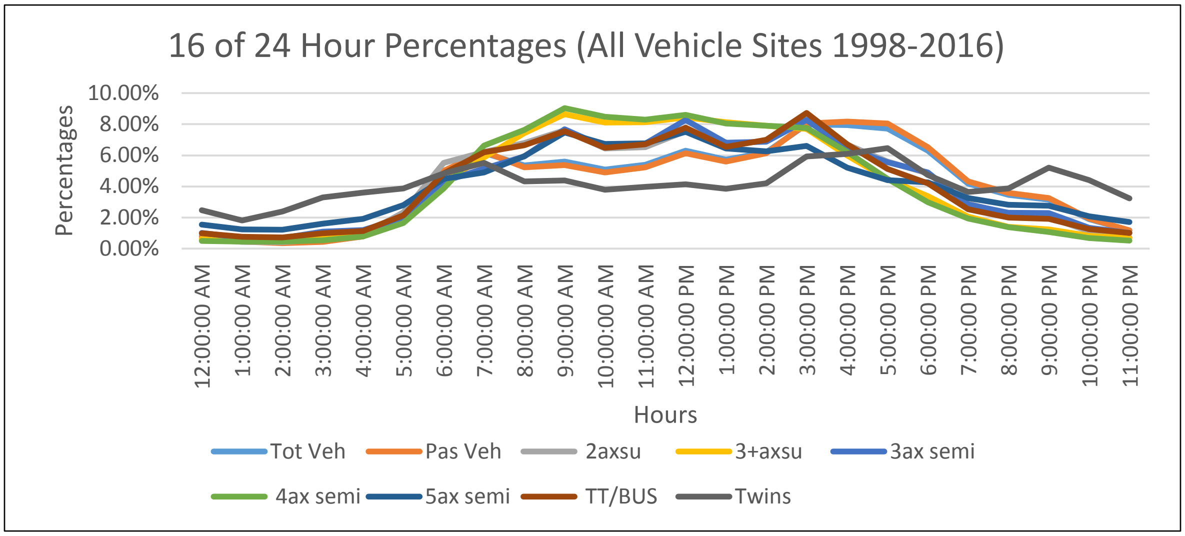
16 Hour Adjustment Factors

These factors are used to adjust 16 hour counts to 24 hours for each vehicle types. The 16 hour traffic volume is the summation of each vehicle type counted from 6:00 AM to 10:00 PM. The summation of 24 hour volumes are divided by the 16 hour volumes for each vehicle type to obtain the adjustment factors. The raw 16 hour volume data is multiplied by the adjustment factors to obtain the 24 hour volumes for each vehicle type. The table below shows the 16 hours as a percent of 24 hours and the factors using all vehicle class sites from 1998-2016.

Vehicle Class Sums	16 Hour (6:00am – 10:00pm)	24 Hour	16 of 24 Percentages	Factor
Passenger vehicles	25244083	27503057	91.79%	1.09
2 Ax Single Unit	848142	913110	92.88%	1.08
3+ Ax Single Unit	320733	343950	93.25%	1.07
3 Ax Semi	273895	301059	90.98%	1.10
4 Ax Semi	66498	70432	94.42%	1.10
5+ Ax Semi	1109569	1292011	85.88%	1.17
Bus and HTWT	218106	239739	90.98%	1.09
Twins	42655	56922	74.94%	1.30
Total Vehicles	28123681	30820280	91.25%	

Analysis of a 16 Hour Count

Typically, a 16 hour count from 6:00am-10:00pm is roughly 90% of the 24 hour total. This statement holds true for both 24 hour total vehicles and 24 hour total passenger vehicles (motorcycles, cars, pickup trucks, and vans) due to the large amount of passenger vehicles compared to heavy commercial traffic. The graph below shows a typical week day traffic pattern between vehicle classes.



Typically, passenger vehicles have an AM peak around 7:00am and a PM peak between 4:00-5:00pm. Trucks display a bell shaped traffic pattern between 8:00am-3:00pm. Many larger semis travel between 12:00am-5:00am to avoid general car flow. Delivery trucks (2 and 3 axle single units) operate mid-day between the AM and PM peaks.

Traffic Behavior of 16 Hour Volume Counts

In general, disregarding seasonal variations, a 16 hour volume count from 6:00am to 10:00pm is:

- About 90% of the 24 hour volume total, consisting of about 92% of the cars.
- About the same volume as the HCAADT for the year at that site.
- Growing faster on higher volume routes than on lower volume routes for both rural and urban areas.
  - Note: when going from a rural area into a town on a trunk highway, trucks increase by about 2-7%. A small increase (2%) means there are very few 5 axle semis. A larger increase (7%) means there are significantly more 5 axle semis.

HOURLY DISTRIBUTIONS OF TRAFFIC BY VEHICLE TYPE

An analysis of hourly tube counts from the vehicle class program has revealed certain hourly trends. Excluding short count and manual count analysis, it is helpful to have guidelines of hourly distribution of traffic when nothing else is known. We can estimate the hourly distribution of truck type by factoring the hour(s) compared to AADT or other 24 hour tube counts.

The tables below shows a statistical average of trend data from the vehicle class tube counts taken between 1998 and 2016. For an example, say you have 20 5+ axle semis from 8:00am-9:00am. The forecaster could use the 8:00am factor (16.78) and multiple it by 20 to get 336 5+ axle semis in a typically 24 hour volume count. This is strictly another analysis tool, and should not be used in project level analysis.

VEHICLE CLASS DATA TUBE COUNT FACTORS - 1998-2018

Hourly Distribution of traffic by vehicle type (Metro and Gtr Mn)

Note: For 24 hour estimated raw traffic, multiply the one hour count by the factor in the right hand column

TIME	Tot Veh	Factor	Pas Veh	Factor	2axsu	Factor	3+axsu	Factor	3ax semi	Factor	4ax semi	Factor	5ax semi	Factor	TT/BUS	Factor	Twins	Factor
12:00 AM	0.86%	115.68	0.83%	120.23	0.64%	155.06	0.69%	145.96	1.06%	93.95	0.94%	106.36	1.58%	63.17	1.03%	97.13	2.62%	38.15
1:00 AM	0.54%	183.60	0.50%	199.17	0.47%	214.71	0.62%	162.28	0.76%	130.91	0.87%	115.29	1.29%	77.52	0.81%	123.80	1.93%	51.74
2:00 AM	0.44%	226.63	0.39%	258.83	0.45%	221.89	0.64%	155.88	0.76%	132.35	0.92%	108.71	1.28%	77.90	0.78%	128.76	2.57%	38.98
3:00 AM	0.56%	177.06	0.49%	206.13	0.66%	152.42	0.84%	118.79	1.17%	85.24	1.20%	83.55	1.71%	58.50	1.05%	95.20	3.63%	27.54
4:00 AM	1.01%	98.86	0.94%	106.26	1.04%	96.59	1.18%	84.90	1.33%	75.35	1.67%	59.77	2.13%	46.91	1.32%	75.85	4.04%	24.78
5:00 AM	2.73%	36.63	2.72%	36.79	2.64%	37.82	2.28%	43.80	2.18%	45.81	3.01%	33.21	3.18%	31.45	2.57%	38.87	4.41%	22.65
6:00 AM	5.68%	17.59	5.71%	17.51	6.14%	16.28	5.12%	19.53	4.58%	21.85	5.52%	18.11	5.03%	19.89	5.70%	17.53	5.34%	18.74
7:00 AM	7.29%	13.72	7.37%	13.56	7.19%	13.91	6.95%	14.38	5.58%	17.93	8.72%	11.46	5.68%	17.62	7.81%	12.80	6.16%	16.23
8:00 AM	6.41%	15.59	6.28%	15.92	7.79%	12.84	8.65%	11.56	6.41%	15.60	9.99%	10.01	6.86%	14.58	8.33%	12.00	5.01%	19.97
9:00 AM	6.50%	15.38	6.25%	16.01	8.52%	11.74	9.80%	10.20	8.11%	12.34	11.20%	8.93	8.31%	12.03	8.91%	11.22	4.79%	20.87
10:00 AM	6.02%	16.61	5.81%	17.22	7.33%	13.64	9.37%	10.68	7.06%	14.17	11.00%	9.09	7.67%	13.04	7.89%	12.67	4.18%	23.94
11:00 AM	6.36%	15.72	6.18%	16.19	7.40%	13.51	9.41%	10.63	7.35%	13.60	11.38%	8.78	7.70%	12.99	8.20%	12.19	4.49%	22.27
12:00 PM	7.26%	13.78	7.09%	14.10	8.37%	11.95	9.56%	10.46	8.80%	11.36	11.59%	8.63	8.32%	12.03	9.23%	10.83	4.76%	21.02
1:00 PM	6.75%	14.82	6.62%	15.10	7.53%	13.29	9.36%	10.69	7.38%	13.56	11.06%	9.04	7.32%	13.66	8.21%	12.17	4.40%	22.73
2:00 PM	7.28%	13.75	7.21%	13.87	7.83%	12.77	9.15%	10.93	7.44%	13.44	10.94%	9.14	7.12%	14.05	8.67%	11.53	4.68%	21.35
3:00 PM	9.13%	10.96	9.20%	10.87	9.14%	10.93	8.78%	11.39	8.75%	11.43	10.75%	9.30	7.32%	13.66	10.23%	9.78	6.46%	15.47
4:00 PM	9.34%	10.70	9.62%	10.40	7.46%	13.41	6.88%	14.54	7.02%	14.24	9.58%	10.44	5.82%	17.18	8.75%	11.43	7.05%	14.19
5:00 PM	9.07%	11.02	9.45%	10.58	6.23%	16.06	5.19%	19.28	6.04%	16.57	7.58%	13.19	4.89%	20.47	7.03%	14.22	7.36%	13.60
6:00 PM	7.20%	13.89	7.47%	13.39	5.20%	19.24	3.85%	25.99	5.18%	19.32	5.19%	19.27	4.56%	21.93	5.17%	19.35	5.18%	19.30
7:00 PM	4.87%	20.52	5.06%	19.78	3.18%	31.40	2.39%	41.77	3.05%	32.75	3.51%	28.48	3.48%	28.72	3.13%	31.98	3.89%	25.68
8:00 PM	3.99%	25.06	4.15%	24.11	2.39%	41.85	1.66%	60.30	2.47%	40.41	2.61%	38.25	2.96%	33.77	2.44%	41.05	4.29%	23.33
9:00 PM	3.51%	28.46	3.64%	27.50	2.13%	47.05	1.39%	71.83	2.38%	41.98	1.95%	51.39	2.84%	35.24	2.14%	46.77	5.71%	17.52
10:00 PM	2.14%	46.76	2.19%	45.64	1.19%	83.95	0.96%	104.11	1.42%	70.34	1.36%	73.64	2.15%	46.57	1.42%	70.58	4.89%	20.47
11:00 PM	1.32%	75.75	1.32%	75.59	0.78%	128.40	0.75%	132.94	1.09%	92.17	1.06%	94.00	1.75%	57.02	1.11%	89.90	3.62%	27.66

	Pas Veh	2axsu	3+axsu	3ax semi	4ax semi	5ax semi	TT/BUS	Twins
Pct 4 of 24	21.74%	28.31%	33.03%	29.17%	31.46%	28.84%	28.08%	16.35%
4 hr factor 9AM-1PM Class Count	**4.60**	**3.53**	**3.03**	**3.43**	**3.18**	**3.47**	**3.56**	**6.12**

Hourly Expanding

We can use the hourly traffic distributions above to calculate the estimated 24 hour volume by vehicle type. For an example, say we have a tube count from 11:00am-12:00pm grouped by vehicle type. The one hour volume is multiplied by the percentages above to get the daily (24 hour) volume by vehicle type used for forecasting. This data could then be added to the MnESAL Vehicle Class Expansion Worksheet.

VEH TYPE	1 HR				
PASS VEH	322	/	.0522	=	6169
2 AX SU	19	/	.0652	=	291
3+AX SU	25	/	.0814	=	307
3 AX SEMI	2	/	.0676	=	28
4 AX SEMI	4	/	.0831	=	48
5+ AX SEMI	20	/	.0678	=	295
TRKL TRLR/BUS	6	/	.0672	=	89
TW INS	0	/	.0397	=	0
TOTAL	398				2772

This method may be used on streets or roadways where vehicle class data is unavailable. A minimum of four hours that covers the morning or afternoon peak is recommended for project level forecasts. In this example, the forecast should request a special count to obtain more data.

DESIGN HOURLY VOLUME (DHV)

The design hourly volume is derived from the 30th highest hour in the year. The design hourly volume is similar to the peak hour volumes used primarily in the Metro area. In Greater Minnesota, we refer to the peak hour volumes as DHV or the 30th highest hour.

ATR and WIM sites are the only source from which we can obtain DHV. The data can be found at http://www.dot.state.mn.us/traffic/data/data-products.html under Volume listed as ATR/WIM Highest Volume Report. The design hourly volume is available by direction, but frequently requested for both directions. There is a DHV summary and AADT at the bottom of the report. The data is also available by month and hour.

A study of historical ATR data revealed that the average DHV is from 8% in town, and 10-13% out of town. The average 30th highest hour on a rural trunk highway is about 10% of the AADT. If the AADT is 3000, and you determine that DHV both directions is 10%. Then the DHV is 300, which is the maximum vehicles on the roadway per hour in both directions.

ESAL CONCEPT

An ESAL measures the amount of damage being done on a roadway over time. One ESAL is defined as an 18,000 pound load on a single axle with dual tires.

Below is a table of the ESAL factors for single and tandem axles by gross axle weight in pounds (lbs.). Using the ESAL factors below, consider a 5 axle semi-truck that has a 12,000 pound single axle (0.189) in the front and two 34,000 pound tandem axles (1.095). The ESAL factor for the 80,000 pound 5 axle semi is 2.39.

ESALs and 1 fully loaded 5-axle semi (80,000 lbs)

Axle Group	Weight	Flexible ESAL Factor
Front	12,000	0.19
Tandem	34,000	1.10
Tandem	34,000	1.10
	80,000	2.39 ESAL Factor

Example:
Consider that there are 50 5+axle semis:
50 (5+ axle semis) x 7308 (days in 20 years) x 2.40 (flex ESAL factor) = 876,960 ESALS

Note: 1 ESAL is equal to the damage to a flexible pavement caused by one 18,000 axle load

In this example, we considered that 50 fully loaded (80,000 pound) 5+ axle semis per day over the 20 year period of a bituminous roadway produces 876,960 ESALs for flexible pavement.

ESAL EQUIVALENCE FACTORS FOR FLEXIBLE PAVEMENT

18- Kip Axle Equivalence Factors Flexible Pavement

Gross Axle Load (lbs.)	Single Axles	Tandem Axles	**Gross Axle Load (lbs.)**	Single Axles	Tandem Axles
1,000	0.00002		**41,000**	23.27	2.29
2,000	0.00018		**42,000**	25.64	2.51
3,000	0.00072		**43,000**	28.22	2.75
4,000	0.00209		**44,000**	31	3
5,000	0.005		**45,000**	34	3.27
6,000	0.01043		**46,000**	37.24	3.55
7,000	0.0196		**47,000**	40.74	3.85
8,000	0.0343		**48,000**	44.5	4.17
9,000	0.0562		**49,000**	48.54	4.51
10,000	0.0877	0.00688	**50,000**	52.88	4.86
11,000	0.1311	0.01008	**51,000**		5.23
12,000	0.189	0.0144	**52,000**		5.63
13,000	0.264	0.0199	**53,000**		6.04
14,000	0.36	0.027	**54,000**		6.47
15,000	0.478	0.036	**55,000**		6.93
16,000	0.623	0.0472	**56,000**		7.41
17,000	0.796	0.0608	**57,000**		7.92
18,000	1	0.0773	**58,000**		8.45
19,000	1.24	0.0971	**59,000**		9.01
20,000	1.51	0.1206	**60,000**		9.59
21,000	1.83	0.148	**61,000**		10.2
22,000	2.18	0.18	**62,000**		10.84
23,000	2.58	0.217	**63,000**		11.52
24,000	3.03	0.26	**64,000**		12.22
25,000	3.53	0.308	**65,000**		12.96
26,000	4.09	0.364	**66,000**		13.73
27,000	4.71	0.426	**67,000**		14.54
28,000	5.39	0.495	**68,000**		15.38
29,000	6.14	0.572	**69,000**		16.26
30,000	6.97	0.658	**70,000**		17.19
31,000	7.88	0.753	**71,000**		18.15
32,000	8.8	0.857	**72,000**		19.16
33,000	9.98	0.971	**73,000**		20.22
34,000	11.18	1.095	**74,000**		21.32
35,000	12.5	1.23	**75,000**		22.47
36,000	13.93	1.38	**76,000**		23.66
37,000	15.5	1.53	**77,000**		24.91
38,000	17.2	1.7	**78,000**		26.22
39,000	19.06	1.89	**79,000**		27.58
40,000	21.08	2.08	**80,000**		28.99

TRUCK WEIGHTS AND AXLE CONFIGURATIONS

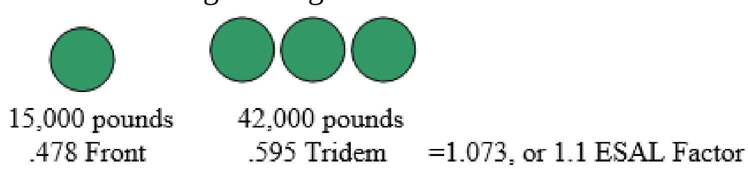
The table below is the standard ESAL factors in the MnESAL.

	ESAL FACTORS	
	FLEXIBLE	RIGID
2AX-6TIRE SU	0.25	0.24
3AX+ SU	0.58	0.85
3AX TST	0.39	0.37
4AX TST	0.51	0.53
5AX+ TST	1.13	1.89
(5AX+ TST MAX)	2.40	4.07
(5AX+ TST OTH)	0.87	1.44
TR TR, BUSES	0.57	0.74
TWIN TRAILERS	2.40	2.33

Sometimes it is necessary to change the ESAL factors for various heavy trunk movement when information becomes available. In the two examples below, the ESAL default is 0.58. However, both examples have a higher ESAL factor than the default. Therefore, the forecaster could change the ESAL factor in the MnESAL, but should only if they have information of heavier trucks on the roadway.

Examples of Configurations:

- A typical loaded 4 axle single unit gravel truck

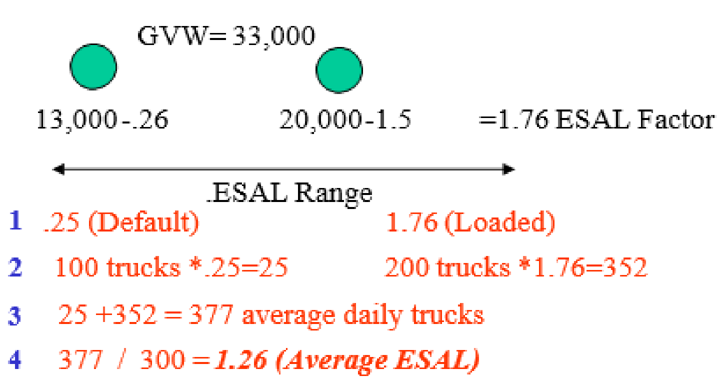


- A heavy 3 axle single unit gravel truck

Example of Modifying Default ESAL Values for Heavy Trucks

The information below are averages derived from the State Patrol and can be used to determine the weight for 2, 3, and 4 axle single unit gravel dump trucks loaded. The numbers include gross vehicle weight (GVW), front axle and rear group (tandem or tridem). Assume there are 100 unloaded trucks and 200 heavy loaded gravel trucks.

1. 2-axle dump truck – 33,000 GVW. Up to 13,000 steering axle and 20,000 drive axle



2. 3-axle dump truck – 45,000 GVW. Up to 13,000 steering axle and 34,000 tandem

GVW=47,000

13,000-.26 34,000-1.1 =1.36 ESAL Factor

ESAL Range

1 .58 (Default) 1.36 (Loaded)

2 100 trucks *.58=58 200 trucks *1.36=272

3 330 average daily trucks

4 330 / 300 = ***1.1(Average ESAL)***

3. 4-axle dump truck – 57,000 GVW. 14,000+ on steering axle and 43,000 tridem

GVW=57,000

14,000-.36 43,000-.66 =1.02 ESAL Factor

ESAL Range

1 .58 (Default) 1.02 (Loaded)

2 100 trucks *.58=58 200 trucks *1.02=204

3 58 +204 = 262 average daily ESAL

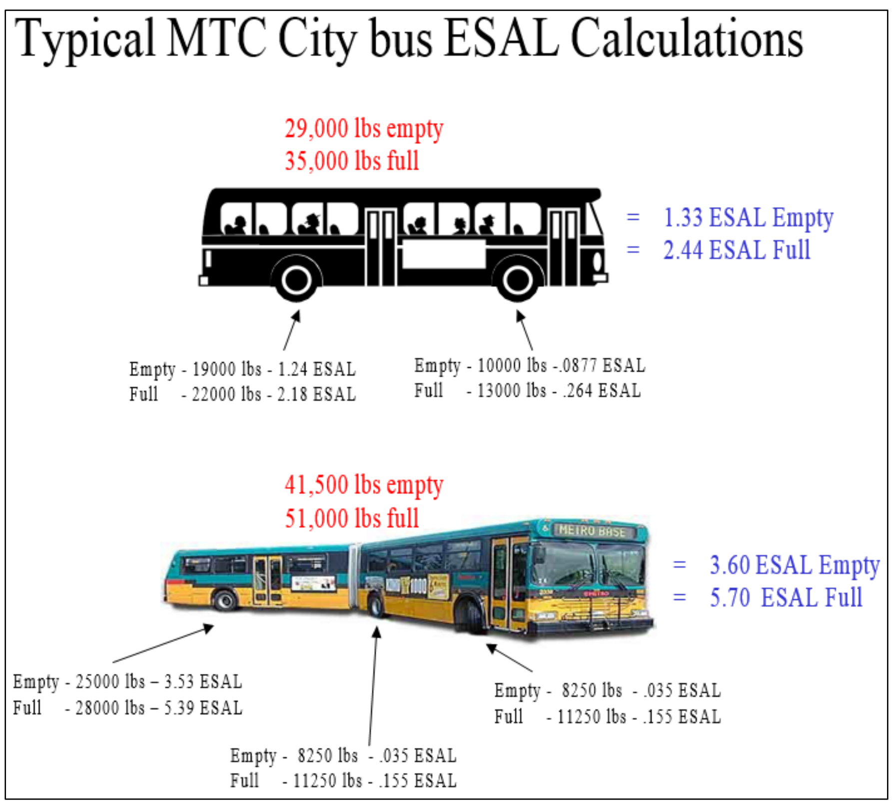
4 262 / 300 = ***0.87 (Average ESAL)***

All of the ESAL examples above have been for flexible ESALs. The rigid ESAL is the concrete equivalent to the bituminous number. The rigid ESALs are always higher than the flexible ESALs. The flexible and rigid ESALs do not relate to one another. They are results of the formula used in the process that develops the factors. The summation of total vehicle volumes by class are equal. The only difference is in the results of the formula.

Transit, Bus, and ESAL Information

Recent research has shown that in many cases ESALS have been underestimated for buses, especially heavy loaded regular and articulated Metropolitan Transport Corporation (MTC) buses. A regular MTC bus is 40 feet. It weighs about 29,000 pounds empty and about 35,000 pounds full (150 pound person with 43 seats). An articulated MTC bus has 3 axles and is 60 feet long. It weighs about 41,500 pounds empty and 51,000 pounds full (150 pound person with 65 seats).

Our current ESAL factors for buses (which we lump in with truck trailers) is 0.51 for flexible and 0.53 for rigid. Therefore, if a forecaster knows their route is a bus lane facility and contains MTC buses, they should increase the ESAL factors on the A and B ESAL worksheet(s) in the MnESAL.



Sugar Beet Routes

The data below was taken on a sugar beet hauling route. These routes show additional 4 axle semis and 5 axle semis that should be added to the Vehicle Type Breakdown for ESAL Calc. Trucks are underestimated when the data is not taken during the sugar beet hauling season, therefore, trucks have to be added to the data. These additional trucks are assumed to be spread out over the entire year. It is important to accurately estimate the number of heavy trucks because they have the largest impact on ESALs. Below is the bottom portion of tube data taken on a sugar beet hauling route. In this example, the raw data that is entered in the MnESAL on the expansion worksheet would be (51 + 56) = 107 for 4 axle semis and (34 + 66) = 100 for 5+ axle semis.

DIRECTION TOTALS	18	327	204	4	67	14	0	8	19	1	0	0	0	
% of Total Vehicles	56%	48%	52%	36%	72%	52%	0%	53%	33%	13%				
SITE TOTALS	32	683	392	11	93	27	19	15	57	8	0	0	0	1337

Veh Type Breakdown for ESAL Calc	MotoCycl	PASS VEH	2 AX SU	3+ AX SU	3 AX SEMI	4 AX SEMI	5+ AX SEMI	TRKTLR/BUS	TWINS	TOTAL	%HC
	16	538	47	23	3	56	66	6	0	755	26.6%

This Site Is Located On A Sugar Beet Hauling Route

51 Four Axle Trucks Added to Veh Type Breakdown for ESAL Calc

34 Five Axle Trucks Added to Veh Type Breakdown for ESAL Calc, 1/2 are Heavies

ESAL THRESHOLDS

Forecasters should show more concern of forecasts that are at or near a threshold.

County Road Thresholds

Category	ESALs
Low	Less than 250,000
Medium	250,000 – 600,000
High	600,000 – 1,000,000

Truck Highway Thresholds

Category	ESALs
Very Low	Less than 300,000
Low	300,000 – 1,000,000
Medium	1,000,000 – 7,000,000
High (Choice of Bituminous or Concrete)	7,000,000 – 10,000,000
Very High (Concrete)	10,000,000 and Greater

PAVEMENT SECTION PROCESS AND ESALS

(From Technical Memorandum No. 04-06-MAR-01)

There are three pavement section process categories:

1. **District Process** – where short projects meet the following criteria:
    - Two-Lane Roadways – Projects less than 2 miles long
    - Projects less than 30,000 square yards

    The projects length/size listed above are determined using only the driving lanes, no turn lanes, parking lanes or auxiliary lanes.

2. **Informal Process** - involves determining the pavement type based on the amount of traffic, as measured by the length-weighted Bituminous Equivalent Standard Axle Loads (BESALs), and the sub grade soil strength.
    - *Informal Flexible*: Projects where the 20-year design lane BESALS (flexible /bituminous) are 7 million or less and the design sub grade R-value is greater than 40. Projects in this category will be constructed with bituminous.
    - *Informal Rigid*: Projects where the 20-year design lane BESALS exceed 10 million. Projects in this category will be constructed with concrete.

3. **Formal Process** – All projects not meeting the Informal criteria listed above. The pavement type will be determined by a detailed cost estimate

Pavement Selection Process and Design Options

20 Year Design Lane BESALs	Subgrade Soil R-Value	Process Type Design(s)	Description of Design(s)
1,000,000 or less	>40	Informal Flexible Design #6	Flexible - Aggregate Base (BAB) Flexible - Deep Strength (BDS)
1,000,000 or less	<=40	Formal Design #3 & 6	Rigid - Aggregate Base Flexible - Aggregate Base (BAB) Flexible - Deep Strength (BDS)
1,000,001 to 7,000,000	>40	Informal Flexible Design #4 & 5	Flexible - Aggregate Base (BAB) Flexible - Deep Strength (BDS)
1,000,001 to 7,000,000	<=40	Formal Design #1,2,4 & 5	Rigid - Open Graded Base Rigid - Selected Granular Flexible - Aggregate Base (BAB) Flexible - Deep Strength (BDS)
7,000,001 to 10,000,000	All Values	Formal Design #1,2,4 & 5	Rigid - Open Graded Base Rigid - Selected Granular Flexible - Aggregate Base (BAB) Flexible - Deep Strength (BDS)
Over 10,000,000	All Values	Informal Rigid Design #1 and 2	Rigid - Aggregate Base Rigid - Open Graded Base

MNPAVE

A program called MnPAVE is being used for flexible pavement design purposes. An ESAL combined with an R-value determines structural design. The MnPAVE model inputs such as climate, road structure, and load spectra may be used to determine potential pavement designs. Thus, in the future, ESALs might no longer be produced, rather, we will be providing designers with traffic inputs necessary to use the new American Association of State Highway Officials (AASHTO) pavement design software.

ADDITONAL PRODUCTS

Planning Tool

Every year it is a federal requirement that the Traffic Data & Analysis section produces a 20 year forecasted AADT and HCAADT on every segment of roadway in Minnesota. The planning tool uses least squares linear regression to calculate the 20 year projections and an annual growth rate for both AADT and HCAADT. The segments are identified by sequence number. Additional fields include county, district, route system, route number, location description, route identification, beginning and ending true miles, beginning and ending reference points, vehicle class site, historical AADT and heavy commercial as a percent of AADT.

Other than actual historical data, the 20 year forecasted volumes are only to be used for system wide or district planning purposes. They are not to be used for project specific analysis or project level forecasting. Contact the Traffic Forecast & Analysis section to receive information from the Planning Tool.

ESAL Forecasting Tool

Annually, a historical record is updated with the new expanded historical vehicle class data by site. This spreadsheet contains the same expanded vehicle class data derived from the MnESAL process. This data is the output from the expansion of raw counts that shows up on the Vehicle Class Count Averages Worksheet. Using the expanded data, the ESAL Forecasting Tool calculates the 10, 15, 20, 25, 30, and 35 year flexible and rigid ESALs from the entered base year. The spreadsheet also shows the yearly actual and estimated HCAADT. Additional fields include district, county, location description, route, axle correction factor (ACF), HC%, number of lanes, design lane factor (DLF), annual growth rate, beginning and ending true miles, and beginning and ending reference points.

The ESAL Forecasting Tool is to be used for preliminary ESAL planning for resurfacing and reconditioning projects. Contact the Traffic Forecast & Analyst section to receive information and data regarding this tool.

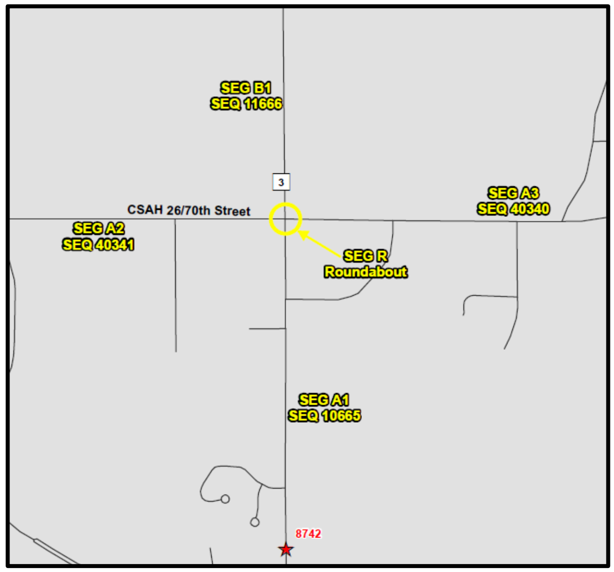
ESAL Calculator

This tool was created by State Aid and is used to estimate the 20 and 35 year flexible and rigid ESALs on low AADT roadways. Inputs are project information, base year, number of lanes, and four years of historical AADT data. The ESAL default factors are used to calculate the forecasted ESALs. The ESAL calculator can be found at this link under Pavement Design Tools: http://www.dot.state.mn.us/stateaid/pavement.html.

Contact State Aid Pavement Engineer, Joel Ulring at Joel.Ulring@state.mn.us if you have any questions regarding this tool.

Roundabout Tool

When forecasting a roundabout, the forecaster needs to know the AADT and vehicle class data on all four legs on the roundabout. The urban or rural vehicle type defaults should be used on the legs that do not contains vehicle class data. To the right is an example of a roundabout at MN 3 and CSAH 26/70th Street in Inver Grove Heights.



The forecaster should first input the data of all four legs into the MnESAL. Then copy the AADT and vehicle class volumes for base year and future year from the ESAL worksheets into the roundabout tool (shown in red below).

CUMULATIVE ESALS WORKSHEET — SEGMENT A1

SP#: 1908-74
ROUTE: MN 3 — # LANES: 2 — DATE: 01/12/17
LOCATION: MN 3, S of CSAH 26/70th Street
VCL SITE #: 8742

	YEAR	AADT	CALC HCADT	INIT CALC 5AX TST
BASE YEAR:	2018	$\boxed{7520}$	278	24
FORECAST YEAR:	2038	$\boxed{16990}$	628	54

BASE YEAR PROPORTIONS		BASE YR. VOLUME	Additonal Trucks	FORECAST %	FUTURE VOL.
2AX-6TIRE SU	1.7%	127	0	1.7%	287
3AX+ SU	0.6%	42	0	0.6%	95
3AX TST	0.0%	3	0	0.0%	6
4AX TST	0.1%	6	0	0.1%	13
5AX+ TST	0.3%	24	0	0.3%	54
(5AX+ TST MAX)	0.0%	0	0	0.0%	0
(5AX+ TST OTH)	0.0%	0	0	0.0%	0
TR TR, BUSES	1.0%	77	0	1.0%	173
TWIN TRAILERS	0.0%	0	0	0.0%	1

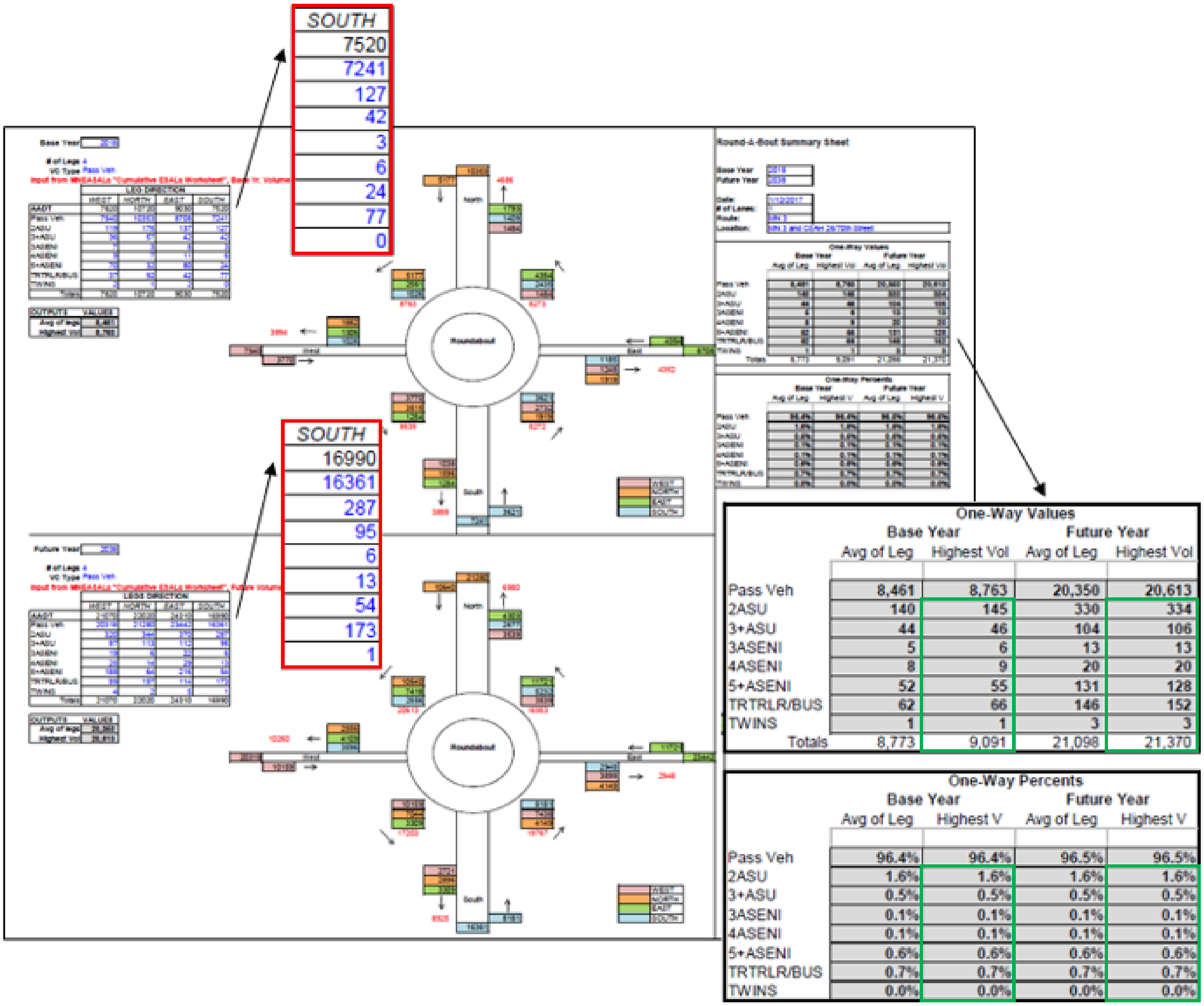
SUMMARIES:		AADT	HCADT	HCADT %	20 YR DESIGN LANE CUMULATIVE ESAL	
2018	FORECAST:	7520	278	3.7%		
2038	FORECAST:	16990	628	3.7%		
					FLEXIBLE	RIGID
DESIGN LANE FACTOR:		0.5			955,000	1,246,000

ADDITIONAL OUTPUTS:

	BASE %	FORECAST %	ESAL FACTORS FLEXIBLE	ESAL FACTORS RIGID
2AX-6TIRE SU	1.7%	1.7%	0.25	0.24
3AX+ SU	0.6%	0.6%	0.58	0.85
3AX TST	0.0%	0.0%	0.39	0.37
4AX TST	0.1%	0.1%	0.51	0.53
5AX+ TST	0.3%	0.3%	1.13	1.89
(5AX+ TST MAX)	0.0%	0.0%	2.40	4.07
(5AX+ TST OTH)	0.0%	0.0%	0.87	1.44
TR TR, BUSES	1.0%	1.0%	0.57	0.74
TWIN TRAILERS	0.0%	0.0%	2.40	2.33

Notes:

Once the data is in the roundabout tool for all four legs, then the roundabout data will show in the gray box on the right side (shown below). There is data for the average of all four legs and the leg with the highest volume. The forecaster should use the highest volume because the legs with volumes lower than the average will be underestimated. It is always better to overestimate ESALs so the design of the road will last longer. Next, copy the highest volume vehicle class data and percentages into the ESAL worksheet of the MnESAL for the roundabout (shown in green below).



Now the forecaster has the ESALs for all four legs of the roundabout and the actual roundabout itself.

CUMULATIVE ESALS WORKSHEET — **SEGMENT R (Roundabout)**

SP#: 1908-74
ROUTE: MN 3 — # LANES: 1 — DATE: 01/12/17
LOCATION: Mn 3 and CSAH 26/70th Street
VCL SITE #: 8742

	YEAR	AADT	CALC HCADT	INIT CALC 5AX TST
BASE YEAR:	2018	9091	328	55
FORECAST YEAR:	2038	21370	769	128

BASE YEAR PROPORTIONS		BASE YR. VOLUME	Additonal Trucks	FORECAST %	FUTURE VOL.
2AX-6TIRE SU	1.6%	145	0	1.6%	334
3AX+ SU	0.5%	46	0	0.5%	106
3AX TST	0.1%	6	0	0.1%	13
4AX TST	0.1%	9	0	0.1%	20
5AX+ TST	0.6%	55	0	0.6%	128
(5AX+ TST MAX)	0.0%	0	0	0.0%	0
(5AX+ TST OTH)	0.0%	0	0	0.0%	0
TR TR, BUSES	0.7%	66	0	0.7%	152
TWIN TRAILERS	0.0%	1	0	0.0%	3

SUMMARIES:		AADT	HCADT	HCADT %
2018	FORECAST:	9090	328	3.6%
2038	FORECAST:	21370	769	3.6%

20 YR DESIGN LANE CUMULATIVE ESAL

FLEXIBLE	RIGID
2,545,000	3,462,000

DESIGN LANE FACTOR: 1

ADDITIONAL OUTPUTS:

	BASE %	FORECAST %	ESAL FACTORS FLEXIBLE	ESAL FACTORS RIGID
2AX-6TIRE SU	1.6%	1.6%	0.25	0.24
3AX+ SU	0.5%	0.5%	0.58	0.85
3AX TST	0.1%	0.1%	0.39	0.37
4AX TST	0.1%	0.1%	0.51	0.53
5AX+ TST	0.6%	0.6%	1.13	1.89
(5AX+ TST MAX)	0.0%	0.0%	2.40	4.07
(5AX+ TST OTH)	0.0%	0.0%	0.87	1.44
TR TR, BUSES	0.7%	0.7%	0.57	0.74
TWIN TRAILERS	0.0%	0.0%	2.40	2.33

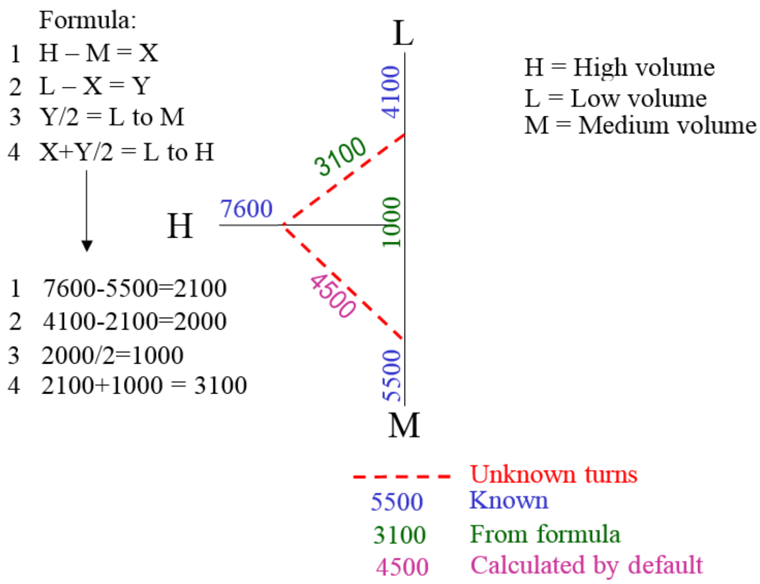
Notes:

ADDITIONAL FORECAST KNOWLEDGE

Obtaining Data from a 3 Legged Intersection

Below are formulas to calculate the unknown volume of a leg if the volume of the other two legs are known

Sample of a 3 legged intersection



Traffic Forecasting from Proposed (Non-Existent) Roadways

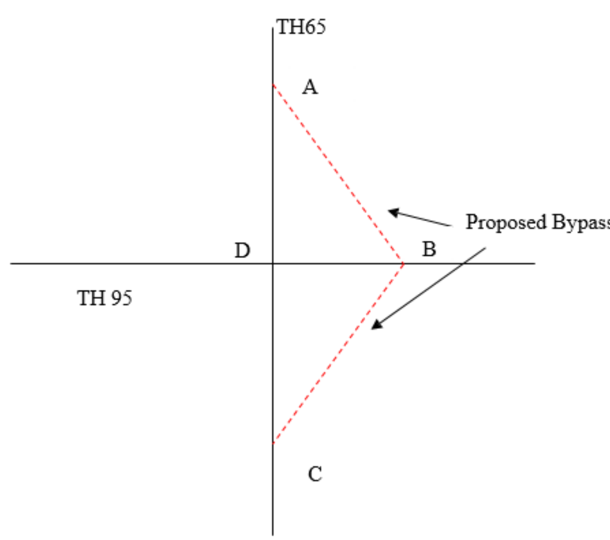
This section is designed to outline the procedures for completing traffic and load forecasts on new roadways such as bypasses, new alignments, or new routes for which there is no existing route serving a similar trip purpose.

The forecaster must use their best judgment as to which and how many vehicle class sites should be used to represent all or a portion of the new roadways or new alignment. The forecaster may use an average of two or more vehicle class site percentages to represent the movement on a particular roadway. It is important to distinguish where the truck movements originate from and where it is headed. This will ultimately help determine the vehicle type percentages affecting any particular roadway.

Bypass

A bypass is generally constructed around a city for the purpose of removing through traffic from a local street. The bypass example below was recently constructed on a portion of TH 65 around the east side of the city of Cambridge in Isanti County. The designers needed to know the projected traffic volumes for the base year, the forecasted 20 year, and forecasted 35 year cumulative ESALS to construct the bypass properly.

The traffic that currently uses TH 65 is the maximum number of vehicles that could be assigned to the new bypass. However, not all traffic is through traffic. The schematic diagram below shows the general layout for the bypass.



How to determine the percent of through traffic?

In general, the larger the town or city the fewer the number of through trips it will have. Practice has shown that small towns that have a population less than 5000 will usually have from 70 to 85% through trips. The only reliable way to determine the through trip percentage is to perform an Origin/Destination (O-D) study.

Origin and destination studies can be accomplished by a license plate matching study, a driver interview, or by following vehicles to find their destinations. A license plate matching study is performed by recording the license plates of vehicles entering and leaving the study area and at relevant locations within the study area. In the example above, license plates should be recorded for both directions of traffic at points A, B, C and D. Ideally, the study should run from 6 AM – 9 AM, 10 AM – 2 PM and 3 PM – 6PM. Unfortunately, you may not be able to collect data for that length of time. At minimum, data should be collected during either the AM or PM peak period and for 2 hours during the off-peak period of 10 AM – 2 PM.

Once the data has been collected, vehicles that travel from points A to C through D or through B within a specified amount of time, can be assigned to the bypass. Once the percentages of through trips and destinations in town trips have been calculated they can be applied to the base and design year AADTs projected using least squares regression analysis.

For the above example, let's assume that at point A we collected license plate data from 1000 southbound vehicles and 1000 northbound vehicles in the 10 hours arranged above. Assume that the AADT at this location is 4000. The data collected yielded the following matches: A-B or B-A = 500, A-C or C-A = 1300, A-D or D-A = 1960. The next step would be to double all of the point-to-point movements, thus bringing the 2000 counted vehicles up to the 4000 AADT.

All of the vehicles that travel from points A to C or C to A can be assigned to the entire length of the bypass. Vehicles that travel through points A-B or B-A can be assigned to the A to B portion of the bypass. Similarly, vehicles traveling from points B-C or C-B can be assigned to the C to B portion of the bypass. Some portion of the vehicles that pass through points A-D and C-D that turn east at D can be assigned to the appropriate portion of the bypass if their destinations were near the bypass. Also, vehicles that appeared at A or C and passed through D but not C or A may be assigned to portions of the bypass depending on the destinations, the access and the decrease in trip time caused by using the faster bypass.

The only other vehicles that should be considered for assignment to the bypass are the additional trips that will be generated by new construction of businesses and residential developments that are located near the bypass after it is built. To answer these questions, the forecaster has to get information from the city regarding land development plans. The additional vehicle trips generated from new development can be calculated using the Institution of Transportation Engineers' (ITE) manual on Trip Generation. The ITE manual is organized by development type of the average number of trips generated by square footage, the number of residential houses, or the number of employees at new businesses.

New Alignment

The second type of forecast where the road does not currently exist is a new alignment. When forecasting future traffic and loadings for a new alignment the forecaster must know if the in place alignment will remain or if it will be closed. The other issue to consider is whether or not the access points remain the same. If the access points change vehicles must be reassigned to the appropriate road segments. If the current alignment is going to be closed, all traffic that is currently using the route can be reassigned to the new alignment. The forecaster should produce this type of forecast in the same manner as any other major construction project. If the old alignment is going to remain open to traffic, an Origin/Destination (O-D) study is necessary and the forecasting method for a bypass should be used.

New Route

The last type of new road construction is a new route with no existing route serving the same trip purpose. In this case, all of the traffic must be assigned by using trip generation information from the Institution of Transportation Engineers' (ITE) manual. The volume and heavy commercial vehicle types, using the appropriate defaults, plus the addition of trucks based on the proposed developments are used to forecast.

TRAFFIC TERMINOLOGY AND DEFINITIONS

Annual Average Daily Traffic (AADT) – the estimate of daily traffic on a road segment represented by the total traffic on a segment that occurs in a one year period divided by 365.

Average Daily Traffic (ADT) – a 24-hour traffic volume that should be stated with a time period. (Ex: MADT – monthly average daily traffic, or ADT for 6/21/2011-6/23/2011)

Average Summer Weekday Traffic (ASWDT) – the average Monday through Friday traffic volume on a road segment from June through August.

Vehicle Classification – the classification of traffic by vehicle types. (Ex: cars, trucks, single unit trucks, semis with single or twin trailers, etc.)

Vehicle Type Breakdown – a specific vehicle with the following differences; motorcycles, cars, pickups, 2 axle single units, 3 or more axle single units, 3 axle semis, 4 axle semis, 5 or more axle semis, buses, trucks with trailers, and twin trailer semis.

Heavy commercial vehicle – all vehicles with at least two axles and six tires.

Heavy Commercial Annual Average Daily Traffic (HCAADT) – The estimate of daily heavy commercial traffic on a road segment represented by the total heavy commercial traffic on a segment that occurs in a one year period divided by 365.

Equivalent Single Axle Load (ESAL) factor – a numeric factor that represents the average effect of each vehicle type on the pavement based on the equivalent load concept. The concept relates the effect that the axles have on pavement performance compared to the effect of a single 18,000 pound axle.

Average Daily Load (ADL) – the estimate of a daily load on a roadway segment calculated from the daily total vehicle type multiplied by their appropriate ESAL factors.

Axle Load – the total load transmitted by all wheels in a single, tandem, or tridem axle configuration extending across the full width of the vehicle.

Maximum Loaded Vehicle – a heavy commercial vehicle that is usually loaded to the legal gross weight limit. (Ex: tank truck, dump truck, grain truck, and stake loaded truck)

Annual Design Lane ESAL – the estimate of the total ESAL in the design lane of a roadway segment for a period of one year.

Design Hour Volume (DHV) – the traffic for a selected hour of the day - usually the 30th highest hour of the year for Greater Minnesota and the peak hour for the Metro Area.

Design Lane Factor (DLF) – the factor to estimate traffic volume and truck components on the heaviest traveled lanes.

Directional Distribution (DD) – the split of traffic by direction for a selected period of time, usually the design hour. (Ex: 50/50, where north or east direction is the first number and south or west is the second number)

Tube Counters – The portable devices used to count axles and vehicle class based on their axle spacing.

Automatic Traffic Recorders (ATR) – Devices with loops in the pavement that continuously collect traffic volume and sometimes vehicle classification and/or speed data.

Weigh in Motion (WIM) – a permanent device that continually collects and stores volume, axle spacing, length, speed, vehicle type, and weight data.

APPENDIX

1980-2010 Seasonal Adjustment Factors

The following tables show the historical 24 hour seasonal adjustment factors for MnDOT's eight vehicle type categories in urban and rural areas.

Seasonal adjustment factors were first developed in the 1980's. The factors were developed averaging the five weigh in motion (WIM) sites we had at that time. This resulted in adjustment factors for each vehicle type by month for Monday through Friday counts. In 2007, we revisited the adjustment factors based on 15 continuous classification counter (ATR) sites. The adjustment factors were updated in 2008, and 2009. In 2010, 7 WIMs and 16 ATR sites were used to update the adjustment factors.

1980's Seasonal Adjustment Factors

Body Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CARS+PICKUP	1.14	1.06	1.04	0.99	0.94	0.87	0.87	0.83	0.92	0.96	0.99	1.02
2ASU	1.19	1.07	1.06	0.92	0.74	0.72	0.80	0.78	0.65	0.72	0.87	1.00
3+ASU	1.09	1.05	1.29	1.15	0.72	0.60	0.70	0.65	0.61	0.63	0.84	1.06
3A SEMI	1.18	1.13	1.31	0.94	0.66	0.68	0.75	0.73	0.72	0.86	0.93	1.27
4A SEMI	1.04	1.00	1.09	0.94	0.71	0.66	0.71	0.63	0.76	0.75	0.85	1.03
5+A SEMI	1.00	0.94	0.94	0.87	0.75	0.69	0.80	0.69	0.70	0.74	0.78	0.91
TT/BUS	1.19	1.07	1.06	0.92	0.74	0.72	0.80	0.78	0.65	0.72	0.87	1.00
TWINS	1.00	0.94	0.94	0.87	0.75	0.69	0.80	0.69	0.70	0.74	0.78	0.91

2007 24 Hour Seasonal Adjustment Factors for Urban Areas

Body Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CARS+PICKUP	1.10	1.04	1.02	0.98	0.98	0.95	0.90	0.89	0.85	0.98	1.05	1.13
2ASU	0.90	0.92	0.88	0.84	0.80	0.91	0.80	0.75	0.67	0.81	0.88	0.95
3+ASU	1.19	1.20	1.15	0.88	0.79	0.84	0.68	0.67	0.58	0.61	0.74	1.00
3A SEMI	1.12	1.10	1.03	0.90	0.84	0.86	0.79	0.67	0.67	0.89	0.83	1.08
4A SEMI	1.12	1.10	1.03	0.90	0.84	0.86	0.79	0.67	0.67	0.89	0.83	1.08
5+A SEMI	0.87	0.88	0.86	0.81	0.79	0.83	0.71	0.71	0.66	0.75	0.90	0.94
TT/BUS	1.41	1.33	1.16	1.03	0.93	0.86	0.77	0.62	0.59	0.78	0.88	1.17
TWINS	0.89	0.85	0.82	0.75	0.78	0.91	0.83	0.72	0.70	0.75	0.89	0.88

2007 24 Hour Seasonal Adjustment Factors for Rural Areas

Body Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CARS+PICKUP	1.31	1.26	1.22	1.13	0.97	0.88	0.81	0.84	0.95	1.03	1.13	1.20
2ASU	1.04	1.08	1.07	0.97	0.88	0.85	0.85	0.83	0.81	0.83	0.93	0.96
3+ASU	1.34	1.44	1.28	0.93	0.81	0.61	0.71	0.69	0.70	0.70	0.85	1.25
3A SEMI	1.57	1.54	1.49	1.22	0.90	0.82	0.73	0.68	0.74	0.88	1.10	1.27
4A SEMI	1.57	1.54	1.49	1.22	0.90	0.82	0.73	0.68	0.74	0.88	1.10	1.27
5+A SEMI	0.98	0.90	0.86	0.82	0.78	0.72	0.77	0.75	0.76	0.74	0.88	0.93
TT/BUS	2.05	2.06	1.55	1.11	0.87	0.74	0.71	0.67	0.70	0.79	1.01	1.58
TWINS	1.42	0.95	0.94	0.94	0.86	0.87	0.83	0.66	0.69	0.61	0.76	0.89

2008 24 Hour Seasonal Adjustment Factors for Urban Areas

Body Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CARS+PICKUP	1.13	1.07	1.07	1.02	0.95	1.00	0.91	0.88	0.95	0.94	0.98	1.06
2ASU	0.99	0.88	0.93	0.91	0.80	0.85	0.81	0.80	0.78	0.78	0.81	0.94
3+ASU	1.14	1.05	1.14	0.98	0.72	0.70	0.64	0.69	0.64	0.66	0.78	1.14
3A SEMI	1.29	1.11	1.21	1.04	0.78	0.80	0.71	0.65	0.75	0.79	0.99	1.45
4A SEMI	1.29	1.11	1.21	1.04	0.78	0.80	0.71	0.65	0.75	0.79	0.99	1.45
5+A SEMI	0.93	1.00	0.93	0.90	0.74	0.77	0.69	0.75	0.71	0.75	0.81	1.02
TT/BUS	1.26	0.99	0.97	0.97	0.72	0.73	0.68	0.72	0.72	0.75	0.98	1.56
TWINS	0.86	0.86	0.86	0.86	0.78	0.81	0.77	0.77	0.77	0.75	0.80	0.96

2008 24 Hour Seasonal Adjustment Factors for Rural Areas

Body Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CARS+PICKUP	1.18	1.13	1.15	1.19	0.95	0.92	0.85	0.85	0.94	0.97	1.06	1.18
2ASU	0.90	0.89	0.92	0.91	0.72	0.83	0.77	0.82	0.89	0.94	0.92	1.02
3+ASU	1.19	1.20	1.06	1.12	0.81	0.70	0.81	0.74	0.63	0.60	0.73	1.03
3A SEMI	1.05	1.08	1.16	0.97	0.71	0.79	0.69	0.90	1.04	1.26	1.58	1.77
4A SEMI	1.05	1.08	1.16	0.97	0.71	0.79	0.69	0.90	1.04	1.26	1.58	1.77
5+A SEMI	0.85	0.84	0.84	0.86	0.74	0.80	0.85	0.76	0.70	0.76	0.80	0.91
TT/BUS	1.50	1.40	1.39	1.05	0.64	0.67	0.66	0.67	0.72	0.82	1.13	1.83
TWINS	0.86	0.97	0.94	0.80	0.68	0.73	0.74	0.79	0.70	0.93	0.79	0.96

2009 24 Hour Seasonal Adjustment Factors for Urban Areas

Body Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CARS+PICKUP	1.10	1.10	1.08	0.97	0.92	0.90	0.88	0.86	0.97	0.95	0.96	1.09
2ASU	1.03	0.96	0.97	0.84	0.78	0.79	0.79	0.76	0.84	0.76	0.81	0.87
3+ASU	1.08	1.22	1.16	0.89	0.69	0.64	0.64	0.60	0.64	0.69	0.79	0.99
3A SEMI	1.47	1.27	1.31	0.96	0.83	0.80	0.76	0.70	0.70	0.76	0.80	1.12
4A SEMI	1.47	1.27	1.31	0.96	0.83	0.80	0.76	0.70	0.70	0.76	0.80	1.12
5+A SEMI	0.99	0.98	0.95	0.82	0.72	0.67	0.66	0.65	0.74	0.75	0.83	1.00
TT/BUS	1.25	1.26	1.17	0.89	0.74	0.68	0.65	0.62	0.66	0.74	0.89	1.33
TWINS	1.04	1.03	1.05	0.82	0.76	0.77	0.69	0.67	0.74	0.86	0.88	0.99

2009 24 Hour Seasonal Adjustment Factors for Rural Areas

Body Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CARS+PICKUP	1.19	1.18	1.16	1.01	0.87	0.87	0.80	0.85	0.88	0.93	0.98	1.22
2ASU	1.18	1.11	1.03	0.94	0.83	0.85	0.82	0.82	0.90	0.89	1.01	1.05
3+ASU	1.36	1.30	1.17	1.03	0.75	0.74	0.76	0.69	0.62	0.68	0.86	1.03
3A SEMI	1.42	1.42	1.37	1.19	0.73	0.71	0.70	0.76	0.78	0.98	1.12	1.36
4A SEMI	1.42	1.42	1.37	1.19	0.73	0.71	0.70	0.76	0.78	0.98	1.12	1.36
5+A SEMI	0.84	0.81	0.89	0.85	0.84	0.83	0.77	0.83	0.70	0.77	0.79	0.89
TT/BUS	1.86	1.70	1.44	1.05	0.67	0.76	0.61	0.76	0.79	0.95	1.11	1.57
TWINS	1.12	0.93	1.06	0.91	0.83	0.72	0.64	0.79	0.74	0.86	0.85	0.93

2010 24 Hour Seasonal Adjustment Factors for Urban Areas												
Body Type	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
CARS+PICKUP	1.11	1.07	1.05	0.99	0.95	0.95	0.90	0.87	0.92	0.95	1.00	1.09
2ASU	0.97	0.92	0.92	0.87	0.79	0.85	0.80	0.77	0.77	0.78	0.83	0.92
3+ASU	1.14	1.16	1.15	0.92	0.73	0.73	0.65	0.65	0.62	0.65	0.77	1.04
3A SEMI	1.29	1.16	1.18	0.97	0.82	0.82	0.75	0.67	0.70	0.81	0.87	1.22
4A SEMI	1.29	1.16	1.18	0.97	0.82	0.82	0.75	0.67	0.70	0.81	0.87	1.22
5+A SEMI	0.93	0.95	0.92	0.84	0.75	0.76	0.69	0.70	0.70	0.75	0.85	0.98
TT/BUS	1.31	1.19	1.10	0.96	0.80	0.76	0.70	0.66	0.66	0.76	0.92	1.35
TWINS	0.93	0.91	0.91	0.81	0.77	0.83	0.76	0.72	0.73	0.79	0.86	0.95

2010 24 Hour Seasonal Adjustment Factors for Rural Areas												
Body Type	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
CARS+PICKUP	1.23	1.19	1.18	1.11	0.93	0.89	0.82	0.84	0.92	0.98	1.05	1.20
2ASU	1.04	1.03	1.01	0.94	0.81	0.84	0.81	0.83	0.87	0.88	0.96	1.01
3+ASU	1.30	1.31	1.17	1.03	0.79	0.68	0.76	0.71	0.65	0.66	0.82	1.10
3A SEMI	1.35	1.35	1.34	1.13	0.78	0.77	0.71	0.78	0.86	1.04	1.27	1.47
4A SEMI	1.35	1.35	1.34	1.13	0.78	0.77	0.71	0.78	0.86	1.04	1.27	1.47
5+A SEMI	0.89	0.85	0.86	0.84	0.79	0.78	0.80	0.78	0.72	0.75	0.82	0.91
TT/BUS	1.80	1.72	1.46	1.07	0.73	0.72	0.66	0.70	0.74	0.85	1.08	1.66
TWINS	1.13	0.95	0.98	0.88	0.79	0.77	0.74	0.75	0.71	0.80	0.80	0.93

Rural and Urban defaults by AADT Range

The defaults used in the MnESAL were developed primarily for use in the Seven County Metropolitan Area. The chart below show the default percentages by AADT range. These percentages should only be used in special projects off of the truck highway system.

Rural and Urban County State Aid Highway (CSAH) Heavy Commercial Percentages

Rural AADT	Car	2ASU	3+AXSU	3ASEMI	4ASEMI	5+ASEMI	TT/BUS	TWINS	HCPCT
1-300	86.72%	4.71%	2.24%	0.35%	0.71%	3.81%	1.45%	0.01%	13.28%
301-750	86.56%	3.44%	2.17%	0.39%	0.69%	5.32%	1.40%	0.03%	13.44%
751-1500	90.53%	3.69%	1.71%	0.33%	0.57%	2.10%	1.03%	0.02%	9.47%
1500>	91.39%	2.32%	1.24%	0.16%	0.32%	3.33%	1.23%	0.01%	8.61%

Urban AADT	Car	2ASU	3+AXSU	3ASEMI	4ASEMI	5+ASEMI	TT/BUS	TWINS	HCPCT
1-300	95.60%	1.60%	0.40%	0.40%	0.40%	0.40%	1.20%	0.00%	4.40%
301-750	92.53%	3.70%	1.62%	0.14%	0.24%	1.23%	0.48%	0.07%	7.47%
751-1500	94.71%	2.14%	0.98%	0.19%	0.30%	0.94%	0.71%	0.02%	5.29%
1500>	96.44%	1.52%	0.46%	0.09%	0.12%	0.89%	0.47%	0.02%	3.56%

Double Tube Data

Below is an example of double tube count data. Tube counts are taken for 48 hours each direction. The counts are collected hourly. The first page shows the vehicles traveling east (not shown) and the second page shows the vehicles traveling west. The 13 vehicle class breakdown is listed on the top of the table. Note that some counts have bus and heavy truck with trail separated.

Site 9151 **Route** TH 23 **Description** E OF JCT TH18 N OF I-35 **County** PINE **DIST** 1

	DATE	TIME	M-CYCLE	CAR	P/U	BUS/HTWT	2AXSU	3AXSU	4+AXSU	3+4SEMI	5AXSEMI	6+AXSEMI	TWINS	TWINS	TWINS	OTHERS	
West	10/07/14	11:00	0	23	11	0	1	1	0	1	1	1	0	0	0		
	10/07/14	12:00	0	46	19	1	0	1	1	1	1	0	0	0	0		
	10/07/14	13:00	0	43	19	0	0	0	1	0	2	1	0	0	0		
	10/07/14	14:00	0	66	17	0	1	0	1	0	4	0	0	0	0		
	10/07/14	15:00	0	67	31	0	9	1	0	0	4	0	0	0	0		
	10/07/14	16:00	0	69	29	1	1	2	0	0	2	0	0	0	0		
	10/07/14	17:00	0	86	23	0	0	2	0	0	2	0	0	0	0		
	10/07/14	18:00	0	36	14	0	2	2	0	0	1	1	0	0	0		
	10/07/14	19:00	0	26	15	0	0	1	0	0	3	0	0	0	0		
	10/07/14	20:00	0	21	7	1	0	1	0	0	0	0	0	0	0		
	10/07/14	21:00	0	17	2	0	0	0	0	0	0	0	0	0	0		
	10/07/14	22:00	0	14	3	0	0	0	0	0	0	0	0	0	0		
	10/07/14	23:00	0	16	0	0	0	0	0	0	0	0	0	0	0		
	10/08/14	0:00	0	6	0	0	0	0	0	0	0	0	0	0	0		
	10/08/14	1:00	0	10	2	0	0	0	0	0	0	0	0	0	0		
	10/08/14	2:00	0	5	0	0	0	0	0	0	0	0	0	0	0		
	10/08/14	3:00	0	1	1	0	0	0	0	0	0	0	0	0	0		
	10/08/14	4:00	0	3	0	0	0	0	0	0	0	0	0	0	0		
	10/08/14	5:00	0	12	6	0	1	2	0	0	0	0	0	0	0		
	10/08/14	6:00	0	25	10	0	5	1	0	0	1	0	0	0	0		
	10/08/14	7:00	2	54	22	0	2	0	0	0	1	0	0	0	0		
	10/08/14	8:00	0	76	20	2	3	1	0	0	0	0	0	0	0		
	10/08/14	9:00	0	45	12	0	0	0	0	0	0	0	0	0	0		
	10/08/14	10:00	2	70	23	0	0	3	0	0	0	1	0	0	0		
	10/08/14	11:00	0	44	16	0	0	1	0	0	0	0	0	0	0		
	10/08/14	12:00	0	61	20	0	0	0	0	2	2	0	0	0	0		
	10/08/14	13:00	0	48	14	0	0	0	0	0	0	0	0	0	0		
	10/08/14	14:00	2	96	33	1	9	1	0	0	0	0	0	0	0		
	10/08/14	15:00	0	77	18	0	1	1	0	0	1	0	0	0	0		
	10/08/14	16:00	0	76	21	0	1	1	0	0	3	0	0	0	0		
	10/08/14	17:00	0	75	25	0	0	0	0	0	1	0	0	0	0		
	10/08/14	18:00	1	62	16	0	1	0	0	0	2	1	0	0	0		
	10/08/14	19:00	0	30	9	0	0	1	0	0	1	0	0	0	0		
	10/08/14	20:00	0	12	5	0	0	1	0	0	0	0	0	0	0		
	10/08/14	21:00	0	12	11	0	0	0	0	0	0	0	0	0	0		
	10/08/14	22:00	0	10	3	0	0	0	0	0	0	0	0	0	0		
	10/08/14	23:00	0	7	0	0	0	0	0	0	0	0	0	0	0		
	10/09/14	0:00	0	4	1	0	0	0	0	0	0	0	0	0	0		
	10/09/14	1:00	0	4	0	0	0	0	0	0	0	0	0	0	0		
	10/09/14	2:00	0	0	0	0	1	0	0	0	0	0	0	0	0		
	10/09/14	3:00	0	3	1	0	0	0	0	0	0	0	0	0	0		
	10/09/14	4:00	0	2	0	0	0	0	0	0	0	0	0	0	0		
	10/09/14	5:00	0	8	4	0	1	0	0	0	2	0	0	0	0		
	10/09/14	6:00	0	24	8	0	5	1	0	0	2	0	0	0	0		
	10/09/14	7:00	1	58	25	1	1	0	0	0	4	1	0	0	0		
	10/09/14	8:00	1	66	18	0	3	0	0	0	2	0	0	0	0		
	10/09/14	9:00	0	32	32	0	2	0	0	0	3	0	0	0	0		
	10/09/14	10:00	1	36	14	3	0	0	0	0	1	1	0	0	0		
	DIRECTION TOTALS		10	1684	580	10	50	25	3	4	46	7	0	0	0		
	% of Total Vehicles		71%	56%	37%	25%	36%	66%	75%	18%	61%	70%		0%			
	SITE TOTALS		14	2998	1553	40	137	38	4	22	75	10	0	1	0		4892

Veh. Type Breakdown for ESAL Calc	MotoCycl	PASS VEH	2 AX SU	3+ AX SU	3 AX SEMI	4 AX SEMI	5+ AX SEMI	TRKTLR/BUS	TWINS	TOTAL	%HC
	7	2276	69	21	4	7	43	20	1	2,448	6.7%

At the bottom of the second page, is the average daily (24 hour) vehicle type breakdown. Notice that the 13 vehicle classes are joined into the 8 classes used for forecasting.

Breakdown of the 8 Vehicle Types for Forecasting

Type 1: Passenger Vehicles (motorcycles, pickups, and cars) – 2 axle 4 tire single unit vehicle pulling recreational or other trailers.

Type 2: Two Axle Single Unit Trucks – 2 axle 6 tire trucks. This includes all vehicles on a single frame, having 2 axles and dual rear wheels.

Type 3: Three Plus Axle Single Unit Trucks – 3 or more axle single unit trucks. This includes all vehicles on a single frame having 3 or 4+ axles.

Type 4: Three Axle Semis – 3 axles consisting of two units, one of which is the tractor and the other is a trailer.

Type 5: Four Axle Semis – 4 axles consisting of two units, one of which is the tractor and the other is a trailer

Type 6: Five Plus Axle Semis – 5 or more axles consisting of two units, one of which is a tractor and the other is a trailer.

Type 7: Heavy Truck with Trailer / Bus – A heavy truck with trailer can have 3 or more axles.

Type 8: Twins Semis – 5 or more axles with two separate trailers.

Example of Heavy 5+ Axle Semi Types

Truck Types

(Heavy 5+ axles semis = Dump, Grain, Stake Loaded and Tank Trucks)

Dump Truck

Grain Truck

Loaded Stake Truck

Tank Truck

Other

Traffic Counting Schedule

A given County will have both the Truck Highways and Local System Roads counted in the designated "cycle". This same County will have only its Truck Highways counted in the "off-cycle." For an example, Aitkin is in cycle 3. Therefore, in 2016 both Truck Highways and Local System were counted. Then in 2018, only the Truck Highways in Aitkin are counted.

Cycle 1: 2014, 2018, 2022, 2026 (and Trunk Highways from Cycle 3)

4- Beltrami	42- Lyon	77- Todd
34- Kandiyohi	71- Sherburne	26- Grant
63- Red Lake	16- Cook	48- Mille Lacs
8- Brown	45- Marshall	79- Wabasha
38- Lake	72- Sibley	33- Kanabec
67- Rock	21- Douglas	55- Olmsted
9- Carlton	46- Martin	84- Wilkin

Cycle 2: 2015, 2019, 2023, 2027 (and Trunk Highways from Cycle 4)

5- Benton	15- Clearwater	22- Faribault
85- Winona	52- Nicollet	56- Otter Tail
61- Pope	65- Renville	74- Steele
11- Class	18- Crow Wing	25- Goodhue
47- Meeker	53- Nobles	57- Pennington
64- Redwood	69- St. Louis	39- Lake of the Woods

Cycle 3: 2016, 2020, 2024, 2028 (and Trunk Highways from Cycle 1)

1- Aitkin	68- Roseau	50- Mower
32- Jackson	12- Chippewa	81- Waseca
59- Pipestone	41- Lincoln	29- Hubbard
3- Becker	78- Traverse	54- Norman
36- Koochiching	17-Cottonwood	83- Watonwan
66- Rice	44- Mahnomen	30- Isanti
6- Big Stone	80- Wadena	58- Pine
86-Wright	28- Houston	37- Lac Qui Parle

Cycle 4: 2017, 2021, 2025, 2029 (and Trunk Highways from Cycle 2)

7- Blue Earth	14- Clay	23- Fillmore
31- Tasca	40- LeSueur	49- Morrison
60- Polk	75- Stevens	87- Yellow Medicine
13- Chisago	20- Dodge	
35- Kittson	43- McLeod	24-Freeborn
73- Stearns	76- Swift	51- Murray

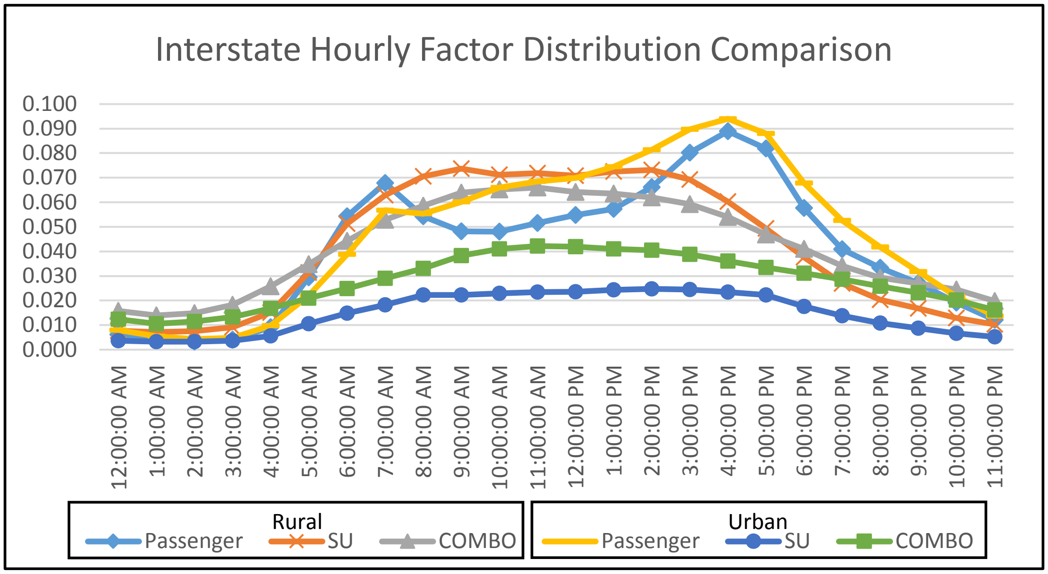
Metro Cycle: Two year continual count

Trunk Highways (I, US, MN) cycle begins in the odd year and ends in the even year
County Roads (CSAH, CR) cycle begins in the even year and ends in the odd year

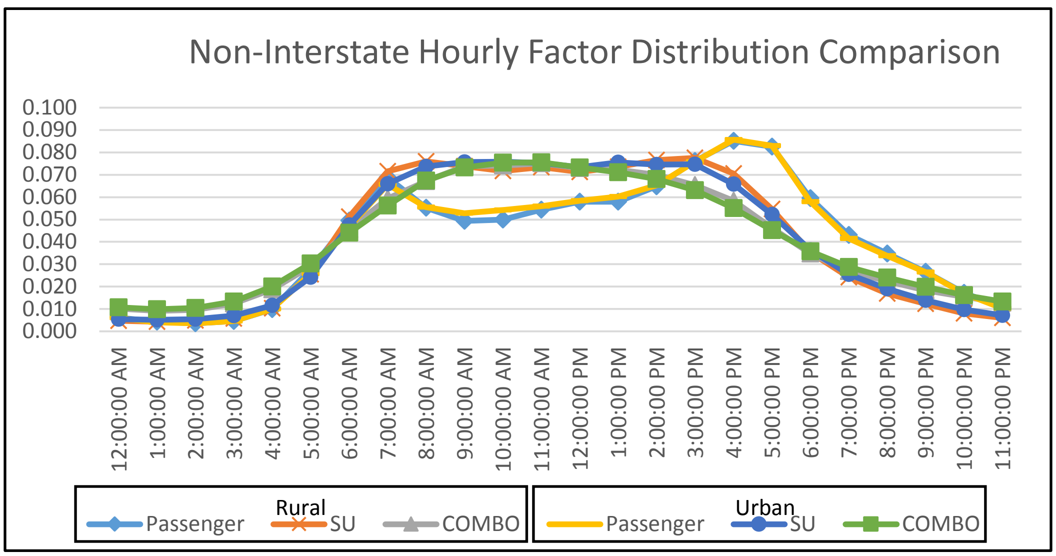
2- Anoka	19- Dakota	62- Ramsey
10- Carver	27-Hennepin	70- Scott
		82- Washington

Comparing Interstates and Non-Interstates Hourly Factor Distribution by Rural and Urban

The following two charts show the percent of passenger vehicles, single unit trucks, and combo trucks by hour on interstates and non-interstates (US and MN Trunk Highways) in rural and urban areas. On average, rural areas have a lower AADT, which usually produces a higher percent of trucks. There is a greater number of passenger vehicles than trucks on interstates in urban areas.



However, the percent of passenger vehicles, single unit trucks, and combo trucks are very similar in both rural and urban areas on non-interstates.



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