Montana Department of Transportation

TRANSPORTATION REGIONAL ECONOMIC DEVELOPMENT

TRED

THEODORE ROOSEVELT EXPRESSWAY

Working Paper #3: Methodological Framework

Final

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1: INTRODUCTION

This Working Paper is part of the US 2/MT 16 Theodore Roosevelt Expressway Development Study. The purpose of the study is to identify the economic, regulatory, or operational changes that would result in traffic and safety conditions justifying the expansion of the Theodore Roosevelt Expressway section in Montana to a 4-lane facility.

This Working Paper provides the methodological framework for the creation of a traffic and freight forecasting model for the study corridor. The paper builds upon research conducted for the previous working papers: Working Paper #1, an assessment of existing conditions and Working Paper #2, an analysis of existing and future economic opportunities in the study area.

In developing the forecasting model, several steps were carried out. After an initial review of existing conditions in the study area, telephone interviews were conducted to gain an understanding of opportunities for structural changes in the regional and local economy. A Risk Analysis Process Reference Book and Workbook introducing the traffic forecasting model designed by the research team and presenting historical data and baseline estimates for all key inputs to the model was then presented to a team of experts and stakeholders in the region. During this "RAP (Risk Analysis Process) Session," panelists were provided the opportunity to evaluate the model's variables and input values. Using the feedback from this session, the research team created the final traffic and freight forecasting model.[1]

The methodology discussed in this Working Paper utilizes input assumptions designed to forecast long-term average traffic volumes along the study area corridor. By focusing on long-term averages, any short-term fluctuations due to such events as economic booms, recessions, or droughts are evened out over time. Therefore, the research team believes the forecasting results generated by this modeling process are neither overly optimistic nor pessimistic in nature.

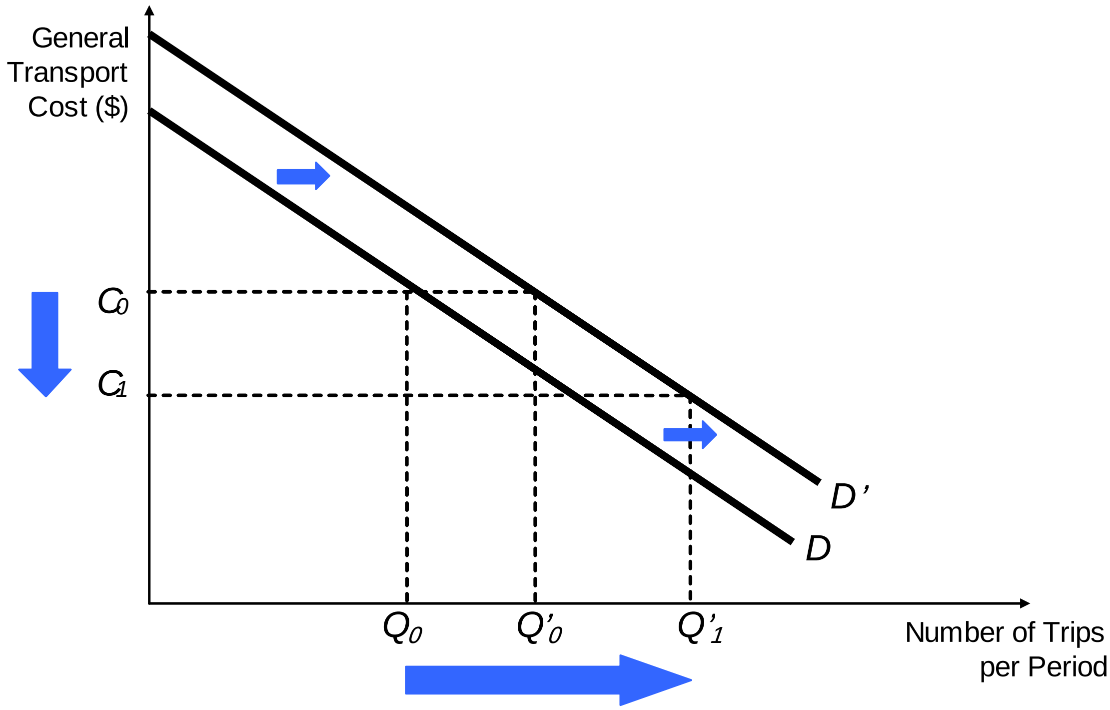
After this introductory chapter, Chapter 2 provides a conceptual framework for the model used. Chapter 3 then gives an overview of the forecasting model and Chapter 4 provides a summary of the forecasting assumptions used. An overview of the spreadsheet model is provided in Chapter 5. Finally, Chapter 6 presents the immediate next steps of the study. A list of the panelists who participated in the RAP session as well as a RAP Primer can be found in the appendices.

[1] Although the model methodology does not explicitly address ADT suppression possibilities within the "Opportunity Register", these negative ADT effects are partially reflected in 1) the probability of an ADT opportunity occurring as expressed by the expert panelists, and 2) the traffic impact values assumed for specific opportunities.

2: CONCEPTUAL FRAMEWOK AND METHODOLOGY

The framework developed for this study is best described by considering the demand for transportation, a relationship between the generalized price of transportation and the number of trips (per day, week or year), as shown in Figure 1 below. [2]

Figure 1: The Demand for Transportation, *an Illustration*



C_0: Initial price of the cost of transportation.

Q_0: Initial quantity of transportation demanded.

C_1: Price level of transportation after highway infrastructure improvements are completed.

Q_1: New quantity of transportation demanded after highway infrastructure improvements are completed.

Q'_0: New quantity of transportation demanded because of an increase in demand due to growth in existing opportunities.

[2] Due to low congestion levels in the study area, the supply curve for transportation is essentially flat, and can be ignored in this graphical representation.

The demand schedule is downward sloping: as the general price of transportation decreases (due to improved access or lower vehicle operating costs, for example), people are willing to make more trips; in other words the quantity of trips demanded increases. Conversely, as the generalized price of transportation increases (due to higher gasoline prices, for example), people are less willing to make trips, resulting in a decrease in the quantity of trips demanded.

This framework can be used to illustrate the changes considered in the study:

- The impact of existing development opportunities is represented by a shift in the demand curve, from D to D': at any transport cost level, there will be more trips demanded in the study area.

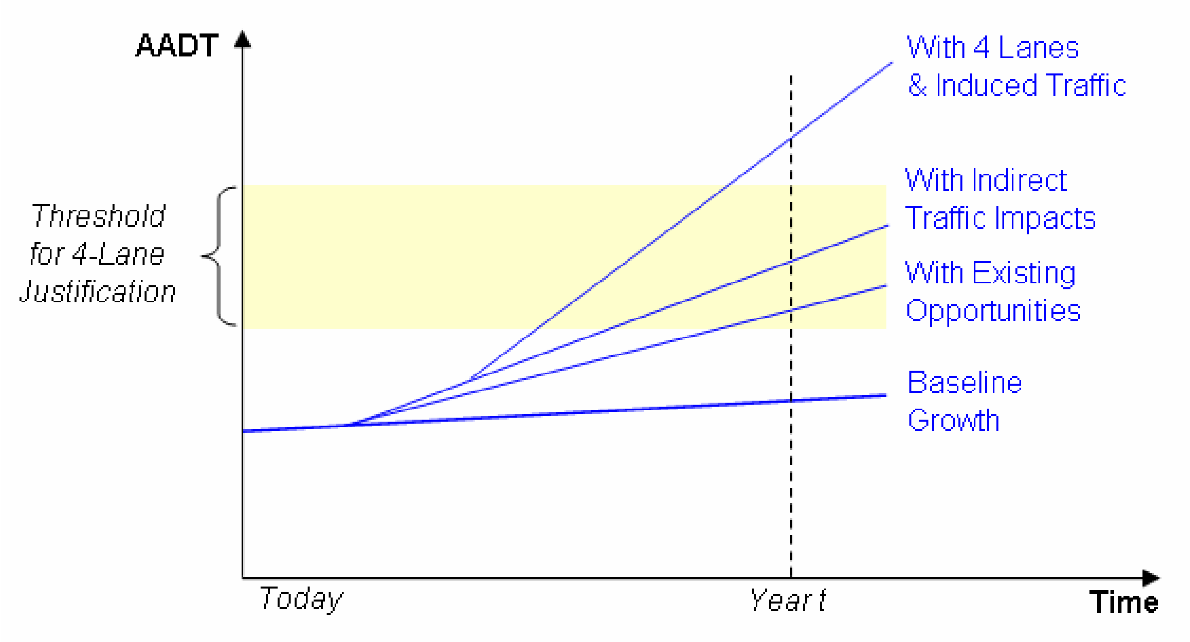
- The impact of future infrastructure improvements is represented by a reduction in the general cost of transport from C_0 to C_1, and a movement along the (new) demand curve D.'

The methodology and forecasting model, introduced in the next chapter, seeks to estimate the change in completed trips from Q_0 to Q'_0 (resulting from a shift in the demand schedule from D to D') and from Q'_0 to Q'_1 (resulting from future highway improvements and "induced" demand).

Figure 2 below further illustrates the different traffic growth components considered in the study. Traffic growth resulting, directly and indirectly, from existing opportunities (represented as a shift in the demand curve in Figure 1) will be "added" to a long term baseline growth trend. Traffic growth originating from the 4-lane configuration is represented by the vertical distance between the top "With 4 Lanes & Induced Traffic" line and the lower "With Indirect Traffic Impacts" curve. This is further explained in Section 3.2 below.[3]

[3] See Appendix 3 for an alternate view of the model components.

Figure 2: Traffic Growth Components, *an Illustration*



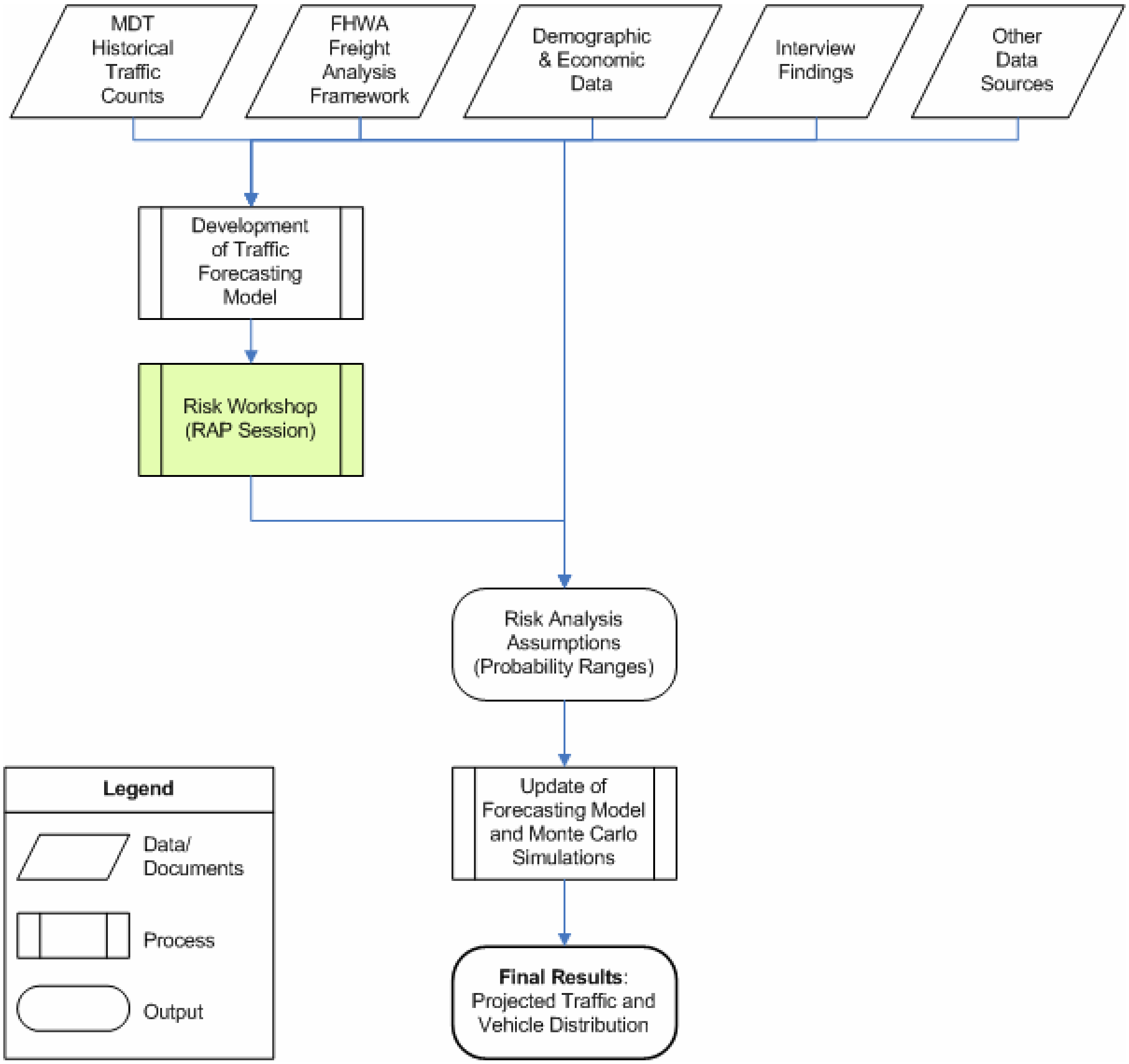
3: FORECASTING MODEL

This chapter provides an overview of HDR | HLB's approach to forecasting traffic on the Montana portion of the TRED corridor as well as a description of the variables used as inputs to the model.

3.1 Structure and Logic Diagrams

An overview of the method used in the development and estimation of the traffic forecasting model (including a list of the data sources considered, the proposed risk elicitation techniques and future refinements to the modeling framework) is shown in Figure 3, on the next page. Figure 4 then goes into a presentation of the different components (variables, parameters and relationships) of the forecasting model itself.

Figure 3: Risk Analysis Process Overview



The approach illustrated in the above chart comprises **seven major steps**:

1. Collect and analyze historical traffic data and commodity movements in the TRED corridor and larger study area;
2. Collect and review information on existing and future development opportunities, and try to assess their impact on future traffic conditions;
3. Develop a risk analysis traffic (and vehicle distribution) forecasting model;
4. Develop preliminary assumptions for all key variables and parameter values in the forecasting model;
5. Conduct a risk workshop (a RAP session) with all major project stakeholders;
6. Update all risk analysis assumptions and run Monte Carlo simulations to generate traffic and truck traffic probability distributions;
7. Report and document the simulation results.

The traffic forecasting model developed by HDR | HLB is illustrated in Figure 4, on the next page. Figure 4 provides a detailed description of how different input variables are combined together to arrive at total traffic.

The analysis began with baseline historical traffic counts for the sections that make up the Montana segment of the Theodore Roosevelt Expressway. From these traffic counts, a baseline forecast was developed, assuming the continuation of historical growth rates for both personal vehicles and trucks.

Next, a second forecast of traffic growth was calculated utilizing changes to the historical growth based on an assessment of the impacts on traffic that result from various itemized economic opportunities.

A third forecast builds on the growth from the local and regional economic opportunities, and adds traffic occurring from the "indirect" travel demand created by the expansion of industry and commerce within the region.

A final forecast adds the impact of so-called "induced demand" resulting from the four-lane expansion.

Figure 4: Structure and Logic Diagram, Traffic Forecasting Model

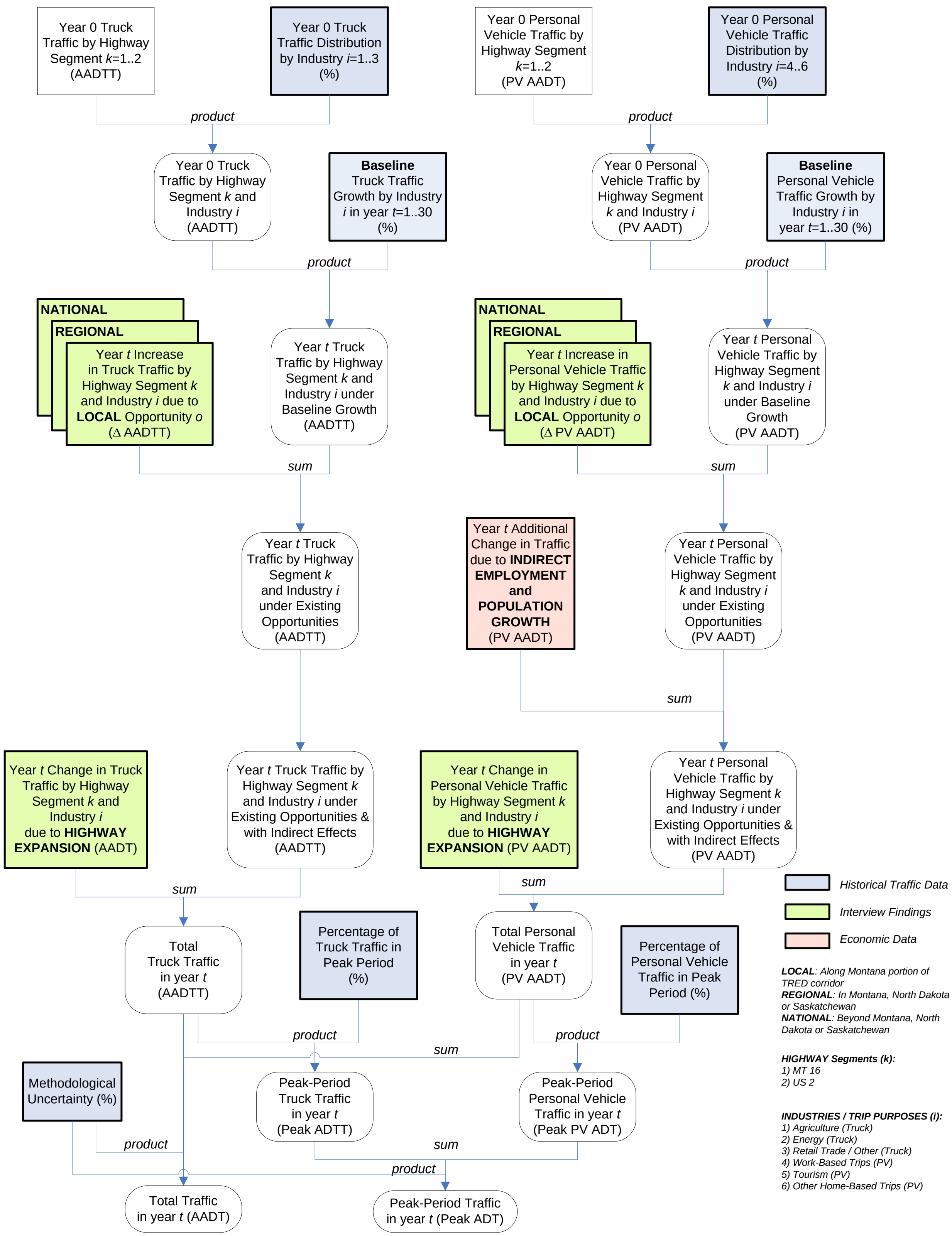
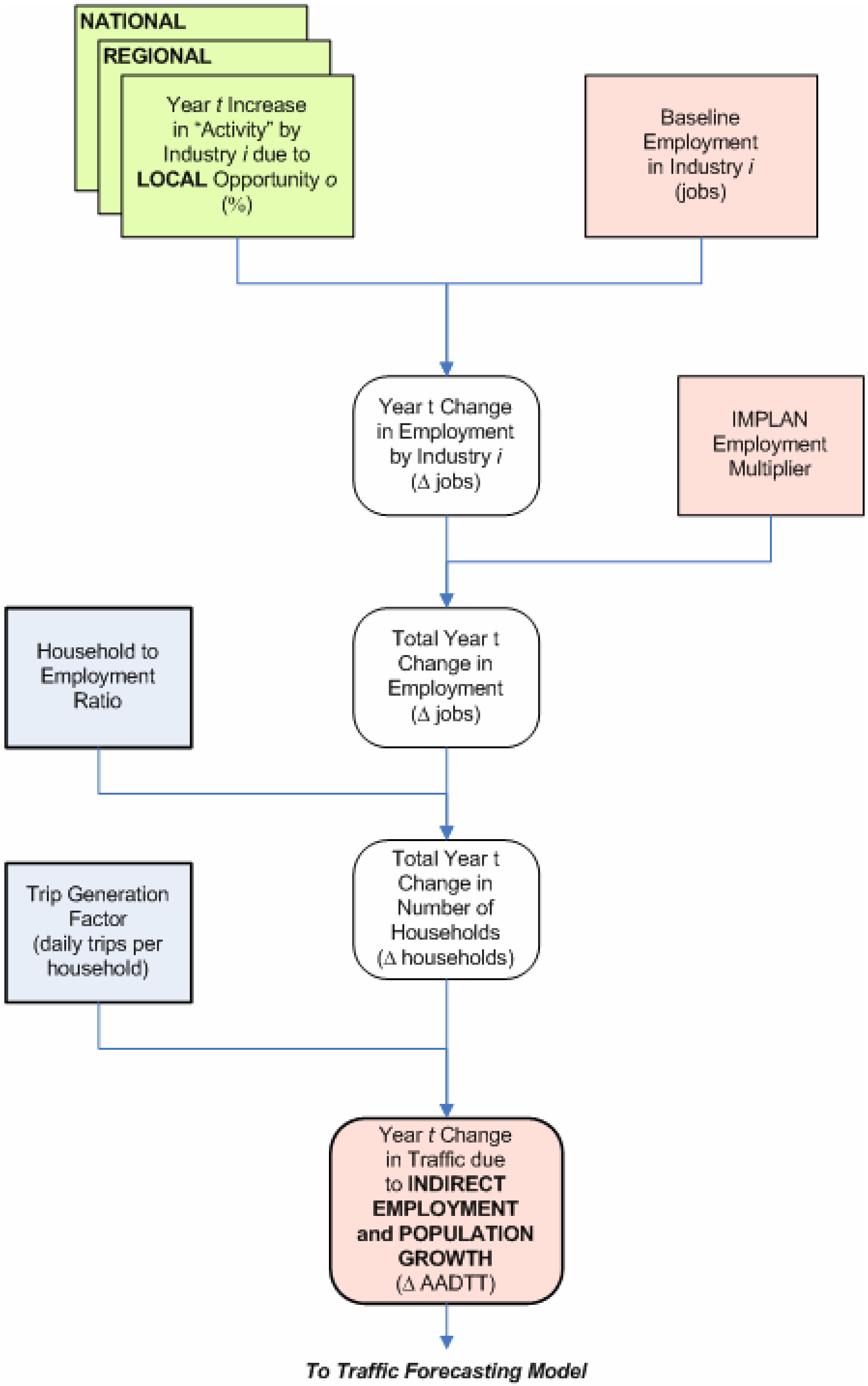


Figure 5 below illustrates the estimation of traffic changes resulting from the indirect travel demand created by the realization of existing development opportunities.

Figure 5: Structure and Logic Diagram, Estimation of Traffic Changes due to Indirect Employment and Population Growth



3.2 Variables Used in the Model

The variables used as inputs to the model are as follows:

- Base year traffic counts;
- Base year truck traffic distribution by industry;
- Base year personal vehicle traffic distribution by trip purpose;
- Baseline truck and personal vehicle traffic growth;
- Change in personal vehicle and truck traffic due to local, regional, and national opportunities (opportunity matrix);
- Additional change in traffic due to local, regional, and national opportunities without four-lane expansion;
- Additional change in traffic due to local, regional, and national opportunities with four-lane expansion;
- Percent of traffic in peak season;
- Household-to-employment ratio;
- Household trip generation factor; and
- Methodological uncertainty.

4: SUMMARY OF FORECASTING ASSUMPTIONS

This section presents the assumptions used in HDR | HLB's risk analysis traffic forecasting model. To facilitate the risk analysis framework employed in the forecasting model, each variable assumption is presented with a median, an upper 10%, and a lower 10% value.

To generate traffic projections for the next 30 years, the Opportunity Matrix presented in Section 4.6 was populated. The probability of the various economic opportunities presented in the matrix coming to fruition given different infrastructure constraints has been estimated using historical data and the views of expert panelists. The traffic volume ranges attributed to each opportunity were calculated based on general economic calculations, survey responses, and the input of expert panelists. For example, survey responses indicated that a bio-diesel plant could expect enough input and output to require an additional 5,000 to 7,500 truckloads annually, therefore, a conservative range of 20 to 40 trucks per day was assumed for that opportunity. Likewise, for agricultural opportunities the expected increase in acreage and volume of crops for the opportunity effect was calculated on an annual basis and the number of trucks necessary to transport the increased produce in daily terms was then recorded for the opportunity.

As is true for all input variables used in the model, the final variable values recorded in the opportunity register were reviewed and validated by the expert panelists.

Wherever possible the methods employed to arrive at the values in the following section used in the forecasting model are itemized.

4.1 Base Year Traffic Counts

Variable Description: The traffic counts represent the average annual daily traffic by class of vehicle (personal vehicles or large trucks) recorded along specific sections of the study area corridor. The mileage weighted averages of these counts were used as the base year traffic for the study area's sections of MT 16 and US 2.

Segment	Mileage	2005	
		Personal Vehicles	Trucks
1) Raymond to Plentywood (MT 16)	16	1,140	104
2) Plentywood to Antelope (MT 16)	10	3,945[4]	186
3) Antelope to Medicine Lake (MT 16)	14	1,360	144
4) Medicine Lake to Culbertson (MT 16)	25	1,349	143
5) Culbertson to Bainville (US 2)	12	2,140	127
6) Bainville to North Dakota Border (US 2)	10	1,330	127
Mileage Weighted Average	**---**	**---**	**---**
MT 16 Segment	**65**	**1,699**	**140**
US 2 Segment	**22**	**1,771**	**127**

Source: Montana Department of Transportation Temporary Traffic Data Recorders (See Appendix C)

4.2 Base Year Truck Traffic Distribution by Industry

Variable Description: This percentage accounts for how total truck ADT is distributed amongst various sectors or categories. A higher percentage means that the total share of ADT attributed to that category is larger.

Modeling Probability Ranges

Variable Name	Median	Lower 10% Limit	Upper 10% Limit
% Truck ADT, Agriculture	40	35	50
% Truck ADT, Energy	30	20	40
% Truck ADT, Retail Trade / Other	30	10	45

[4] This section of roadway has atypically high traffic (See Appendix C)

Values were derived from Freight Analysis Framework (FAF) data, first-hand observations, interview responses, and other anecdotal evidence, and were reviewed and validated by panel experts.

4.3 Base Year Personal Vehicle Traffic Distribution by Trip Purpose

Variable Description: This percentage accounts for how total Personal Vehicle (PV) ADT in the corridor is distributed amongst various categories or trip purposes. A higher percentage means that the total share of ADT attributed to that category is larger.

Modeling Probability Ranges

Variable Name	Median	Lower 10% Limit	Upper 10% Limit
% PV ADT, Work Trips	25	20	35
% PV ADT, Tourism	6	3	9
% PV ADT, Other Home-Based Trips	69	56	77

Personal vehicle distributions were generated based on aggregate tourism trips, general assumptions regarding work trips, and expert panelist input.

4.4 Baseline Truck and Personal Vehicle Traffic Growth

Variable Description: This percentage represents the average annual growth rate per year in vehicle ADT (Truck or Personal Vehicle) by the various sectors or categories (assuming existing highway infrastructure) based on historical growth trends only. A positive percentage means that ADT is expected to increase for the specific sector or category.

These rates were used for all years, except for the growth rate for energy trucks. For energy trucks a ramp-down over time of the growth rate to a more sustainable level was employed. (See Section 4.5)

Historical vehicle counts and growth rates from 2002-2005 are presented in Appendix C, Table 2.

Modeling Probability Ranges

Variable Name	Median	Lower 10% Limit	Upper 10% Limit
Truck Traffic Growth, Agriculture, %	1.0	0.0	2.0
Truck Traffic Growth, Energy, %	10.0	5.0	15.0
Truck Traffic Growth, Retail Trade / Other, %	1.0	0.5	1.5
PV Traffic Growth, Work Trips, %	0.5	0.0	1.0
PV Traffic Growth, Tourism, %	0.5	-0.5	3.0
PV Traffic Growth, Other Home-Based Trips, %	0.5	0.0	2.0

Estimates were calculated from survey responses, historical growth data, and expert panelist input.

4.5 Energy Sector Truck Traffic Growth (2012-2036)

Variable Description: This percentage represents the average annual growth rate per year in truck ADT by the energy sector for 2012-2036. Because of the higher than normal current growth rate for energy trucks, we assume that this high growth is unsustainable over the long-run; therefore, conservatively, we utilize a gradual convergence of this growth rate to a longer term historical average over time. A positive percentage means that ADT is expected to increase for the specific sector or category.

Modeling Probability Ranges

Variable Name	Median	Lower 10% Limit	Upper 10% Limit
Truck Traffic Growth, Energy, % (2012-2016)	8.0	4.0	12.0
Truck Traffic Growth, Energy, % (2017-2021)	6.0	3.0	9.0
Truck Traffic Growth, Energy, % (2022-2026)	4.0	2.0	6.0
Truck Traffic Growth, Energy, % (2027-2031)	2.0	1.0	3.0
Truck Traffic Growth, Energy, % (2032-2036)	1.0	0.5	1.5

The convergence of the energy sector truck traffic growth rates to the historical rate was calculated by HDR | HLB and assumes that energy will be an important growth element in the future.

4.6 Change in Personal Vehicle and Truck Traffic due to Local, Regional, and National Opportunities

Matrix Description: This matrix is a method to capture the expected traffic impacts due to specifically cited opportunities that could or will occur at the local, regional, and national levels. The traffic impacts are to be expressed in additional ADT affecting the specific corridor segment. Traffic impacts will be included in the model after being adjusted by the probability of the opportunity occurring under the 4-lane highway and no 4-lane highway scenarios, and the impact values will vary according to the distribution defined by the lower value, most likely, and upper values.

Items Provided in the Matrix of Specific Opportunities:

Index: A number to associate with each opportunity for ease of referral.

Description: A short description of the opportunity being examined.

Opening Year: The expected or planned opening year when the opportunity could have an influence on ADT.

Sector: The broad category indicating which sector the ADT adjustment will affect.

Location: The specific location, if possible, from where the opportunity is derived.

Segment: The section of the study area corridor that would experience the adjustment in ADT due to the specific opportunity.

Without a 4-Lane Highway

Truck or PV: Whether the opportunity would result in an increase in truck or in personal vehicle traffic.

Probability: The likelihood that the opportunity comes to fruition, without expansion of the existing corridor to a 4-lane highway.

Low: In the event that the opportunity occurs, this is the lowest level of ADT impact that could be expected.

Median: In the event that the opportunity occurs, this is the median level of ADT impact that could be expected.

High: In the event that the opportunity occurs, this is the upper level of ADT impact that could be expected.

With a 4-Lane Highway

Probability: The likelihood that the opportunity comes to fruition, if the expansion of the existing corridor to a 4-lane highway occurs.

Truck or PV: Whether the opportunity would result in an increase in truck or in personal vehicle traffic.

Low: In the event that the opportunity occurs, this is the lowest level of ADT impact that could be expected.

Median: In the event that the opportunity occurs, this is the median level of ADT impact that could be expected.

High: In the event that the opportunity occurs, this is the upper level of ADT impact that could be expected.

Opportunity Matrix

Opportunity Register						*Without a 4-Lane Corridor*					*With a 4-Lane Corridor*				
Index	**Description**	**Opening Year**	**Sector**	**Location**	**Segment**	**Truck or PV**	**Probability**	**Median**	**Low**	**High**	**Truck or PV**	**Probability**	**Median**	**Low**	**High**
1	Pulse Crops - can be planted in fallow crop rotation; benefit of adding nitrogen to soil	2006	Agriculture	Study Area	Entire Corridor	Truck	100%	20	10	30	Truck	100%	25	15	40
2	Popularity of organic products	2006	Agriculture	Study Area	Entire Corridor	Truck	100%	2	1	3	Truck	100%	3	2	4
3	Increase in safflower production - trend toward use of healthier oils (safflower oil)	2007-2016	Agriculture	Study Area	Entire Corridor	Truck	50%	2.5	1.5	3.5	Truck	60%	3	2	4
4	Vegetable processing plant (including onions, potatoes, carrots, etc.)	2007-2016	Agriculture	Study Area	Along MT 16	Truck	15%	20	10	30	Truck	40%	20	10	30
5	Milk reduction facility	2007-2016	Agriculture	Sidney	Along MT 16	Truck	15%	2	1	5	Truck	25%	2	1	5
7	Growth in truck traffic from Canada - imports (specifically Canola oil) will be needed to have adequate seed to crush for maintenance of bio-diesel refinery	2007-2016	Agriculture	Roosevelt County (Culbertson)	Entire Corridor	Truck	50%	20	10	30	Truck	65%	25	20	30

Opportunity Register						Without a 4-Lane Corridor					With a 4-Lane Corridor				
Index	**Description**	**Opening Year**	**Sector**	**Location**	**Segment**	**Truck or PV**	**Probability**	**Median**	**Low**	**High**	**Truck or PV**	**Probability**	**Median**	**Low**	**High**
9	Increase in cattle WEIGHT (from 400 lbs to 750 lbs) as a result of increased feed grain from ethanol byproduct.	2006	Agriculture	Study Area	Entire Corridor	Truck	75%	20	10	30	Truck	85%	20	10	30
10	Irrigation projects on the Fort Peck reservation. 10,000 acres added under current plan.	2006	Agriculture	Fort Peck	Entire Corridor	Truck	25%	30	20	40	Truck	25%	30	20	40
11	Increased truck traffic resulting from further consolidation of loading facilities	2007-2016	Agriculture	Study Area	Entire Corridor	Truck	25%	10	5	15	Truck	40%	15	10	20
12	Plans to build a 110-car loading facility in Culbertson	2007-2016	Agriculture	Culbertson	Entire Corridor	Truck	15%	12	5	15	Truck	50%	15	10	20
13	Possibility of 110-car loading facility being built in Westby	2007-2016	Agriculture	Westby or Fortuna	Along MT 16	Truck	50%	2	1	5	Truck	65%	2	1	5
15	Oil exploration	2006	Energy	Study Area	Entire Corridor	Truck	100%	30	20	40	Truck	100%	30	20	40
16	Increased truck traffic resulting from need to truck oil	2006	Energy	Study Area	Entire Corridor	Truck	100%	40	20	60	Truck	100%	50	30	70

Opportunity Register						Without a 4-Lane Corridor					With a 4-Lane Corridor				
Index	**Description**	**Opening Year**	**Sector**	**Location**	**Segment**	**Truck or PV**	**Probability**	**Median**	**Low**	**High**	**Truck or PV**	**Probability**	**Median**	**Low**	**High**
17	Talks of building oil refinery outside of Culbertson (DeltaT engineering)	2007-2016	Energy	Culbertson	Entire Corridor	Truck	1%	25	15	35	Truck	2%	35	20	50
18	Coal / Fischer-Trop plant (to turn coal into liquid fuel)	2007-2016	Energy	Otter Creek	Along US 2	Truck	10%	5	2	10	Truck	15%	5	2	10
19	Valley County Wind Energy Project	2008	Energy	Valley County	Along MT 16	Truck	80%	2	1	3	Truck	90%	2	1	3
20	Nelson Creek Project (lignite-fired power plant)	2009	Energy	Circle	Along US 2	Truck	75%	5	3	8	Truck	85%	10	4	15
21	Montola / Sustainable Systems Project (bio-diesel refinery)	2006	Agriculture	Roosevelt County (Culbertson)	Entire Corridor	Truck	100%	30	20	40	Truck	100%	50	35	70
22	Ethanol production plant	2007-2016	Agriculture	Fort Peck	Along MT 16	Truck	25%	15	10	20	Truck	40%	20	10	30
23	Yellowstone Ethanol LLC Plant	2008	Agriculture	Between Williston and Fairview	Along US 2	Truck	100%	20	10	30	Truck	100%	20	10	30

Opportunity Register						Without a 4-Lane Corridor					With a 4-Lane Corridor				
Index	**Description**	**Opening Year**	**Sector**	**Location**	**Segment**	**Truck or PV**	**Probability**	**Median**	**Low**	**High**	**Truck or PV**	**Probability**	**Median**	**Low**	**High**
27	Talks of developing a destination resort in the Fort Peck area. Built on the old airport site (after airport relocation).	2007-2016	Tourism	Fort Peck	Along US 2	PV	25%	200	100	300	PV	25%	250	150	350
28	Completion of museums and dig sites along the Dinosaur Trail (note: paleo-center and field station exists).	2007-2016	Tourism	Study Area	Entire Corridor	PV	100%	10	5	20	PV	100%	30	15	45
30	Increased signage	2007-2016	Tourism	Study Area	Entire Corridor	PV	50%	2	0	3	PV	75%	3	2	5
31	Standardization of regulatory codes with other states and Canada; e.g., single weight standard between MT, ND and SK would stimulate regional traffic. For cross-border traffic: too many states involved, local harmonization would not help.	2007-2016	Retail Trade / Other	Study Area	Entire Corridor	Truck	15%	5	2	10	Truck	15%	5	2	10
32	Time incentive for trucks to cross at Port of Raymond as opposed to Port of Portal. Distance is key to access Midwest markets, Portal is shorter distance. Preferred route even though average wait time at Portal is 2 hours vs. 10 minutes at Raymond. Truckers know when to show up to avoid queuing.	2007-2016	Retail Trade / Other	Port of Raymond	Along MT 16	Truck	50%	5	2	10	Truck	75%	10	4	20

Opportunity Register						Without a 4-Lane Corridor					With a 4-Lane Corridor				
Index	**Description**	**Opening Year**	**Sector**	**Location**	**Segment**	**Truck or PV**	**Probability**	**Median**	**Low**	**High**	**Truck or PV**	**Probability**	**Median**	**Low**	**High**
33	Fed Ex hub	2007-2016	Retail Trade / Other	Plentywood	Along MT 16	Truck	5%	10	5	12	Truck	5%	12	8	14
34a	Municipal and Rural Water Pipeline project	2007-2016	Other Home-Based Trips	Glasgow to Plentywood	Along MT 16	PV	50%	50	20	75	PV	60%	60	30	100
34b	Municipal and Rural Water Pipeline project	2007-2016	Retail Trade / Other	Glasgow to Plentywood	Along MT 16	Truck	50%	2	1	3	Truck	60%	2	1	3
35	Harmonization of hours of operation across the border at Raymond / Regway.	2007-2016	Retail Trade / Other	MT/SK Border	Along MT 16	Truck	10%	10	5	15	Truck	10%	15	10	20
36	Interchange of freight traffic between W. SK & Southern US.	2007-2016	Retail Trade / Other	Unknown	Entire Corridor	Truck	10%	20	15	35	Truck	50%	40	30	60
37	MT Cowboy Hall of Fame	2006	Tourism	Wolf Point	Along US 2	PV	100%	10	5	20	PV	100%	30	15	45

4.7 Additional Personal Vehicle and Truck Traffic due to Local, Regional, and National Opportunities without Four-Lane Expansion

Variable Description: This value represents the additional vehicle ADT (Truck or Personal Vehicle) due to existing local, regional, and national opportunities (without a four-lane corridor) beyond those listed in the Opportunity Matrix. A positive number means that ADT will increase for that vehicle classification. These ADT values are added into the model over the years 2007 to 2011.[5]

Modeling Probability Ranges

Variable Name	Median	Lower 10% Limit	Upper 10% Limit
Additional Truck Traffic, ADT	210	200	220
Additional Personal Vehicle Traffic, ADT	90	70	100

The values represent 20% of the potential additional ADT arising from itemized opportunities in the opportunity matrix for a two-lane roadway. Values are assumed to be additional ADT that would occur due to synergies created by the opportunities themselves, and also accounts for any unspecified opportunities that may arise. The 20% assumption was derived by the research team and discussed during the RAP session. It is believed to represent a conservative value.

[5] Model results, including the contribution to overall ADT by the itemized opportunities are presented in Working Paper #4.

4.8 Additional Personal Vehicle and Truck Traffic due to Local, Regional, and National Opportunities with Four-Lane Expansion

Variable Description: This value represents the additional vehicle ADT (Truck or Personal Vehicle) due to existing local, regional, and national opportunities (with a four-lane corridor) beyond those listed in the Opportunity Matrix.[6] A positive number means that ADT will increase for that vehicle classification. These ADT values are added into the model over the years 2007 to 2011.

Modeling Probability Ranges

Variable Name	Median	Lower 10% Limit	Upper 10% Limit
Additional Truck Traffic, ADT	280	270	290
Additional Personal Vehicle Traffic, ADT	200	180	220

The values represent 20% of the potential additional ADT arising from itemized opportunities in the opportunity matrix for a four-lane roadway. Values are assumed to be additional ADT that would occur due to synergies created by the opportunities themselves, and also accounts for any unspecified opportunities that may arise. The 20% assumption was derived by the research team and discussed during the RAP session and is believed to represent a conservative value.

4.9 Percent of Traffic in Peak Season

Variable Description: This percentage represents the relative ratio of average daily traffic that occurs in the peak traffic season compared to the overall yearly average. A higher number indicates more traffic, relative to the average annual daily traffic, occurs within the peak traffic season.

Modeling Probability Ranges

Name	Median	Lower 10% Limit	Upper 10% Limit
Peak Season Traffic Relative to Yearly AADT, %	125	110	200

[6] Non-itemized national "opportunities" may include diversion from adjacent corridors, or increases in truck traffic along the GPITC corridor.

Percentages were generated by observing monthly traffic counts over several years for the study area corridor (See Appendix C).

4.10 Household-to-Employment Ratio

Variable Description: This variable establishes a relationship between the number of employees and the number of households in the immediate study area. It is used to estimate the indirect impacts of existing opportunities: if an opportunity materializes and leads to an increase in local employment, what will the likely increase in the number of households be? A value of 1.0 implies that each job created / retained would lead to one additional / retained household. A value of 0.5 implies that two jobs would have to be created in the study area for one household to move-in / stay. A higher household-to-employment ratio implies that, other things being equal, a given job-creating opportunity will lead to more households moving into, or staying in, the study area.

Modeling Probability Ranges

Name	Median	Lower 10% Limit	Upper 10% Limit
Household to Employment Ratio	0.65	0.60	0.70

Values were calculated by HDR | HLB using employment and household data from the 2000 Census and the Bureau of Economic Analysis for the six-county study[7] area. Total households were divided by the total employment within the study area to arrive at the median estimate.

4.11 Household Trip Generation Factor

Variable Description: This variable represents the average daily number of trips generated by one household, including commuting trips, schooling and shopping trips, family visits and others. It is used to estimate the indirect traffic impacts associated with existing development opportunities. Other things being equal, a higher trip generation factor will lead to more indirect traffic resulting from existing opportunities.

Modeling Probability Ranges

Name	Median	Lower 10% Limit	Upper 10% Limit
Household Trip Generation Factor	3.0	2.0	6.0

[7] The six-county study area comprises Daniels, McCone, Richland, Roosevelt, Sheridan, and Valley Counties in Montana.

Values were derived by HDR | HLB based on data provided in the Trip Generation Manual.

4.12 Methodological Uncertainty

Variable Description: This factor accounts for the error in the traffic estimates due to methodological uncertainty. A positive value means that the traffic estimates are too low, while a negative value means that the estimates are too high. A higher (positive) percentage implies a higher overall traffic count (the traffic estimates are adjusted upward).

Modeling Probability Ranges

Variable Name	Median	Lower 10% Limit	Upper 10% Limit
Methodological Uncertainty, %	0.0	-10.0	10.0

Values are HDR | HLB's assumptions accounting for the general uncertainty inherent in a modeling process.

5: OVERVIEW OF THE SPREADSHEET MODEL

This chapter presents details of how the model calculates forecasts for overall traffic and freight distributions for each segment of the study area corridor. This section analyzes the generation of the two-lane forecasts, the four-lane forecasts, and the peak season forecasts.

5.1 Two-Lane Forecasts

The forecasting model begins with the base year traffic counts (Section 4.1). These are the mileage-weighted AADT numbers for MT 16 and US 2 for 2005 and being the most recent comprehensive data these were used as the base year values.

The raw AADT counts for trucks are then multiplied by the truck traffic distribution by industry (Section 4.2) to arrive at the number of trucks attributable to agriculture, energy, and retail trade / other traffic. Similarly, the raw personal vehicle AADT numbers are multiplied by the personal vehicle traffic distributions by trip purpose (Section 4.3) to arrive at the number of personal vehicles attributable to work-based trips, tourism, and other home-based trips. The results are AADT numbers for trucks and personal vehicles on MT 16 and US 2 in the base year.

A traffic forecast is then created that assumes the base AADT numbers increase at the traffic growth rates (Sections 4.4–4.5) from 2007 to 2036. Output from this forecast takes the form of overall AADT on MT 16 and US 2 for each year along with the percentage of this overall AADT that is attributable to truck traffic.

(Model screenshot for illustration purposes only)[8]

Figure 6: Two-Lane Forecasts, Historical Growth Rates Only

ADT Calculations	Year Year Index	2006 0	2007 1	2008 2	2009 3	2010 4	2011 5	2012 6	2013 7	2014 8	2015 9	2016 10	2017 11	2018 12	2019 13	2020 14	202 15
Historical Growth Forecast																	
Truck Traffic																	
Agriculture																	
	MT 16	59.01	59.60	60.20	60.80	61.41	62.02	62.64	63.27	63.90	64.54	65.18	65.84	66.49	67.16	67.83	68.
	US 2	53.53	54.07	54.61	55.15	55.70	56.26	56.82	57.39	57.97	58.55	59.13	59.72	60.32	60.92	61.53	62.
	Overall	59.01	59.60	60.20	60.80	61.41	62.02	62.64	63.27	63.90	64.54	65.18	65.84	66.49	67.16	67.83	68.
Energy																	
	MT 16	42.00	46.20	50.82	55.90	61.49	67.64	74.40	81.84	90.03	99.03	108.93	119.83	131.81	144.99	159.49	175.
	US 2	38.10	41.91	46.10	50.71	55.78	61.36	67.49	74.24	81.67	89.83	98.82	108.70	119.57	131.53	144.68	159.
	Overall	42.00	46.20	50.82	55.90	61.49	67.64	74.40	81.84	90.03	99.03	108.93	119.83	131.81	144.99	159.49	175.
Retail Trade / Other																	
	MT 16	38.99	39.38	39.78	40.17	40.58	40.98	41.39	41.80	42.22	42.65	43.07	43.50	43.94	44.38	44.82	45.2
	US 2	35.37	35.73	36.08	36.44	36.81	37.18	37.55	37.92	38.30	38.69	39.07	39.46	39.86	40.26	40.66	41.0
	Overall	38.99	39.38	39.78	40.17	40.58	40.98	41.39	41.80	42.22	42.65	43.07	43.50	43.94	44.38	44.82	45.2
Personal Vehicle Traffic																	
Work Based Trips																	
	MT 16	461.29	463.60	465.91	468.24	470.58	472.94	475.30	477.68	480.07	482.47	484.88	487.30	489.74	492.19	494.65	497
	US 2	480.84	483.24	485.66	488.09	490.53	492.98	495.44	497.92	500.41	502.91	505.43	507.95	510.49	513.05	515.61	518.
	Overall	480.84	483.24	485.66	488.09	490.53	492.98	495.44	497.92	500.41	502.91	505.43	507.95	510.49	513.05	515.61	518.
Tourism																	
	MT 16	101.94	103.11	104.29	105.48	106.69	107.92	109.15	110.40	111.67	112.95	114.24	115.55	116.88	118.22	119.57	120.
	US 2	106.26	107.48	108.71	109.95	111.21	112.49	113.78	115.08	116.40	117.74	119.09	120.45	121.83	123.23	124.64	126.
	Overall	106.26	107.48	108.71	109.95	111.21	112.49	113.78	115.08	116.40	117.74	119.09	120.45	121.83	123.23	124.64	126.
Other Home-Based Trips																	
	MT 16	1135.77	1146.35	1157.03	1167.81	1178.69	1189.67	1200.75	1211.93	1223.22	1234.62	1246.12	1257.73	1269.44	1281.27	1293.20	1305
	US 2	1183.91	1194.93	1206.06	1217.30	1228.64	1240.08	1251.63	1263.29	1275.06	1286.94	1298.93	1311.03	1323.24	1335.56	1348.01	1360
	Overall	1183.91	1194.93	1206.06	1217.30	1228.64	1240.08	1251.63	1263.29	1275.06	1286.94	1298.93	1311.03	1323.24	1335.56	1348.01	1360
Total ADT																	
	MT 16	1839.00	1858.23	1878.02	1898.41	1919.44	1941.16	1963.64	1986.93	2011.11	2036.25	2062.43	2089.75	2118.30	2148.20	2179.56	2212
	(% Trucks)	7.61%	7.81%	8.03%	8.26%	8.52%	8.79%	9.09%	9.41%	9.75%	10.13%	10.53%	10.97%	11.44%	11.94%	12.49%	13.0
	US 2	1898.00	1917.35	1937.22	1957.64	1978.67	2000.35	2022.72	2045.86	2069.81	2094.65	2120.46	2147.32	2175.31	2204.54	2235.13	2267
	(% Trucks)	6.69%	6.87%	7.06%	7.27%	7.49%	7.74%	8.00%	8.29%	8.60%	8.93%	9.29%	9.68%	10.10%	10.56%	11.04%	11.5
	Overall	1898.00	1917.35	1937.22	1957.64	1978.67	2000.35	2022.72	2045.86	2069.81	2094.65	2120.46	2147.32	2175.31	2204.54	2235.13	2267
	(% Trucks)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[8] Complete graphical and tabular model results are presented in Working Paper #4

Figure 6 is an illustration of the model's two-lane forecasting calculations using historical growth rates only. Forecasts are calculated by vehicle type, sector, and corridor segment.

A second incremental forecast is then generated that takes into account traffic growth that can occur beyond that created by the baseline traffic growth rates. This forecast is created by acknowledging that there are certain opportunities within the region that can lead to increased truck or personal vehicle traffic.

A matrix of traffic opportunities (Section 4.6) itemizes the specific opportunities within the model along with the probabilities of their occurrence, the year they occur, which roadway they would affect, whether it would result in truck or personal vehicle traffic, and the range of additional traffic that would be generated if the opportunity occurred. This matrix records these values for both a two-lane highway (base case) and for a four-lane highway.

The year of occurrence within the matrix can be uncertain and in those cases the model assumes the opportunity will happen sometime between 2007 and 2016 with uniform probability. AADT output from this matrix of opportunities is added, over a five year ramp-up period, to the base year AADT numbers for the corresponding year in which they occur. Similarly, additional AADT (Section 4.7) that accounts for additional truck or personal vehicle traffic arising from local, regional, or national opportunities, beyond those itemized in the matrix, is also added to the base year AADT over a five year ramp-up period from 2007 to 2011.

Finally, the resulting AADT is assumed to grow at the traffic growth rates (Section 4.4-4.5) from 2007 to 2036. This results in a new traffic forecast that takes into account opportunities for traffic growth beyond just the baseline traffic growth rates.

(Model screenshot for illustration purposes only)

Figure 7: Two-Lane Forecasts, ADT Opportunities Included

ADT Calculations	Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	Year Index	0	1	2	3	4	5	6	7	8	9	10	11
2-Lane With Opportunity Register													
Truck Traffic													
Agriculture													
	MT 16	59.01	74.68	91.05	108.12	125.90	144.40	148.00	151.09	153.68	155.76	157.31	158.8
	US 2	53.53	69.15	89.50	110.60	132.44	155.04	162.79	166.03	168.77	171.00	172.71	174.4
	Overall	59.01	74.68	91.05	110.60	132.44	155.04	162.79	166.03	168.77	171.00	172.71	174.4
Energy													
	MT 16	42.00	62.18	85.42	111.56	140.90	173.76	193.93	215.08	237.76	262.12	288.34	317.1
	US 2	38.10	57.90	80.26	106.64	136.24	169.40	189.88	211.82	234.17	258.18	284.00	312.3
	Overall	42.00	62.18	85.42	111.56	140.90	173.76	193.93	215.08	237.76	262.12	288.34	317.1
Retail Trade / Other													
	MT 16	38.99	39.92	41.40	43.43	46.02	49.17	51.82	53.95	55.57	56.66	57.23	57.80
	US 2	35.37	36.26	37.70	39.70	42.25	45.36	47.97	50.07	51.65	52.70	53.23	53.76
	Overall	38.99	39.92	41.40	43.43	46.02	49.17	51.82	53.95	55.57	56.66	57.23	57.80
Personal Vehicle Traffic													
Work Based Trips													
	MT 16	461.29	464.40	468.33	473.08	478.66	485.08	490.72	495.58	499.67	502.97	505.49	508.0
	US 2	480.84	484.05	488.07	492.93	498.61	505.12	510.86	515.83	520.01	523.42	526.04	528.6
	Overall	480.84	484.05	488.07	492.93	498.61	505.12	510.86	515.83	520.01	523.42	526.04	528.6
Tourism													
	MT 16	101.94	103.92	106.72	110.38	114.88	122.70	129.80	136.17	141.81	146.70	148.39	150.0
	US 2	106.26	110.74	116.09	122.31	129.40	139.85	147.15	153.72	159.56	164.65	166.54	168.4
	Overall	106.26	110.74	116.09	122.31	129.40	139.85	147.15	153.72	159.56	164.65	166.54	168.4
Other Home-Based Trips													
	MT 16	1135.77	1147.16	1159.46	1172.68	1186.84	1201.93	1216.36	1230.11	1243.18	1255.57	1267.27	1279.0
	US 2	1183.91	1195.74	1208.49	1222.17	1236.79	1252.35	1267.24	1281.47	1295.02	1307.89	1320.07	1332.3
	Overall	1183.91	1195.74	1208.49	1222.17	1236.79	1252.35	1267.24	1281.47	1295.02	1307.89	1320.07	1332.3
Total ADT													
	MT 16	1839.00	1892.26	1952.38	2019.25	2093.20	2177.04	2230.61	2281.99	2331.67	2379.79	2424.02	2471.0
	(% Trucks)	7.61%	9.34%	11.16%	13.03%	14.94%	16.87%	17.65%	18.41%	19.17%	19.94%	20.75%	21.60
	US 2	1898.00	1953.84	2020.12	2094.34	2175.73	2267.12	2325.88	2378.93	2429.18	2477.84	2522.58	2570.0
	(% Trucks)	6.69%	8.36%	10.27%	12.27%	14.29%	16.31%	17.23%	17.99%	18.71%	19.45%	20.21%	21.03
	Overall	1898.00	1953.84	2020.12	2094.34	2175.73	2267.12	2325.88	2378.93	2429.18	2477.84	2522.58	2570.0

Figure 7 illustrates model forecasts that include ADT from the Opportunity Matrix for a two-lane highway in addition to the forecasts using only traffic growth rates.

The final overall two-lane traffic forecast is then generated by taking into account indirect traffic growth that would occur from increases in work-based and other home-based personal vehicle trips due to the aforementioned opportunities. The baseline (without traffic growth rates being applied) AADT numbers from the previous opportunities' forecast are incremented over a five year ramp-up period by the AADT attributable to this indirect growth. These indirect effect calculations make use of IMPLAN[9], an input-output model software package.

Specifically, the traffic forecasting model incorporates an employment multiplier associated with Richland, Roosevelt, and Sheridan counties. From this multiplier the indirect effects due to gains in employment can be measured. The gains in employment within other sectors due to an increase in traffic in one sector are calculated by assuming that the amount of traffic increase, as a percentage of overall traffic for that sector, approximates the percentage gain in employment expected.

Once the numbers of indirect employment gains are generated they are multiplied by the household-to-employment ratio (Section 4.10) to arrive at the additional number of households that would be gained within the region due to the new employment opportunities. Next the number of new households is multiplied by the household trip generation factor (Section 4.11) calculate the additional daily personal vehicle trips that can be expected due to the increase in the number of households. The model then calculates the work-based and other home-based

[9] Minnesota IMPLAN Group, Inc. www.implan.com

personal vehicle trips that would be generated by the growth in the agriculture, energy, retail trade / other, and tourism sectors by distributing the additional personal vehicle trips to these categories using a weighted average of existing volumes of work-based and other home-based personal vehicle trips.

After all the additional indirect AADT is calculated, it is summed together with the opportunities AADT and then assumed to grow according to the baseline traffic growth rates (Section 4.4-4.5) from 2007 to 2036. This result is the overall two-lane AADT forecast.

(Model screenshot for illustration purposes only)

Figure 8: Two-Lane Forecasts, Overall Traffic Forecasts

ADT Calculations	Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	Year Index	0	1	2	3	4	5	6	7	8	9	10	11	12
With IMPLAN Indirect Effects														
Truck Traffic														
Agriculture														
	MT 16	59.01	74.68	91.05	108.12	125.90	144.40	148.00	151.09	153.68	155.76	157.31	158.89	160.48
	US 2	53.53	69.15	89.50	110.60	132.44	155.04	162.79	166.03	168.77	171.00	172.71	174.43	176.18
	Overall	59.01	74.68	91.05	110.60	132.44	155.04	162.79	166.03	168.77	171.00	172.71	174.43	176.18
Energy														
	MT 16	42.00	62.18	85.42	111.56	140.90	173.76	193.93	215.08	237.76	262.12	288.34	317.17	348.89
	US 2	38.10	57.90	80.26	106.64	136.24	169.40	189.88	211.82	234.17	258.18	284.00	312.39	343.63
	Overall	42.00	62.18	85.42	111.56	140.90	173.76	193.93	215.08	237.76	262.12	288.34	317.17	348.89
Retail Trade / Other														
	MT 16	38.99	39.92	41.40	43.43	46.02	49.17	51.82	53.95	55.57	56.66	57.23	57.80	58.38
	US 2	35.37	36.26	37.70	39.70	42.25	45.36	47.97	50.07	51.65	52.70	53.23	53.76	54.30
	Overall	38.99	39.92	41.40	43.43	46.02	49.17	51.82	53.95	55.57	56.66	57.23	57.80	58.38
Personal Vehicle Trafic														
Work Based Trips														
	MT 16	461.29	2.96	5.84	8.48	10.91	13.20	14.19	14.79	15.19	15.43	15.51	15.59	15.67
	US 2	480.84	2.96	5.84	8.48	10.91	13.20	14.19	14.79	15.19	15.43	15.51	15.59	15.67
	MT 16	461.29	467.36	474.17	481.57	489.57	498.28	504.91	510.38	514.86	518.41	521.00	523.60	526.22
	US 2	480.84	487.00	493.92	501.41	509.51	518.32	525.05	530.62	535.21	538.85	541.55	544.25	546.98
	Overall	480.84	487.00	493.92	501.41	509.51	518.32	525.05	530.62	535.21	538.85	541.55	544.25	546.98
Tourism														
	MT 16	101.94	103.92	106.72	110.38	114.88	122.70	129.80	136.17	141.81	146.70	148.39	150.09	151.81
	US 2	106.26	110.74	116.09	122.31	129.40	139.85	147.15	153.72	159.56	164.65	166.54	168.45	170.38
	Overall	106.26	110.74	116.09	122.31	129.40	139.85	147.15	153.72	159.56	164.65	166.54	168.45	170.38
Other Home-Based Trips														
	MT 16	1135.77	7.31	14.48	21.07	27.15	32.94	35.54	37.18	38.33	39.10	39.46	39.83	40.20
	US 2	1183.91	7.63	15.13	22.02	28.39	34.46	37.18	38.90	40.10	40.91	41.29	41.67	42.06
	MT 16	1135.77	1154.47	1173.95	1193.75	1213.99	1234.87	1251.90	1267.29	1281.52	1294.67	1306.73	1318.90	1331.19
	US 2	1183.91	1203.37	1223.62	1244.19	1265.18	1286.80	1304.43	1320.37	1335.12	1348.80	1361.36	1374.04	1386.84
	Overall	1183.91	1203.37	1223.62	1244.19	1265.18	1286.80	1304.43	1320.37	1335.12	1348.80	1361.36	1374.04	1386.84
Total ADT														
	MT 16	1839.00	1902.53	1972.71	2048.80	2131.26	2223.18	2280.35	2333.97	2385.20	2434.32	2478.99	2526.45	2576.96
	(% Trucks)	7.61%	9.29%	11.04%	12.84%	14.68%	16.52%	17.27%	18.00%	18.74%	19.49%	20.29%	21.13%	22.03%
	US 2	1898.00	1964.43	2041.09	2124.84	2215.03	2314.77	2377.26	2432.63	2484.48	2534.18	2579.38	2627.34	2678.31
	(% Trucks)	6.69%	8.31%	10.16%	12.09%	14.04%	15.98%	16.85%	17.59%	18.30%	19.02%	19.77%	20.58%	21.44%
	Overall	1898.00	1964.43	2041.09	2124.84	2215.03	2314.77	2377.26	2432.63	2484.48	2534.18	2579.38	2627.34	2678.31
	(% Trucks)	7.38%	9.00%	10.67%	12.50%	14.42%	16.33%	17.18%	17.88%	18.60%	19.33%	20.09%	20.91%	21.78%

Figure 8 presents the model calculations for the overall two-lane traffic forecast by vehicle type, sector, and corridor segment.

5.2 Four-Lane Forecasts

A further traffic forecast was developed that assumes growth occurring if the current two-lane roadway were instead a four-lane highway.

This forecast was generated in the same manner as the overall two-lane forecast but some of the inputs take on different values than in the two-lane forecast. For example, the opportunity matrix uses sections specified for a four-lane roadway assumption, which generally results in either higher AADT expectations or a higher probability of an opportunity occurring.

The additional ADT (Section 4.8) assumed to be generated from opportunities not specifically listed in the opportunity matrix is also higher than in the two-lane case.

(Model screenshot for illustration purposes only)

Figure 9: Four-Lane Forecasts, Overall Traffic Forecasts

ADT Calculations	Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	Year Index	0	1	2	3	4	5	6	7	8	9	10	11	12
4-Lane With IMPLAN Indirect Effects														
Truck Trafic														
Agriculture														
	MT 16	59.01	80.80	103.35	126.66	150.75	181.85	192.06	201.83	211.16	220.04	222.24	224.46	226.71
	US 2	53.53	75.27	101.80	129.14	157.29	191.92	205.68	215.01	223.90	232.33	234.65	237.00	239.37
	Overall	59.01	80.80	103.35	129.14	157.29	191.92	205.68	215.01	223.90	232.33	234.65	237.00	239.37
Energy														
	MT 16	42.00	64.38	90.04	118.84	151.11	187.20	208.70	231.33	255.64	281.79	309.97	340.96	375.06
	US 2	38.10	60.10	84.88	114.83	148.37	185.84	208.88	233.63	258.17	284.57	313.03	344.33	378.77
	Overall	42.00	64.38	90.04	118.84	151.11	187.20	208.88	233.63	258.17	284.57	313.03	344.33	378.77
Retail Trade / Other														
	MT 16	38.99	39.92	41.40	43.43	46.02	51.94	57.39	62.35	66.82	70.80	71.51	72.22	72.94
	US 2	35.37	36.26	37.70	39.70	42.25	45.36	47.97	50.07	51.65	52.70	53.23	53.76	54.30
	Overall	38.99	39.92	41.40	43.43	46.02	51.94	57.39	62.35	66.82	70.80	71.51	72.22	72.94
Personal Vehicle Trafic														
Work Based Trips														
	MT 16	461.29	3.86	7.45	10.70	13.64	16.53	17.72	18.51	19.07	19.47	19.57	19.66	19.76
	US 2	480.84	4.04	7.80	11.23	14.33	17.37	18.61	19.43	20.01	20.42	20.52	20.62	20.73
	MT 16	461.29	467.99	474.97	482.17	489.61	497.56	503.30	508.13	512.20	515.61	518.18	520.78	523.38
	US 2	480.84	487.81	495.07	502.54	510.24	518.44	524.33	529.29	533.49	537.00	539.69	542.38	545.10
	Overall	480.84	487.81	495.07	502.54	510.24	518.44	524.33	529.29	533.49	537.00	539.69	542.38	545.10
Tourism														
	MT 16	101.94	103.65	105.91	108.75	112.15	122.90	133.22	143.13	152.61	161.67	163.52	165.39	167.29
	US 2	106.26	114.08	122.54	131.63	141.37	158.52	169.25	179.57	189.47	198.95	201.23	203.54	205.87
	Overall	106.26	114.08	122.54	131.63	141.37	158.52	169.25	179.57	189.47	198.95	201.23	203.54	205.87
Other Home-Based Trips														
	MT 16	1135.77	9.54	18.46	26.59	33.97	41.27	44.38	46.53	48.11	49.32	49.78	50.24	50.71
	US 2	1183.91	9.98	19.33	27.89	35.68	43.36	46.61	48.84	50.48	51.72	52.20	52.69	53.18
	MT 16	1135.77	1156.43	1177.11	1197.65	1218.09	1252.09	1281.62	1309.88	1337.29	1364.02	1376.72	1389.55	1402.49
	US 2	1183.91	1205.45	1227.02	1248.44	1269.76	1291.62	1308.65	1324.25	1338.85	1352.63	1365.23	1377.95	1390.78
	Overall	1183.91	1205.45	1227.02	1248.44	1269.76	1291.62	1308.65	1324.25	1338.85	1364.02	1376.72	1389.55	1402.49
Total ADT														
	MT 16	1839.00	1913.18	1992.78	2077.50	2167.73	2293.53	2376.29	2456.64	2535.72	2613.92	2662.14	2713.37	2767.87
	(% Trucks)	7.61%	9.68%	11.78%	13.91%	16.05%	18.36%	19.28%	20.17%	21.04%	21.91%	22.68%	23.50%	24.38%
	US 2	1898.00	1978.97	2069.01	2166.28	2269.27	2391.70	2464.77	2531.83	2595.52	2658.18	2707.06	2758.96	2814.18
	(% Trucks)	6.69%	8.67%	10.84%	13.09%	15.33%	17.69%	18.77%	19.70%	20.56%	21.43%	22.20%	23.02%	23.89%
	Overall	1898.00	1978.97	2069.01	2166.28	2269.27	2391.70	2464.77	2531.83	2595.52	2658.18	2707.06	2758.96	2814.18
	(% Trucks)	7.38%	9.35%	11.35%	13.45%	15.62%	18.02%	19.15%	20.18%	21.15%	22.11%	22.87%	23.69%	24.56%

Figure 9 shows the model's generation of the overall four-lane traffic forecasts by vehicle type, sector, and corridor segment.

5.3 Peak Season Traffic Forecasts

Since there are certain times of the year, generally June through October, where overall traffic volumes are uncommonly high, we have also created forecasts of this "peak" season for traffic.

Peak season forecasts are calculated for both the two-lane case and for the four-lane alternative scenario by taking the overall final traffic values and multiplying them by the percent of traffic in peak season (Section 4.9). The peak season forecasts give an estimate of the potential worst case scenario for traffic congestion during each year in the forecast.

6: IMMEDIATE NEXT STEPS

This paper's purpose was to illustrate the methodology used in the forecasting modeling process and to present the model's input variables and their value ranges. The methodology presented was utilized within a risk analysis framework to create distributions of overall AADT and traffic distribution forecasts along a 30 year time horizon.

The next step is to produce a detailed analysis and presentation of the model's results. The results will be presented in the form of 30 year forecasts within an 80 percent confidence interval for both the two-lane and the four-lane scenarios for:

- Overall AADT on MT 16 and US 2;
- Percent Trucks on MT 16 and US 2;
- Peak Season AADT on MT 16 and US 2; and
- Peak Season Percent Trucks on MT 16 and US 2.

The presentation of these results will take the form of Working Paper #4.

APPENDIX A: LIST OF PANELISTS

This appendix provides a list of the panelists who participated in the RAP Session conducted on August 15, 2006.

NAME	AGENCY	PHONE NUMBER	EMAIL ADDRESS
Denver Tolliver	Upper Great Plains Transportation Institute, NDSU	701-231-7190	denver.tolliver@ndsu.edu
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NAME	AGENCY	PHONE NUMBER	EMAIL ADDRESS
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Sandy Straehl	MDT Planning	406-444-7692	sstraehl@mt.gov
Mike Duman	FHWA	406-449-5302 x 236	mike.duman@fhwa.dot.gov
Geoff Parkins	HDR	406-651-6610	geoff.parkins@hdrinc.com
Jan Brown	FHWA	406-449-2302	janice.brown@fhwa.dot.gov

APPENDIX B: RAP PRIMER

Economic forecasts traditionally take the form of a single "expected outcome" supplemented with alternative scenarios. The limitation of a forecast with a single expected outcome is clear -- while it may provide the single best statistical estimate, it offers no information about the range of other possible outcomes and their associated probabilities. The problem becomes acute when uncertainty surrounding the forecast's underlying assumptions is material.

A common approach is to create "high case" and "low case" scenarios to bracket the central estimate. This scenario approach can exacerbate the problem of dealing with risk because it gives no indication of likelihood associated with the alternative outcomes. The commonly reported "high case" may assume that most underlying assumptions deviate in the same direction from their expected value, and likewise for the "low case." In reality, the likelihood that all underlying factors shift in the same direction simultaneously is just as remote as that of everything turning out as expected.

Another common approach to providing added perspective on reality is "sensitivity analysis." Key forecast assumptions are varied one at a time in order to assess their relative impact on the expected outcome. A problem here is that the assumptions are often varied by arbitrary amounts. A more serious concern with this approach is that, in the real world, assumptions do not veer from actual outcomes one at a time. It is the impact of simultaneous differences between assumptions and actual outcomes that is needed to provide a realistic perspective on the risk levels of a forecast.

Risk Analysis provides a way around the problems outlined above. It helps avoid the lack of perspective in "high" and "low" cases by measuring the probability or "odds" that an outcome will actually materialize. This is accomplished by attaching ranges (probability distributions) to the forecasts of each input variable. The approach allows all inputs to be varied simultaneously within their distributions, thus avoiding the problems inherent in conventional sensitivity analysis. The approach also recognizes interrelationships between variables and their associated probability distributions.

The Risk Analysis Process involves four steps:

Step 1: Define the structure and logic of the forecasting problem;

Step 2: Assign estimates and ranges (probability distributions) to each variable and forecasting coefficient in the forecasting structure and logic;

Step 3: Engage experts and stakeholders in assessment of model and assumption risks (the "RAP Session"); and

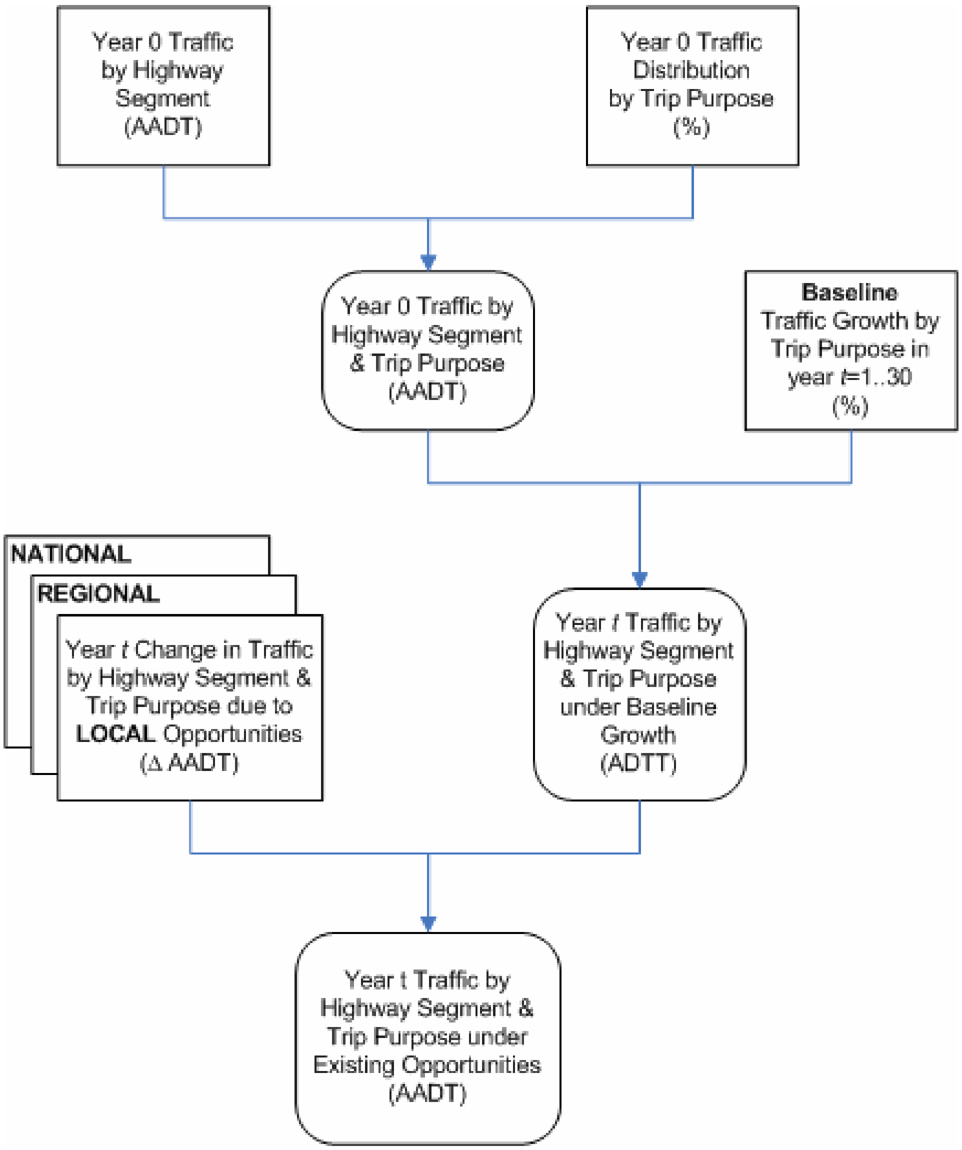
Step 4: Issue forecast risk analysis.

Step 1: Define Structure and Logic of the Forecasting Problem

A "structure and logic model" depicts the variables and cause and effect relationships that underpin the forecasting problem at-hand (Figure 6).

Although the structure and logic model is written down mathematically to facilitate analysis, it is also depicted diagrammatically in order to permit stakeholder scrutiny and modification in Step 3 of the process (see below).

Figure 10: Example of Structure and Logic Model, *an Illustration*



Step 2: Assign Central Estimates and Conduct Probability Analysis

Each variable is assigned a central estimate and a range (a probability distribution) to represent the degree of uncertainty. Special data sheets are used (see Figure 7) to record the estimates. The first column gives an initial median while the second and third columns define an uncertainty range representing an 80 percent confidence interval. This is the range within which there exists an 80 probability finding the actual outcome. The greater the uncertainty associated with a forecast variable the wider the range.

Figure 11: Data Sheet for General Price Inflation, *an Illustration*

Variable	Median	Lower 10% Limit	Upper 10% Limit
Baseline Traffic Growth (2006-2010)	1.0%	0.5%	2.0%

Probability ranges are established on the basis of both statistical analysis and subjective probability. Probability ranges need not be normal or symmetrical -- that is, there is no need to assume the bell shaped normal probability curve. The bell curve assumes an equal likelihood of being too low and being too high in forecasting a particular value. It might well be, for example, that if a projected growth rate deviates from expectations, circumstances are such that it is more likely to be higher than the median expected outcome than lower.

The RAP computer program transforms the ranges as depicted above into formal probability distributions (or "probability density functions"). This liberates the non-statistician from the need to appreciate the abstract statistical depiction of probability and thus enables stakeholders to understand and participate in the process whether or not they possess statistical training.

From where do the central estimates and probability ranges for each assumption in the forecasting structure and logic framework come? There are two sources. The first is an historical analysis of statistical uncertainty in all variables and an error analysis of the forecasting "coefficients." "Coefficients" are numbers that represent the measured impact of one variable (say, income) on another (such as retail sales). While these coefficients can only be known with uncertainty, statistical methods help uncover the magnitude of such error (using diagnostic statistics such as "standard deviation," "standard error," "confidence intervals" and so on).

The uncertainty analysis outlined above is known in the textbooks as "frequentist" probability. The second line of uncertainty analysis employed in risk analysis is called "subjective probability" (also called "Bayesian" statistics, for the mathematician Bayes who developed it). Whereas a frequentist probability represents the measured frequency with which different outcomes occur (i.e., the number of heads and tails after thousands of tosses) the Bayesian probability of an event occurring is the degree of belief held by an informed person or group that it will occur. Obtaining subjective probabilities is the subject of Step 3.

Step 3: Conduct Expert Evaluation: The RAP Session

Step 3 involves the formation of an expert panel and the use of facilitation techniques to elicit, from the panel, risk and probability beliefs about:

1. The structure of the forecasting framework; and

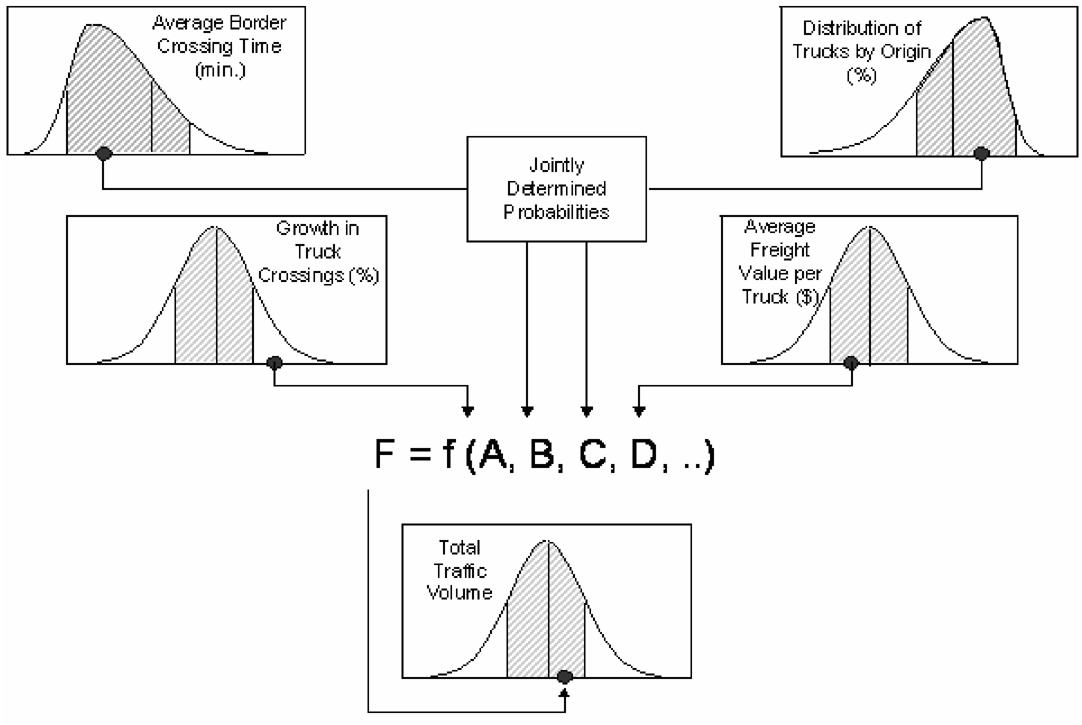
2. Uncertainty attaching to each variable and forecasting coefficient within the framework.

In (1), experts are invited to add variables and hypothesized causal relationships that may be material, yet missing from the model. In (2), panelists are engaged in a discursive protocol during which the frequentist-based central estimates and ranges, provided to panelists in advance of the session, are modified according to subjective expert beliefs. This process is aided with an interactive "groupware" computer tool that permits the visualization of probability ranges under alternative belief systems.

Step 4: Issue Risk Analysis

The final probability distributions are formulated by the risk analyst (HDR | HLB) and represent a combination of "frequentist" and subjective probability information drawn from Step 3. These are combined using a simulation technique (Monte Carlo analysis) that allows each variable and forecasting coefficient to vary simultaneously according to its associated probability distribution (see Figure 8, below).

Figure 12: Combining Probability Distributions, *an Illustration*



The end result is a central forecast, together with estimates of the probability of achieving alternative outcomes given uncertainties in underlying variables and coefficients (see Figure 9 and Table 1, below).

Figure 13: Risk Analysis of Future Corridor Traffic and Percentage of Trucks in Total Traffic, *an Illustration*

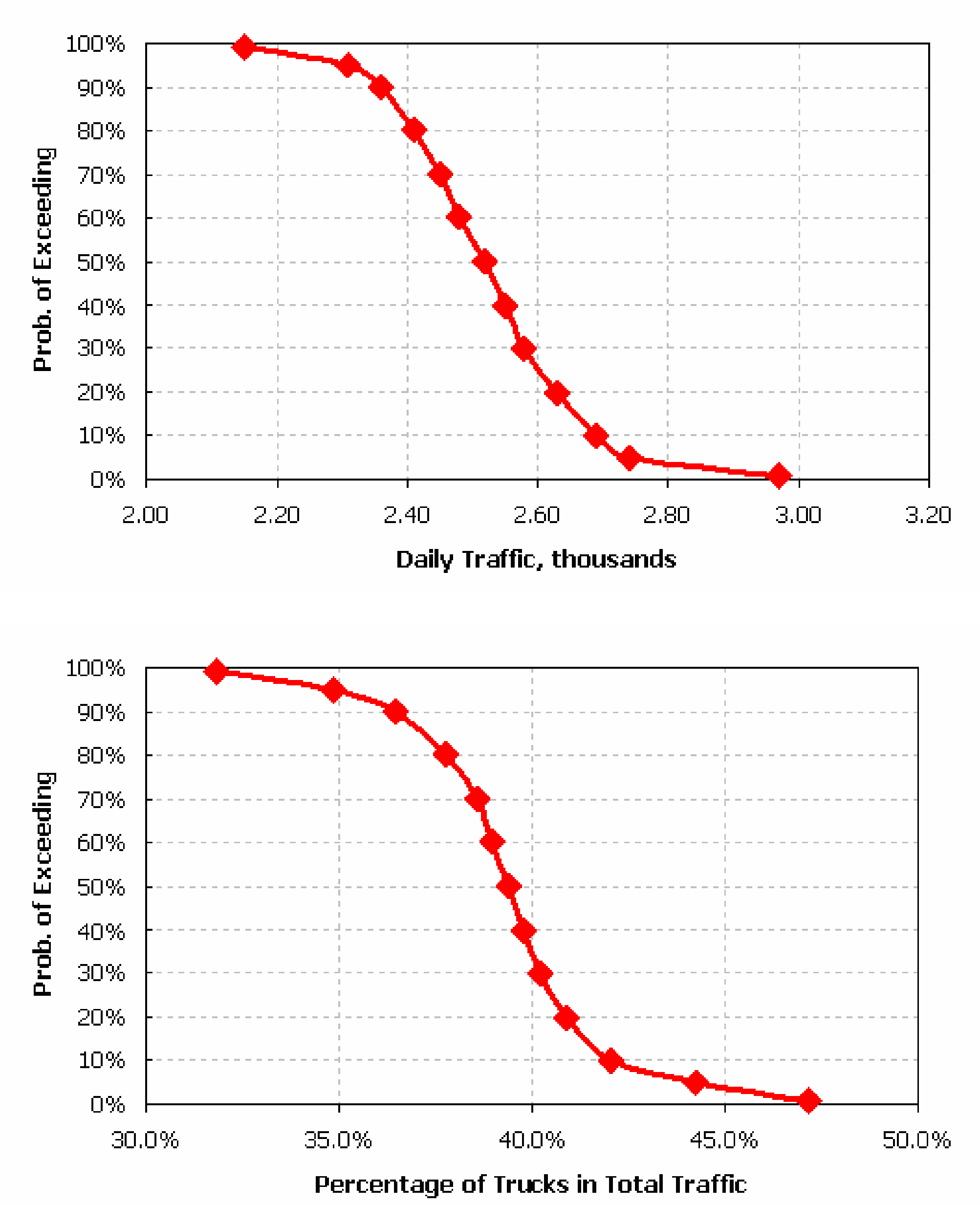


Table 1: Risk Analysis of Future Corridor Traffic and Percentage of Trucks in Total Traffic, *an Illustration*

Future Corridor Traffic, thousands	Probability of Exceeding Value Shown at Left
2.15	99%
2.31	95%
2.36	**90%**
2.41	80%
2.45	70%
2.48	60%
2.52	**50%**
2.55	40%
2.58	30%
2.63	20%
2.69	**10%**
2.74	5%
2.97	1%
2.56	**Mean Expected Outcome**

Percentage of Trucks in Total Traffic, %	Probability of Exceeding Value Shown at Left
31.8%	99%
34.8%	95%
36.5%	**90%**
37.8%	80%
38.6%	70%
39.0%	60%
39.4%	**50%**
39.8%	40%
40.2%	30%
40.9%	20%
42.0%	**10%**
44.3%	5%
47.2%	1%
39.1%	**Mean Expected Outcome**

APPENDIX C: SUPPORTING DATA

Table 2: Historical Traffic Counts along the Project Corridor

Segment	2002		2003		2004		2005	
	Car	Truck	Car	Truck	Car	Truck	Car	Truck
1) Raymond to Plentywood (MT-16)	940	80	940	92	1,140	106	1,140	104
2) Plentywood to Antelope (MT-16)	3,596	186	2,970	186	4,180	185	3,945	186
3) Antelope to Medicine Lake (MT-16)	990	144	970	143	1,090	144	1,360	144
4) Medicine Lake to Culbertson (MT-16)	1,165	183	870	156	1,004	144	1,349	143
5) Culbertson to Bainville (US-2)	1,905	126	1,800	126	2,140	127	2,140	127
6) Bainville to North Dakota Border (US-2)	1,212	126	1,100	127	1,325	127	1,330	127

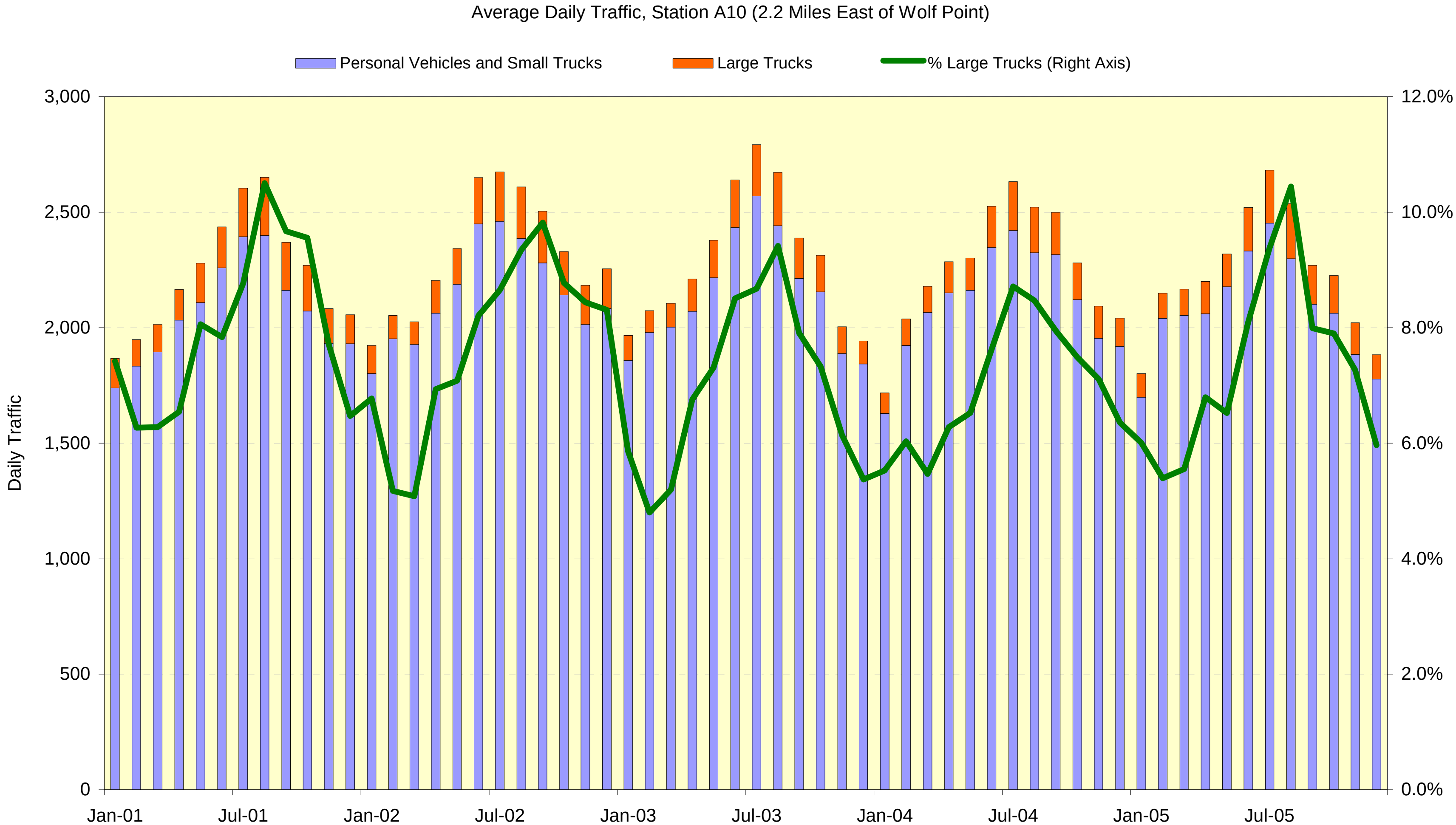
Source: Temporary Traffic Data Recorders

Table Cont': Average Growth per Year along the Project Corridor, 2002-2005

Segment	Growth 2002-2005		
	Cars	Trucks	Overall
1) Raymond to Plentywood (MT-16)	7%	9%	**7%**
2) Plentywood to Antelope (MT-16)	3%	0%	**3%**
3) Antelope to Medicine Lake (MT-16)	11%	0%	**10%**
4) Medicine Lake to Culbertson (MT-16)	5%	-8%	**3%**
5) Culbertson to Bainville (US-2)	4%	0%	**4%**
6) Bainville to North Dakota Border (US-2)	3%	0%	**3%**

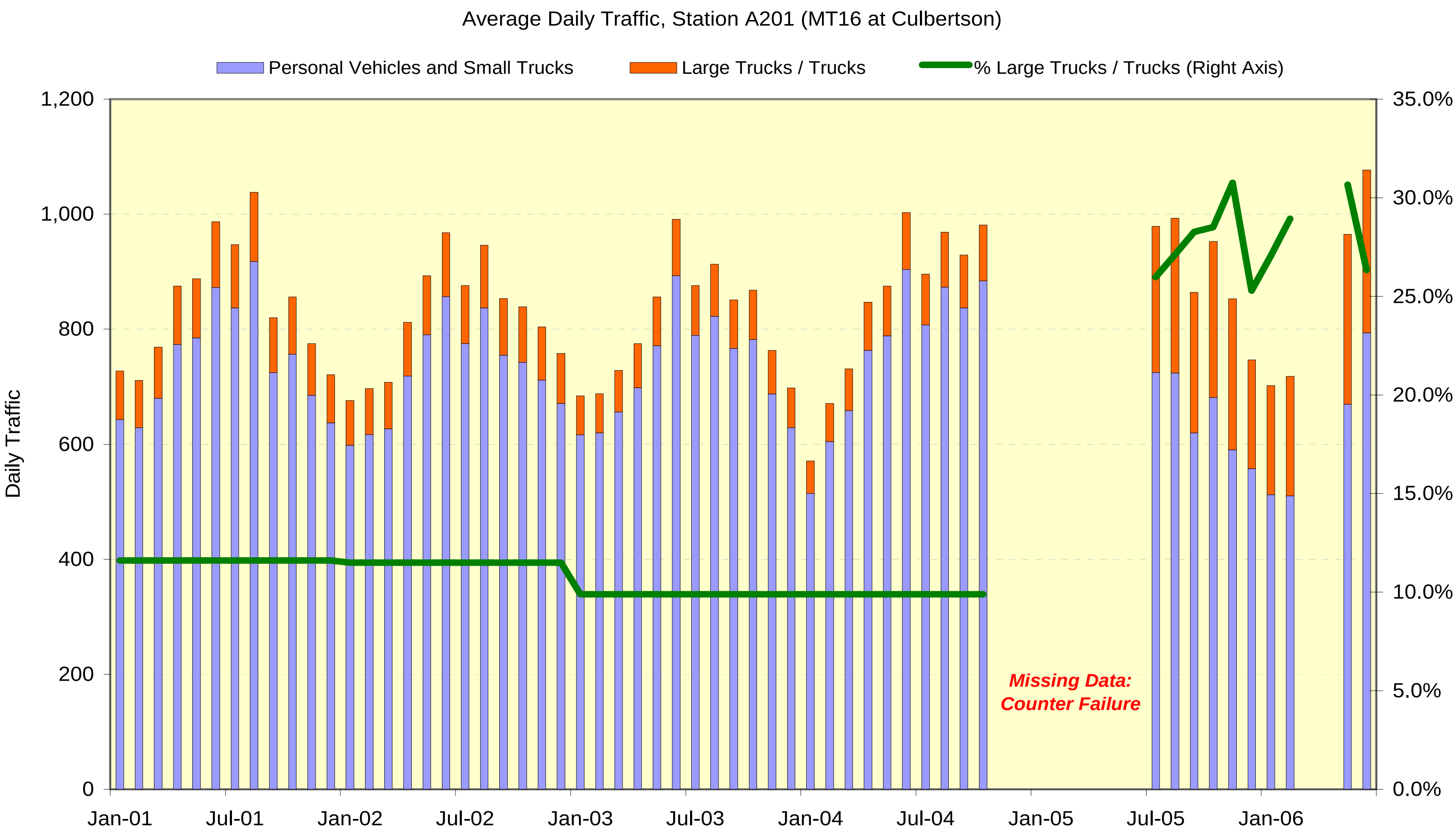
Source: Temporary Traffic Data Recorders

Figure 14: Average Daily Traffic Counts on US 2 at Wolf Point, January 2001 – December 2005



Source: MDT Automatic Traffic Recorders

Figure 15: Average Daily Traffic Counts on MT 16 at Culbertson, January 2001 – June 2006



Source: MDT Automatic Traffic Recorders; http://www.mdt.mt.gov/publications/datastats.shtml
Note: Monthly vehicle distribution (personal vehicles vs. large trucks) not available before 2005. Change in data sources and variable definition (all vs. large trucks) may explain the jump in truck percentage after July 2005. Data after 2005 is for East lane only; multiplied by two to obtain two-way

AADT comparable to pre-2005 data.