Culbertson Corridor Planning Study

EXISTING & PROJECTED CONDITIONS REPORT

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Chapter 1 Introduction

The purpose of this report is to portray the existing and projected roadway conditions and environmental factors throughout the corridor study area for US Highway 2 (US 2) and Montana Highway 16 (MT 16). The findings contained in this report help identify areas of concern and constraints in developing improvement options for the high-level planning process.

US 2 and MT 16 are both functionally classified as Rural Principal Arterials on the National Highway System (NHS) Non-Interstate. The Study area around Culbertson, Montana includes a 4-mile segment of US 2 (between Reference Post (RP) 642.8 and RP 646.8) and a 5-mile segment of MT 16 (between RP 86.6 and RP 88.6 and between RP 0 and RP 3). There are two distinct sections of MT 16 through the corridor study area. The southern section of MT 16 enters the south side of the Study area at RP 3 and continues northwest over the BNSF Bridge, heads west along 1st Street, turns north on Broadway Avenue, and intersects US 2 at RP 0. MT 16 then continues east and is concurrent to US 2 for one block before heading north to begin the northern portion of MT 16 at RP 88.6 and continues north to RP 86.6. The study area boundary and the Town of Culbertson are shown in Figures 1 and 2, respectively.

Due to considerable growth in the oil and gas industry in northeastern Montana and northwestern North Dakota, the Culbertson area has experienced an increase in truck traffic through town. Chapters 1 and 2 will focus on the existing roadway, social, economic, and environmental conditions within the Culbertson Corridor Study area. The information in Chapters 1 and 2 is based on a high-level scan obtained from publicly available sources and as-built construction drawings. If a project is forwarded from this Study, the information presented herein may be used to inform future project level analysis.

Figure 1. Study Area Boundary

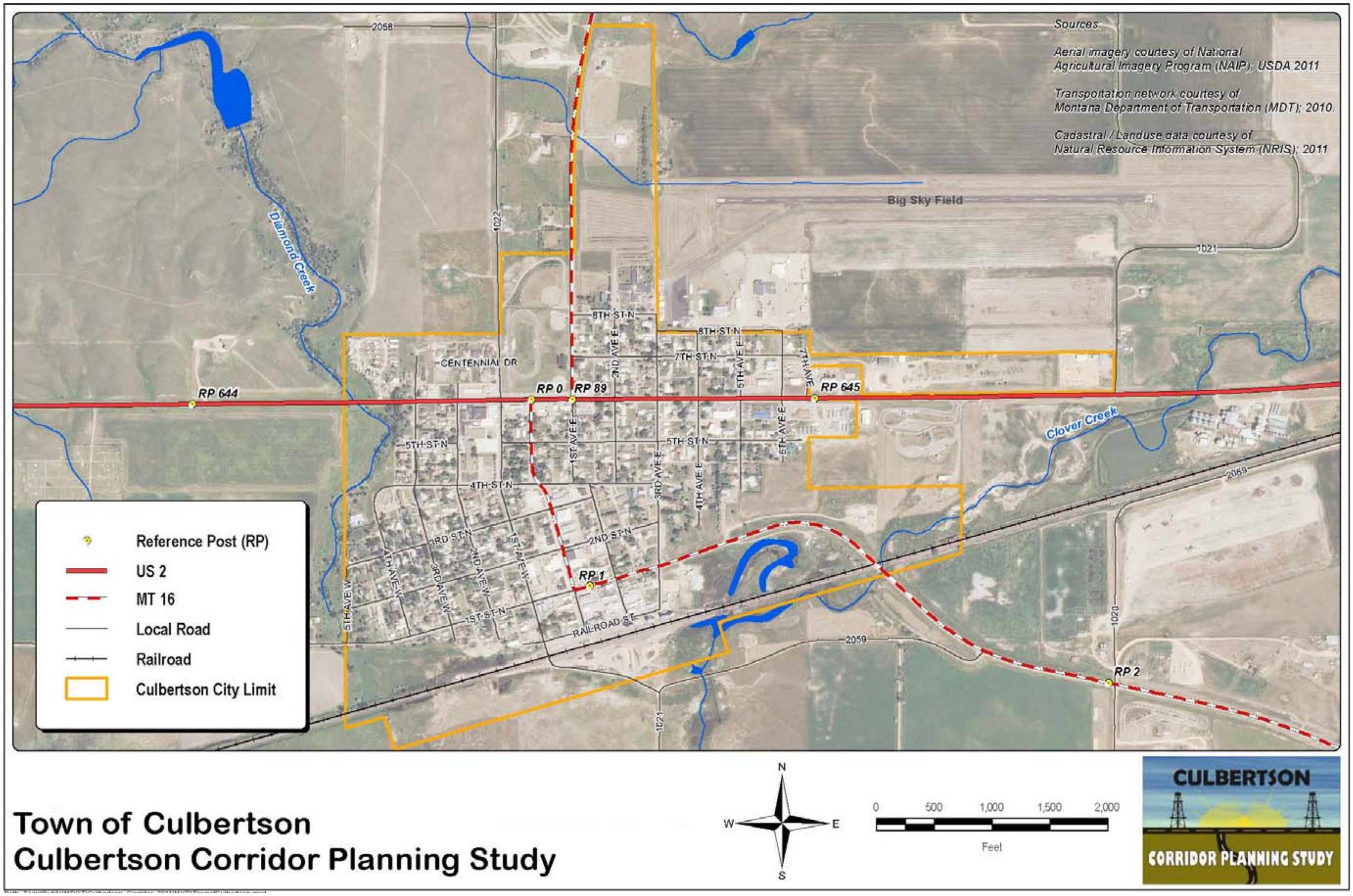
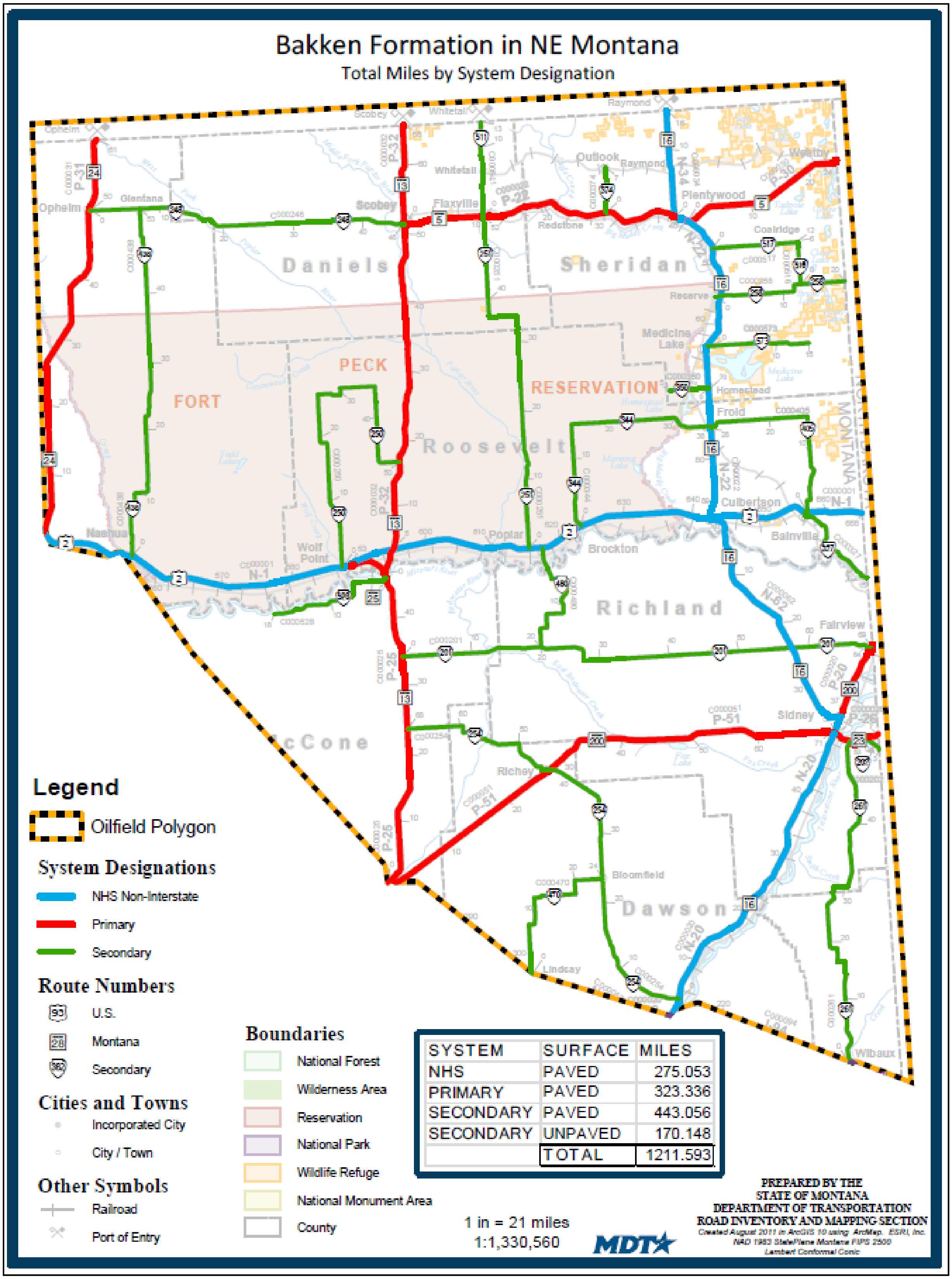


Figure 2. Town of Culbertson

Chapter 2 Existing Socio-Economic Conditions

The Culbertson Corridor Planning Study area is centered around the town of Culbertson in Roosevelt County. Culbertson is an incorporated city with a population of 714, according to the 2010 US Census. In recent years, Culbertson, Roosevelt County, and surrounding communities have experienced socio-economic impacts within the area due to the increase in the oil and gas industry. The Study area is located within the Bakken Shale Formation which is experiencing a boom in oil development. The Bakken region, which includes northeastern Montana, northwest North Dakota, and southern Saskatchewan in Canada, is considered the fastest growing economic area in the United States at the present time. The Bakken is the largest known reserve of light sweet crude oil in North America. The formation of shale source rock covers about 200,000 square miles. Figure 3 shows the Bakken Formation in northeastern Montana.



SYSTEM	SURFACE	MILES
NHS	PAVED	275.053
PRIMARY	PAVED	323.336
SECONDARY	PAVED	443.056
SECONDARY	UNPAVED	170.148
	TOTAL	1211.593

Figure 3. Bakken Formation in Montana

As shown in Figure 3, the Bakken formation encompasses a large region outside the Culbertson Corridor Planning Study area that has been affected by the recent development in the oil and gas industry. Economic activity in this area may be generated by providing materials and resources such as sand and water used in the fracturing process, and by delivering outputs such as oil, gas, and wastewater to transmission stations and injection wells, performing value-added work such as processing, engineering, marketing, and labor. The extent to which counties and cities in the Bakken region participate in the oil boom, either as a location of energy development or as providers of goods and services, continues to evolve.

The socio-economic information and factors contained in this section will reflect conditions in both Roosevelt and Richland Counties. Richland County is located south of Roosevelt County and includes the towns of Sidney and Fairview. Analysts expect oil exploration and development to continue in the Bakken region over the next ten to twenty years. Existing socioeconomic data are mostly out of date in relation to the recent oil boom activity. Projections are made to the 20-year planning horizon, but current economic changes add uncertainty to the social and economic projections. This section presents the most recent socioeconomic statistics available and describes the rapid, recent changes in the area, particularly in the energy industry.

2.1.1 Regional Population and Demographics

The region has been somewhat depressed economically and has experienced negative population growth in recent decades. Current oil activity has brought more people and traffic to the region. Based on the 2010 Census data, Table 1 summarizes basic population information for Roosevelt and Richland Counties.

Table 1. Regional 2010 Census Data

	Roosevelt	Richland
County Population	10,425	9,746
Wolf Point	2,621	
Poplar	810	
Culbertson	714	
Sidney		5,191
Fairview		840
Race		
White	39%	97%
American Indian	63%	3%
Ethnicity: Hispanic or Latino	2%	3%
Housing		
Total housing units	4,063	4,550
Owner-occupied	54%	64%
Renter-occupied	34%	28%
Vacant	13%	8%

Roosevelt County has a large share of its population residing outside communities. Roosevelt County's largest cities are Wolf Point, Poplar, and Culbertson, which account for about 40 percent of the county's population. Sidney and Fairview make up 62 percent of Richland County's population. Roosevelt County includes a large part of the Fort Peck Indian Reservation, consisting of the Assiniboine and Sioux Tribes. The Native American population of Roosevelt County is 63 percent of the total, compared with 3 percent in Richland County. In terms of ethnicity, the Hispanic population is 2 to 3 percent, which is comparable to the state as a whole.

Field reports suggest that an influx of workers has put pressure on housing markets in the Bakken region since the 2010 Census counts were taken. Accounts of housing shortages have become regular, and although the reports are not systematic enough to include in this section, the accounts are consistent with more frequent data reports such as traffic counts and unemployment rates, which are addressed in the following sections. It should be noted, that currently in the Culbertson area, hotels are fully booked, rental properties are occupied, and a future man camp is being planned to house oil workers. Communities throughout the region, including Culbertson, are unable to handle the infrastructure demand due to the rise in oil production and operations. The 2010 Census data are a baseline in comparison against more current information as it becomes available.

Figure 4 shows the population of the regional counties from 2000 to 2010 (shown in blue) and projections out to year 2030 (shown in red) based on NPA Data Services, Inc. through the Department of Commerce. The general trends have been confirmed by the Montana Census and Economic Information Center.

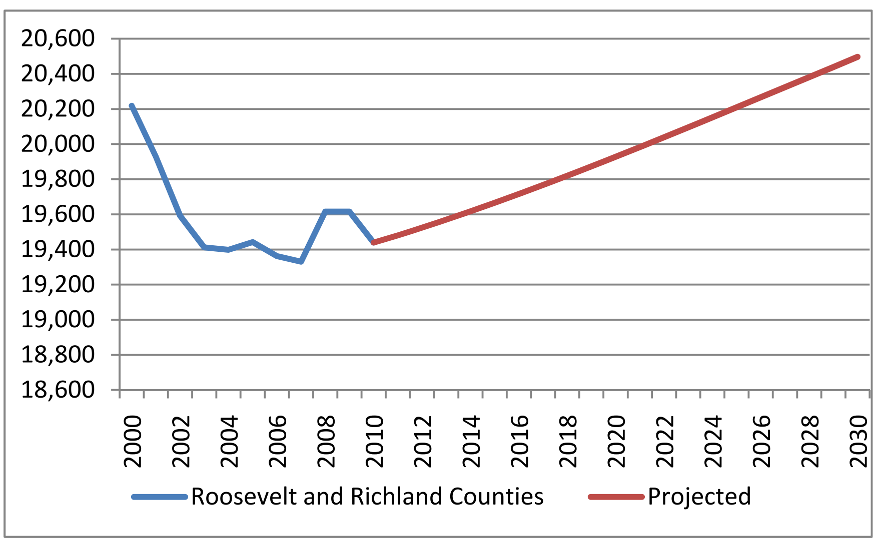


Figure 4. Total Observed and Projected Population in the Study Counties

Between 2000 and 2004, Roosevelt and Richland Counties experienced a population decline of nearly 600 people. Following that was a slight rebound in 2008 and 2009, but the area had a net negative population growth for the decade. Population projections suggest that the population of the two counties will rebound slowly and by 2030 the counties will reach populations slightly higher than in 2000. The long-term population trend in much of eastern Montana outlines a general expectation that population growth will be limited in the 20-year planning horizon. The projections reflect expectations from before the current oil boom, so growth rates may be higher over the 20-year planning horizon. However, the current projections represent a baseline against which future estimate may be measured.

Figure 5 shows both the state and study region historic and projected population in terms of percent changes from the year 2000. The figure shows that the study region is expected to remain near the 2000 population over the forecast period. By contrast, the state as a whole has had moderate positive growth and is expected to grow at a similar rate into the future, increasing to about 140 percent of the state's 2000 population by the year 2030. Again, these projections are based on Census data that does not take into account recent and projected growth in Roosevelt and Richland Counties. Given these recent events, it may be expected that population growth rates for these two counties will compare more closely with state rates by the year 2030.

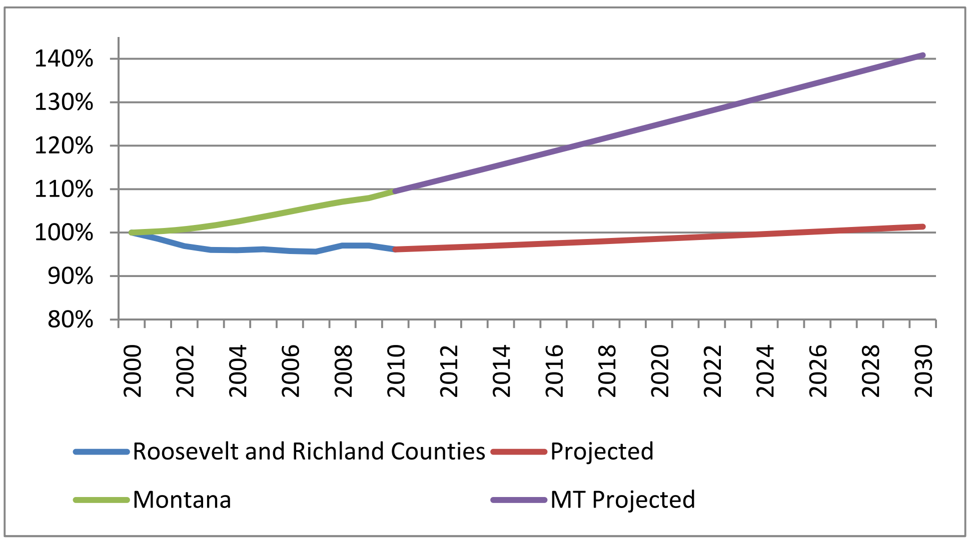


Figure 5. Total Observed and Projected Population of Montana and the Study Counties (Indexed to 2000)

The age distribution of the study area is shown in Figure 6. The figure shows a decline in the percentage of working aged population of the two counties (ages 20 to 64) from a peak of about 55 percent late in the last decade to just over half by 2030. The population 19 and under is expected to decline at a moderate pace compared to the whole population. The population 65 and over is expected to increase by about six percent from its level in the last decade to 2030.

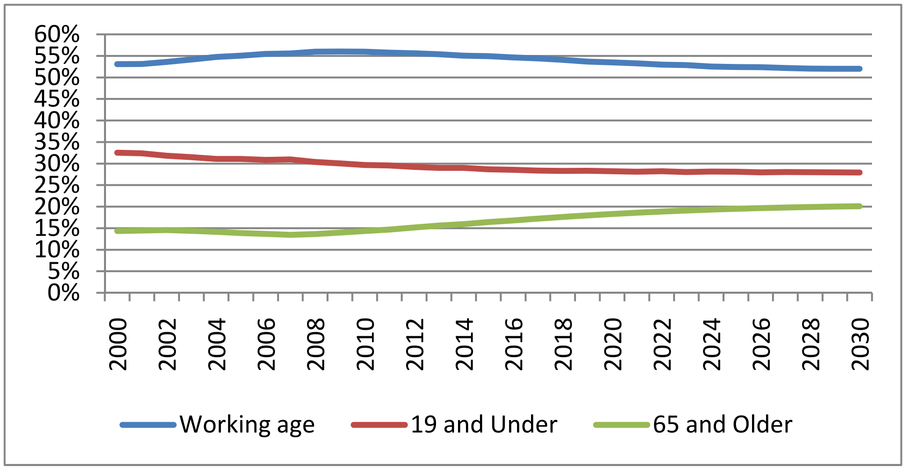


Figure 6. Age Distribution of the Study Counties (Projected after 2010)

2.1.2 Culbertson Population and Demographics

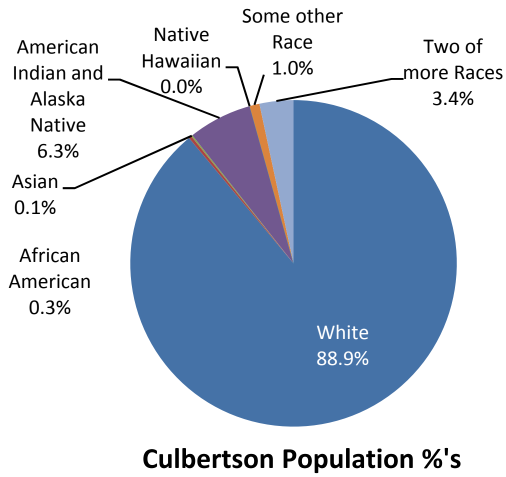
According to the US Census, the population of Culbertson in 2010 was 714. The 2000 US Census, showed the population of Culbertson as 716, indicating the population has basically remained constant over a 10-year period. By comparison, the population of Roosevelt County over the same 10-year period was 10,620 in 2000 and 10,425 in the year 2010. This calculates to be a slight decrease of approximately 2%. Table 2 below shows the population and age distribution percentages for Culbertson and Roosevelt County.

Table 2. 2010 Census Data for Culbertson and Roosevelt County

Distribution	Culbertson		Roosevelt County	
	Number	Percentage	Number	Percentage
Total Population	**714**	**-**	**10,425**	**-**
Male	365	51.1	5,144	49.3
Female	349	48.9	5,281	50.7
Under 18	166	23.2	3,311	31.8
18-65	415	58.1	5,988	57.4
Over 65	133	18.6	1,126	10.8

According to Table 2, nearly a quarter of the Culbertson population includes school-aged children (under the age of 18).

Of the major race categories used by the US Census Bureau, almost 89 percent of the population of Culbertson is categorized as white with the next highest percentage being American Indian and Alaska Native at 6.3 percent. This has shifted slightly over the past 10 years with 93 percent white and 5 percent American Indian back in 2000. For Roosevelt County, in part due to the Fort Peck Indian Reservation as previously mentioned, the percentages are considerably different. The percent population in Roosevelt County considered white is 36 percent and the American Indian/Alaska Native is 60 percent. These and other race percentages for Culbertson and Roosevelt County are shown in the figures below.



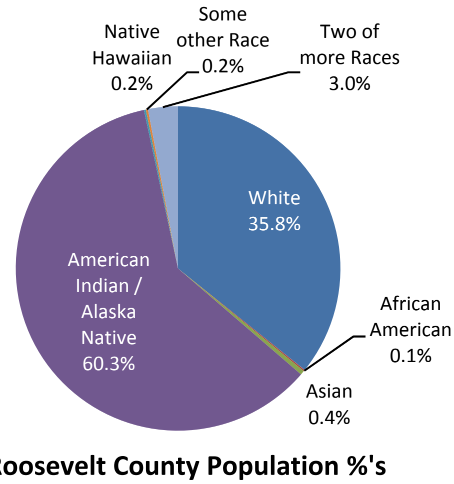


Figure 7. Culbertson and Roosevelt County Populations

2.1.3 Culbertson Employment

From 2006 to 2010, the US Census Bureau, by means of the American Community Survey (ACS), produced the 5-year estimate for industry by occupation for the Town of Culbertson. The study indicated the town of Culbertson has approximately 354 employed persons in the labor force. The top fields of employment are education and health care, followed by the agriculture industry. Table 3 shows the employment within Culbertson by industry, according to ACS.

Table 3. Culbertson Employment by Industry (2006 – 2010)

Industry	Total Estimate
Agriculture, forestry, fishing and hunting	56 (15.8%)
Construction	28 (7.9%)
Manufacturing	14 (4.0%)
Wholesale trade	13 (3.7%)
Retail trade	26 (7.3%)
Transportation and warehousing, and utilities	39 (11.0%)
Information	0 (0.0%)
Finance and insurance, and real estate and rental and leasing	5 (1.4%)
Professional, scientific, and management, and administrative and water management services	2 (0.6%)
Educational services, and health care and social assistance	108 (30.5%)
Arts, entertainment, and recreation, and accommodation and food services	24 (6.8%)
Other services, except public administration	8 (2.3%)
Public Administration	31 (8.8%)
Civilian employed population (16 years and over)	**354**

2.1.4 Regional Economy and Employment

The Bakken region indicates a direct link between national and global conditions, particularly in natural resource-based economies, to those in rural economic markets. Industry and transportation changes beyond the control of local regions can experience shifts in investment and income as a result of the changing industry.

The invention of horizontal drilling (in the Elm Coulee area of Richland County) enabled the entire Bakken formation to be opened to oil and gas development. The discovery of more readily accessible oil pockets of the Bakken within North Dakota has led recent energy development activity to concentrate in that state. Regardless of the epicenter location, this whole region is now bustling with explorers, drillers, workers, drivers, suppliers. Railroads are making improvements and new pipelines are being planned and proposed. In addition, the region is a well-established and production agricultural area. Grain and pulse crops in the area have been productive, agricultural prices are good, and investments in truck-to-rail facilities for farm crops are continuing.

The surge of activity presents a robust situation in a region that some had written off as an economically unviable “Buffalo Commons”, or vast native prairie land. The main challenge for the analysis presented in this study is that the most recent economic data are unable to measure the extent of the recent oil activity and are largely limited to providing information from before the current boom.

The most recent unemployment figures from the state and federal labor departments suggest favorable current employment conditions in the study area, as shown in Table 4. As of December 2011, unemployment in Richland County was 2.3 percent, which is less than half the state-wide rate and nearly a third of the national rate. The rate in Roosevelt County, at 6.8 percent was slightly over the state average.

Table 4. December 2011 Unemployment Numbers (not seasonally adjusted)

	Labor Force	Employed	Unemployed	Rate	County Rank
United States				8.5%	
Montana	496,092	462,673	33,419	6.7%	
Roosevelt County	4,579	4,266	313	6.8%	39
Richland County	6,300	6,153	147	2.3%	2

Low unemployment rates may reflect individuals who have stopped looking for work or out-migration of workers, but this is not likely the case in the region. According to reports of job expansion, it seems as if recent unemployment figures actually reflect economic expansion.

Figure 8 shows an estimation of the economic base of Richland County for the period 2008 to 2010 from the University of Montana Bureau of Business and Economic Research (BBER). The economic base of an economy refers to activities that bring income into an area or the economy remains in the area. Although the figure only considers Richland County, it is the best window available into the basic economy of the larger study area.

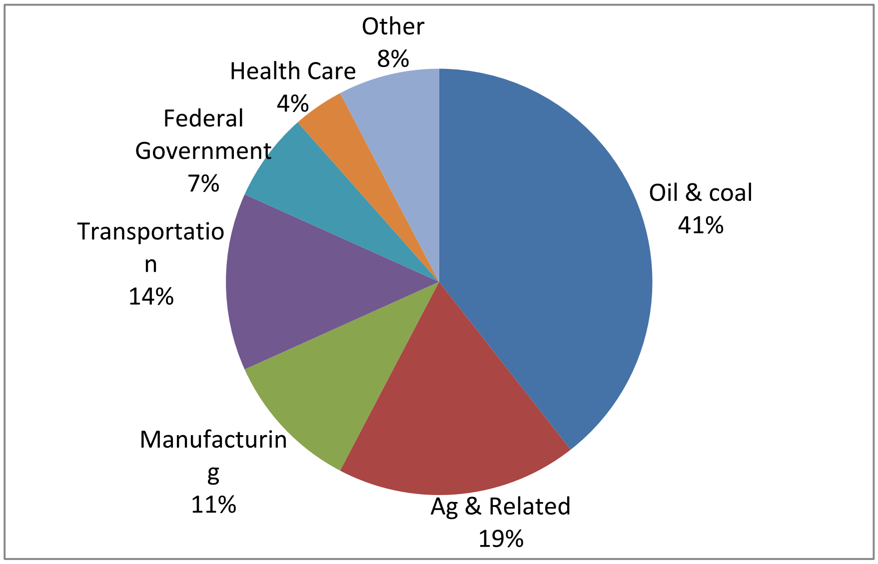


Figure 8. Economic Base of Richland County, Montana 2008 to 2010

The single largest share of the Richland County economy is from the energy industry (41 percent). A slightly larger part is made up from the total of agriculture, manufacturing, and transportation industries (44 percent). Manufacturing and transportation become linked to other economic-base industries when goods like oil and gas, or wheat and sugar beets are processed and shipped. The economic base is rounded out by government activities, health care, and other (including tourism).

Figure 9 shows percentage change in jobs for Montana and the study area. Roosevelt and Richland Counties are indicated by “R&R” in the figure. This figure highlights two industries of interest: mining and transportation. All other industries are combined. Public statistics on industries commonly lag several years behind, in which 2008 projection information is the latest data available.

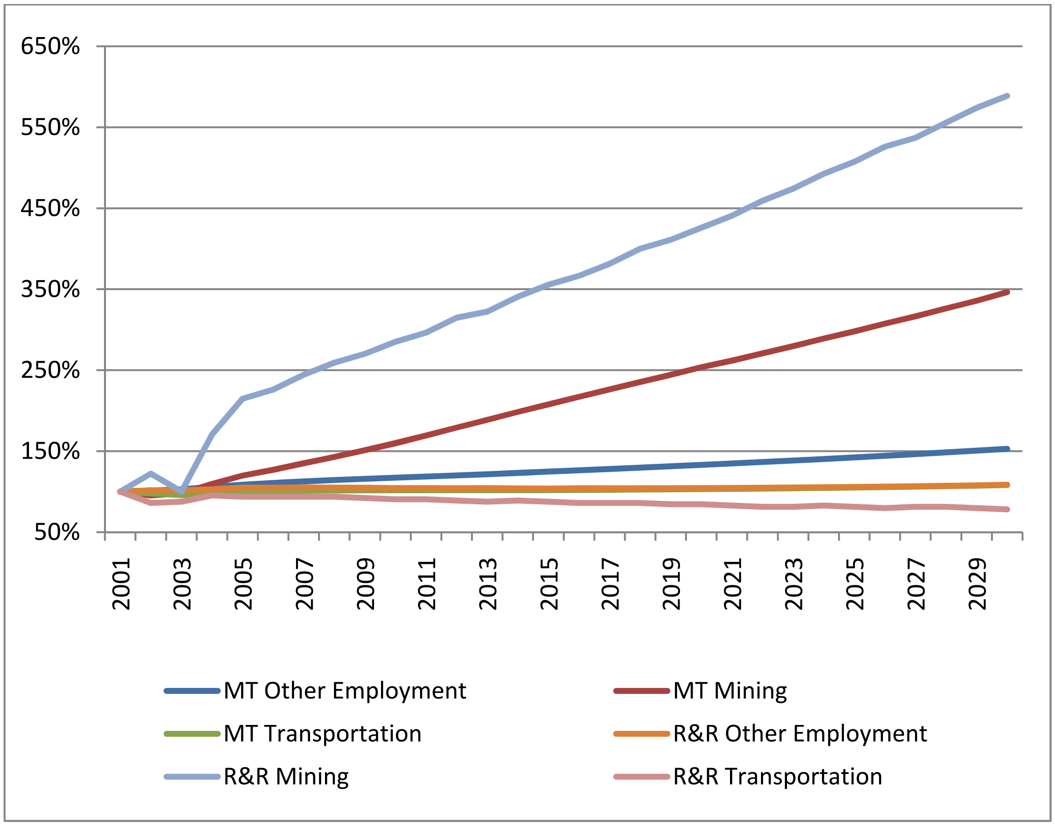


Figure 9. Employment Growth Projections for Montana and the Study Region (Indexed to 2001)

As the employment projections do not reflect the recent oil boom in the Bakken region, the projections may be useful as a baseline reflecting earlier expectations. The projections show the energy sector (mining) growing faster in the study area than in the state as a whole. The remaining industries (transportation and "other") are not projected to grow much through the year 2030.

Figure 10 shows actual and projected numbers of job estimates for mining and transportation sectors in the study region. The figure illustrates mining employment is projected to increase from about 300 in 2002 to about 1,600 by the year 2030. Transportation and public utilities jobs are projected to decline from a high of 640 to 500. As previously noted, such projections preceded the current Bakken oil boom.

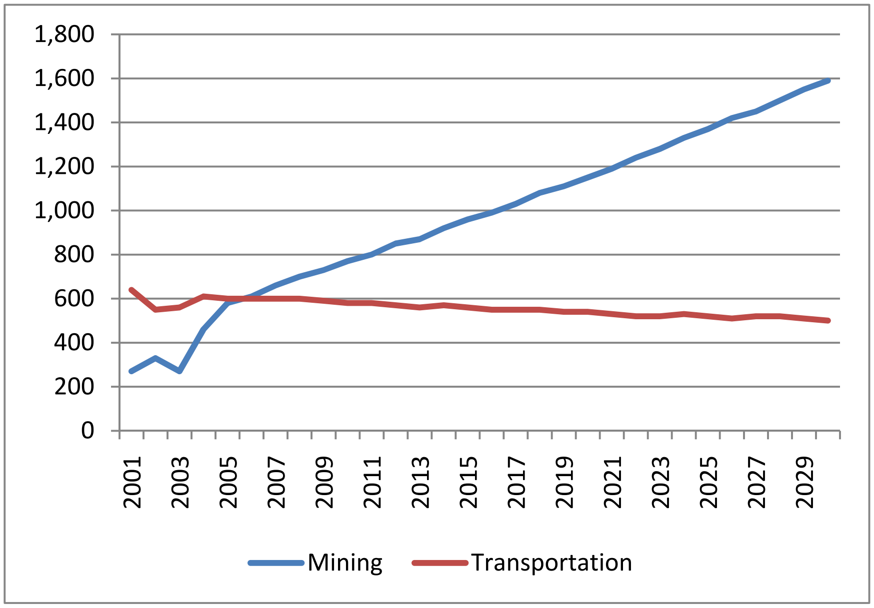


Figure 10. 2008 Data and Projections for Jobs in Mining and Transportation Sectors in the Two-County Area

Figure 11 shows oil activity in Montana as of January 2012 by the Montana Board of Oil and Gas. The green dots represent oil wells that are in the process of development; the yellow dots indicate wells have been permitted but have not begun; and the red dots represent producing oil wells. The thickest center of oil activity in this broader region is within Richland County.

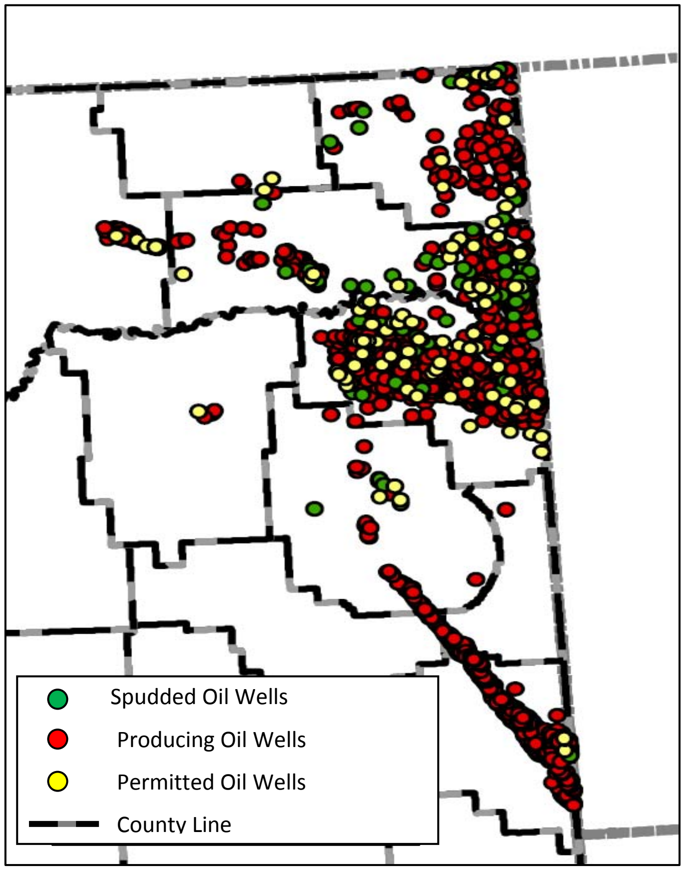


Figure 11. Oil Activity in Northeastern Montana (January 2012)

According to the Montana Board of Oil and Gas of the Montana Department of Natural Resources and Conservation, several oil wells have been identified within the study area boundary and are shown in Figure 12.

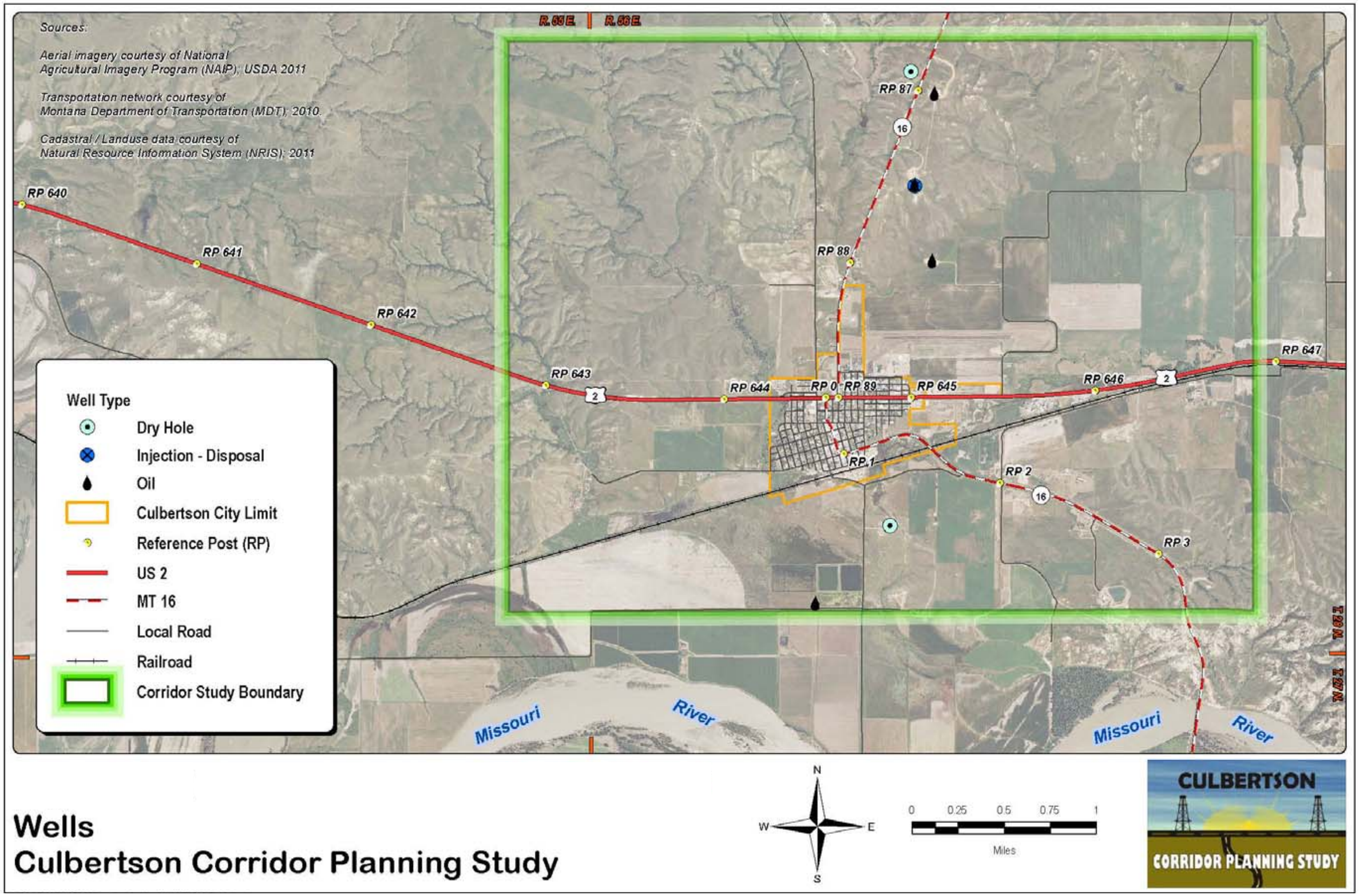


Figure 12. Oil Wells within Study Area Boundary

Agriculture also plays a major role in Culbertson's and the surrounding region's economy. The main products harvested in this region are wheat, sugar beets, alfalfa, beef cattle, and food oils. BNSF Railway loading facility on the south end of Culbertson allows shipping of the regional products to consumers all across the country. Columbia Barge Company plans to build a 110-car grain loading facility in the Culbertson area. The grain loading facilities are designed to load 110-rail cars full of wheat within 24 hours, and they seem to have added major efficiencies in rail hauling of agricultural products. Shuttle loading facilities continue to be added in Montana, and their long-term impacts are difficult to predict. Additional facilities are located approximately 80 miles east of the Culbertson area. Some studies suggest that the emergence of grain loading facilities has, to date, led to heavier grain trucks traveling over longer distances, with potential impacts on Montana roadways.

The Culbertson area offers many recreational opportunities. Fishing, swimming, and boating on the Missouri River, Yellowstone River, and Fort Peck Lake are available with hunting and trap shooting. Several annual events bring visitors and entertainment to the Culbertson area. These events which attribute to the local economy include:

- Frontier Days & Rodeo (mid-June)
- Roosevelt County Fair (mid-August)
- Labor Day Wagon Train/Trail Ride (Labor Day-September)
- Northeast Montana Antique Association Threshing Bee & Show (late-September)

Chapter 3 Existing Roadway Conditions

3.1 *Existing & Projected Traffic Volumes*

3.1.1 Existing Traffic Volumes

US 2 and MT 16 are primarily used by local traffic, commercial trucks, and recreational vehicles in the study area. During harvest months, an increase in truck traffic volumes throughout the Study area is primarily due to movement of harvesting vehicles and transport of wheat and sugar beets. Oil truck related traffic is prevalent year round. During summer months, an increase in roadway users and traffic volumes on these routes are primarily due to tourism.

In order to determine a comprehensive Annual Average Daily Traffic (AADT) count for US 2 and MT 16 in the Study area, a weighted AADT was determined. The weighted average is based on yearly traffic counts by section for the most recent ten-year data. It should be noted that traffic counts were not collected in 2010. Table 5 shows the weighted AADT for each segment for each year.

Table 5. Average Annual Daily Traffic

Length (miles)	Location	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0.305	US 2, entering Culbertson City Limits	1796	1226	1120	1566	1470	1470	1470	1270	1130	1185
0.069	US 2, Junction of MT 16 south	2340	1300	2210	2290	2260	2290	2290	2320	2220	2340
0.389	US 2, Junction of MT 16 north	2345	2026	1905	1800	2140	2140	2135	2115	1645	1920
	US 2 Weighted Average	2125	1641	1619	1751	1883	1886	1883	1796	1491	1664
0.132	MT 16 north, entering Culbertson City Limits	865	900	830	855	940	940	940	1090	885	1020
	MT 16 north Weighted Average	865	900	830	855	940	940	940	1090	885	1020
0.876	MT 16 south, Junction of US 2	1315	1417	1281	1339	1354	1354	1354	1106	1039	1193
2.323	MT 16 south, leave Culbertson City Limits	860	1085	980	960	1160	1130	1305	825	925	940
	MT 16 south Weighted Average	985	1176	1062	1064	1213	1191	1318	902	956	1009

Source: MDT Traffic and Data website

Because local traffic may have increased in the last two years, turning movement data was gathered for four main intersections in the Study area. Turning movement counts were gathered for the intersection of US 2 and MT 16 (north) on September 21, 2011. This intersection was recounted in March 2012 and additional turning movement counts were gathered for the intersections of US 2 and MT 16 (south), MT 16 (south) and 1st Street, and MT 16 (south) and County Road 1020. Each vehicle entering an intersection was lumped into one of the five following categories: car, medium trucks, heavy trucks, bus, or motor bike. Figure 13 shows the total turning movement counts over the course of 24 hours for each of these sites. It should be noted that the March 2012 turning movement counts for the intersection of US 2 and MT 16 (north) did not span a 24-hour window and therefore Figure 13 incorporates the September 2011 data collected for this intersection.

Turning movement counts for each leg were converted to volumes in order to determine the percentage of heavy trucks traveling on each leg of the intersection. These results are shown in Figure 14.

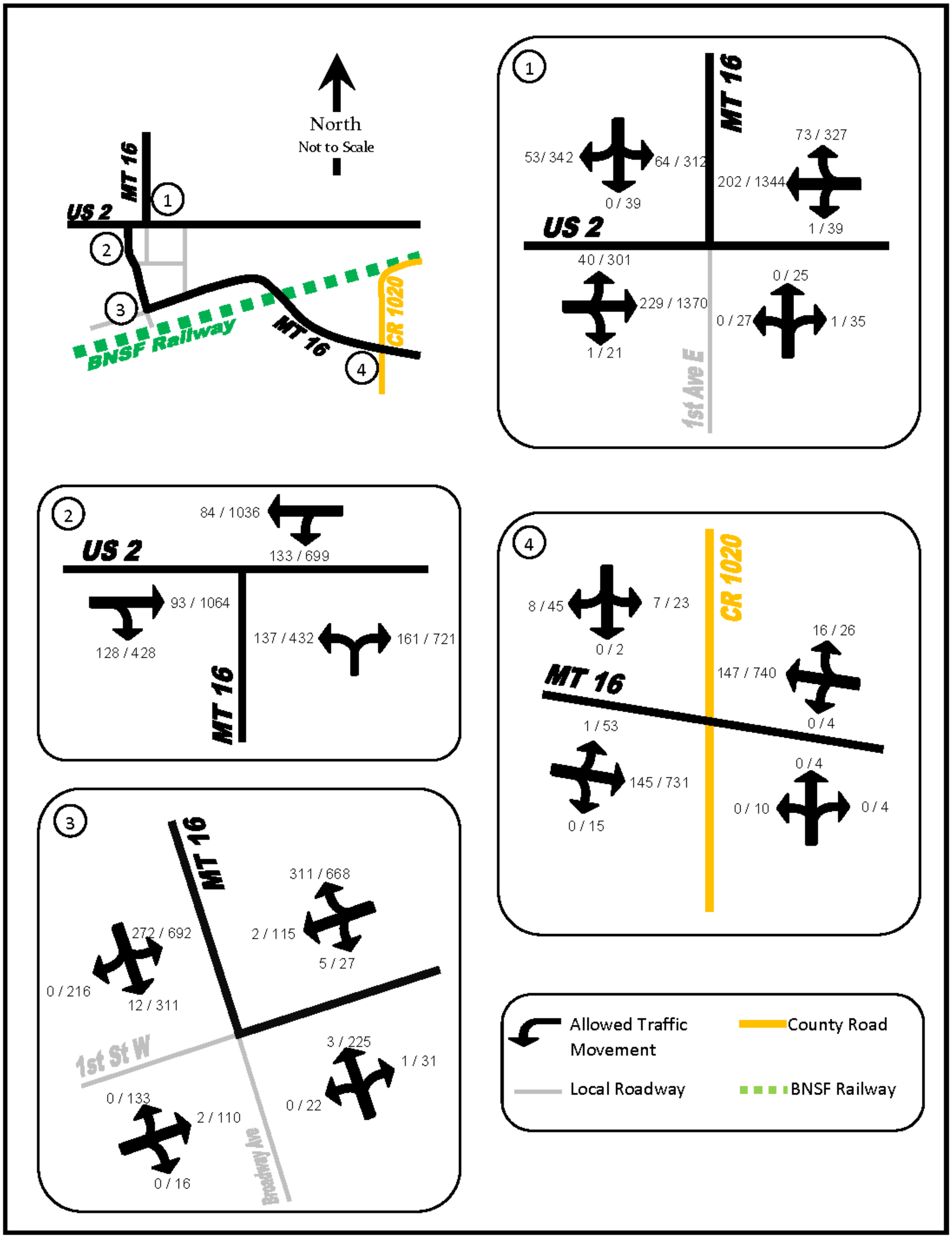


Figure 13. Current 24-Hour Turning Movement Counts (Heavy Vehicle # / Total Vehicle #)

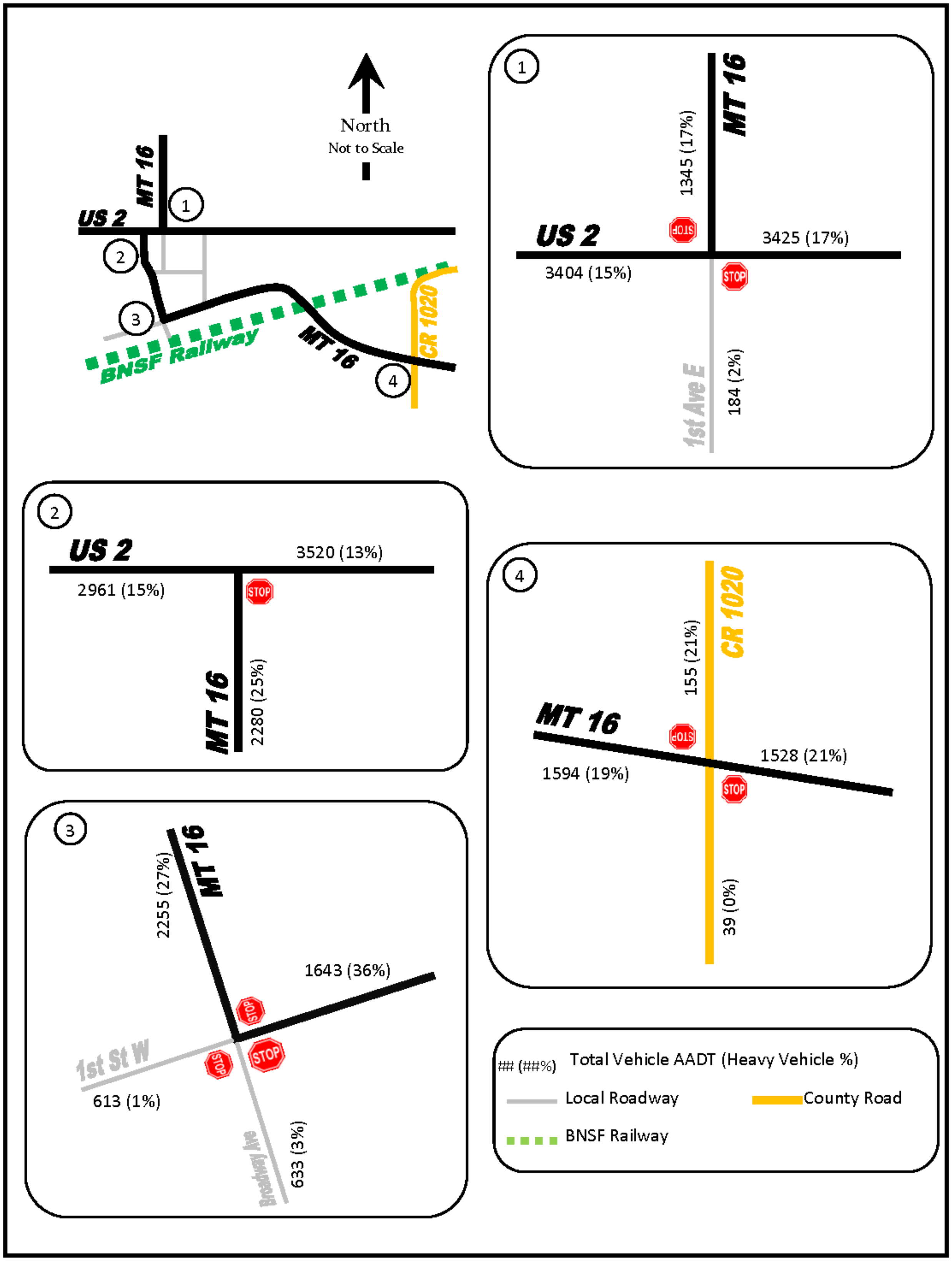


Figure 14. Current AADTs per 24-Hour Turning Movement Counts

All intersections show a high percentage of heavy vehicles on MT 16 and US 2. The intersection of MT 16 (south) and County Road 1020 also shows a high percentage of heavy vehicles on the southbound leg. It has been observed that trucks occupy two lanes to make their turning movements. Truck turning movements and spill containment should be considered if improvement options are carried forward.

Turning movement counts were also used to evaluate the current level of service (LOS) at each intersection. LOS for an intersection is a qualitative measure developed by the transportation profession to quantify driver perception for such elements as travel time, number of stops, total amount of stopped delay, and impediments caused by other vehicles. It provides a scale that is intended to match the perception by motorists of the operation of the intersection. LOS provides a means for identifying intersections that are experiencing operational difficulties, as well as providing a scale to compare intersections with each other. The LOS scale represents the full range of operating conditions. The scale is based on the ability of an intersection to accommodate the amount of traffic using it. The scale ranges from "A" which indicates little, if any, vehicle delay, to "F" which indicates substantial vehicle delay and traffic congestion. LOS was computed using the intersection's peak hour, which was different for each intersection. More detailed information for the 2012 LOS analysis can be seen in Appendix A. Table 6 shows a summary of the LOS for each individual leg of the four intersections studied. Table 6 was based on March 2012 turning movement counts for all legs of all intersections.

Table 6. Current Intersection Level of Service during Peak Hour

ID*	Intersection	EB	WB	NB	SB
1	US 2 and MT 16 (north)	A	A	B	B
2	US 2 and MT 16 (south)	A	A	B	N/A
3	MT 16 (south) and 1st Street	B	A	A	A
4	MT 16 (south) and CR 1020	A	A	B	B

**Note: ID per Figures 13 and 14 of this report.*
(Abbreviations used are as follows: EB = eastbound; WB = westbound; NB = northbound; SB = southbound; N/A = not applicable).

An automatic traffic recorder (ATR) is located along MT 16, north of Culbertson, at approximately RP 88.5, represented as Station A-201. The most recent yearly report for 2011 at this site indicates the month of August experiences the highest volume of traffic with 1,471 vehicles per day. However, Fridays in the month of June experience the highest average daily number of vehicles with 1,651. The percentage of large trucks was recorded to be 9.64% at this location in 2011.

3.1.2 Projected Traffic Volumes

It is difficult to estimate future traffic growth based solely on the most recent historical traffic counts (2000-2009) because local traffic may have increased in the last two years (2010-2011) due to the recent economic conditions in the Culbertson area. A five-year growth rate, which is more indicative of the latest economic activity, was projected by MDT for each roadway. The five-year growth rate for US 2 is

2.6 percent and for MT 16 north and south of US 2 is 3.2 percent and 16.3 percent, respectively. This section provides the analytical approach used to predict the 20-year growth rate.

In order to determine the average growth of traffic in the Study area, the weighted average annual daily traffic (AADT) counts for the most recent ten-year data were plotted. AADT counts for 2010 to 2015 for each roadway were calculated using their respective five-year growth rates and these points were added to each roadway's graph. Once all data points for 2000-2015 were plotted, a linear regression line for the 15 years of data was plotted. Figures 15, 16, and 17 show the 15-year linear regressions for US 2, MT 16 (south) and MT 16 (north), respectively. The slope of the linear regression line shows a potential yearly increase in AADT.

Figure 15. 15-Year Growth

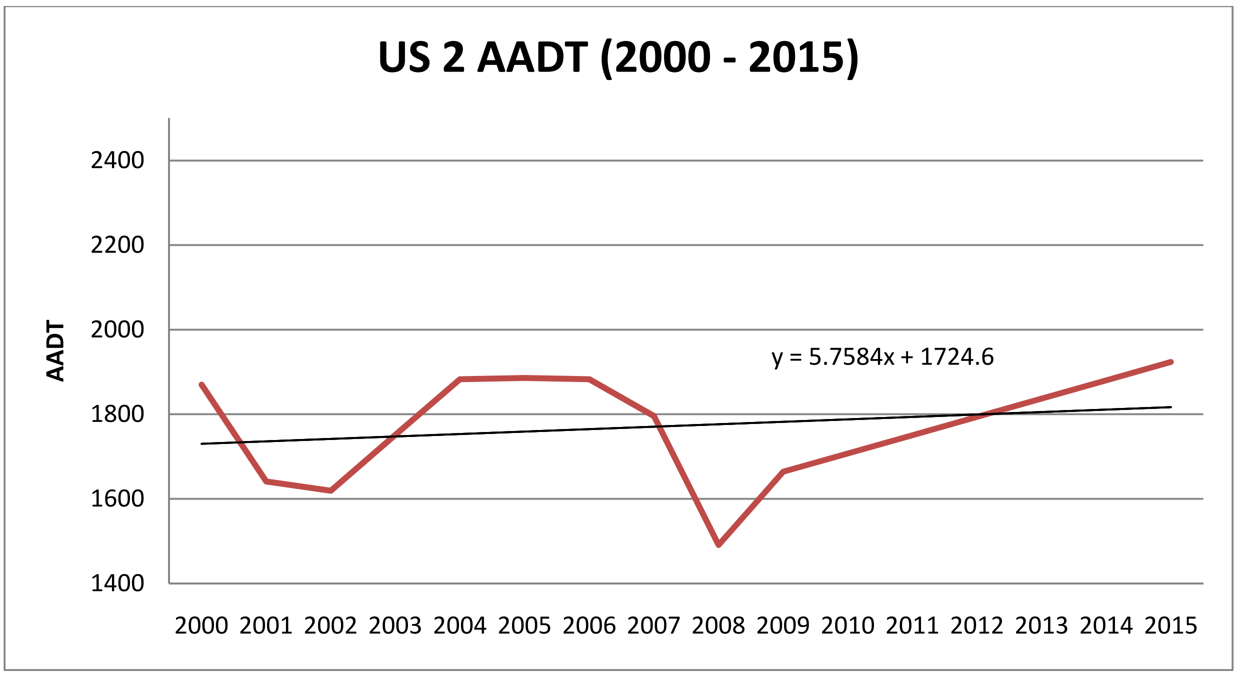


Figure 16. 15-Year Growth Rate for MT 16 (South)

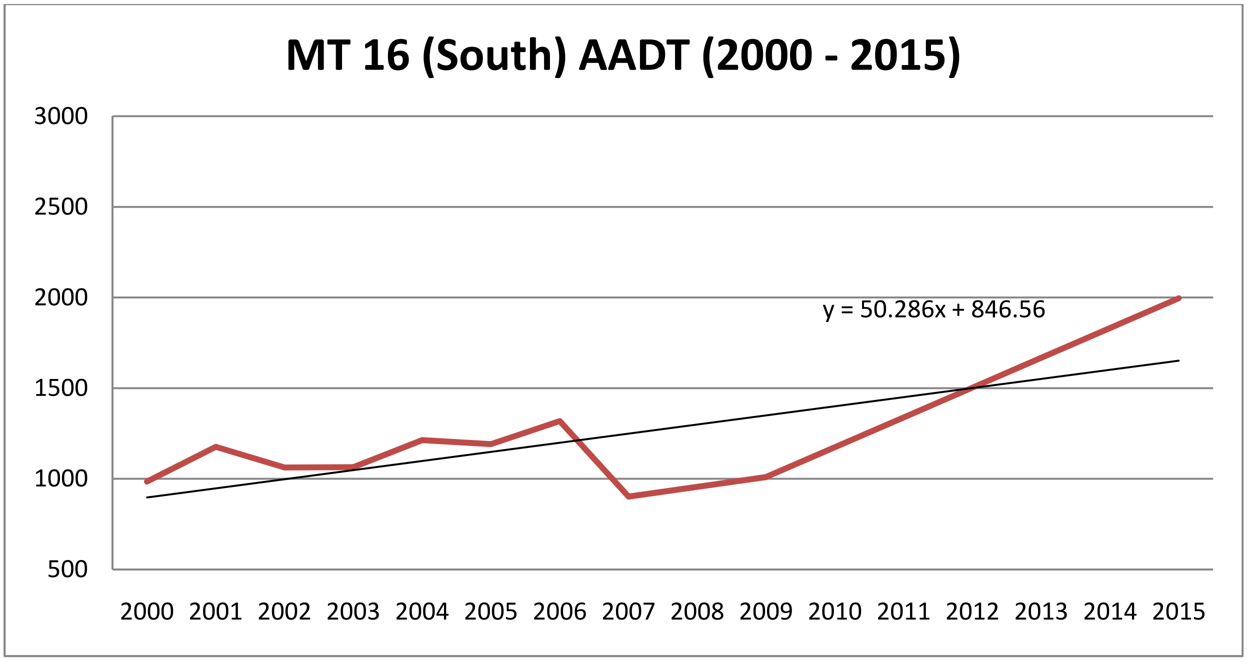
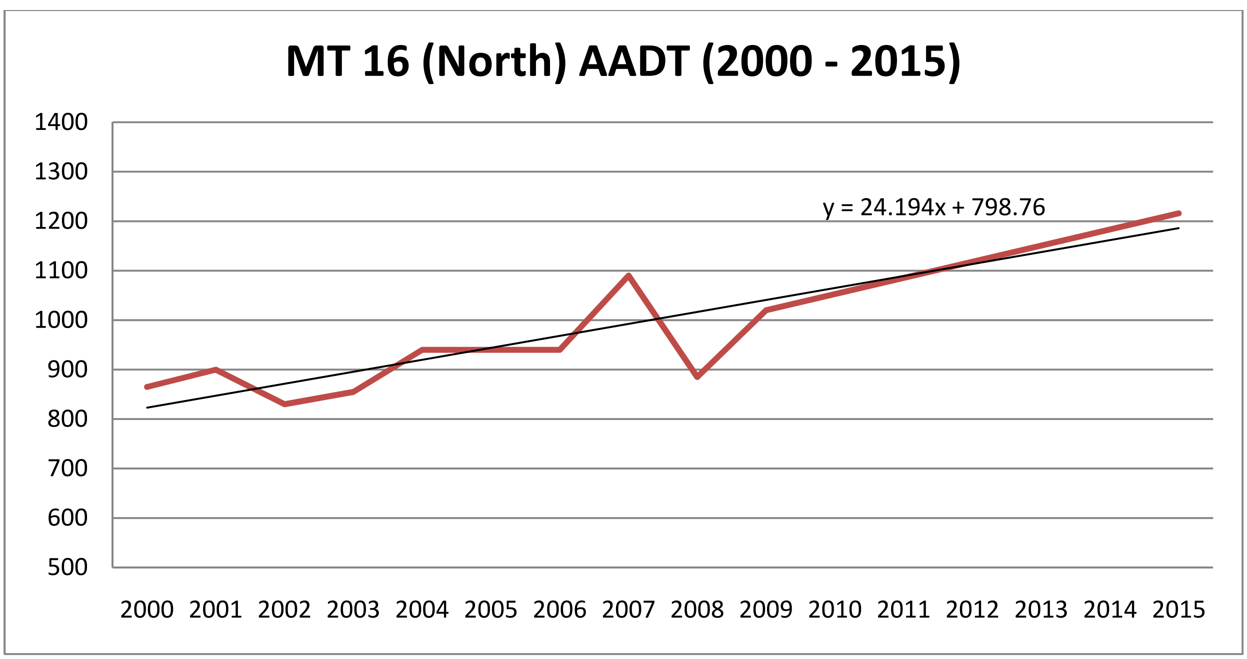


Figure 17. 15-Year Growth Rate for MT 16 (North)



Once the slope of each linear regression line was calculated, future traffic volumes were projected from the 2015 value. The following equation was used to calculate each subsequent year's AADT:

Formula 1. $$A_{future} = m(year - 2015) + A_{present}$$

Where: A_{future}= Future AADT
m=slope of the roadway's linear regression line
year=the future year whose AADT is being calculated (e.g. 2016)
$A_{present}$= the 2015 AADT of the roadway

In essence, the linear regression line was transposed onto the end of the 2015 data. Figures 18 through 21 show the historical and projected growth of each roadway. Specific AADT data points for each year can found in Appendices B through D of this Technical Memorandum.

Figure 18. US 2 AADT (2000-2032)

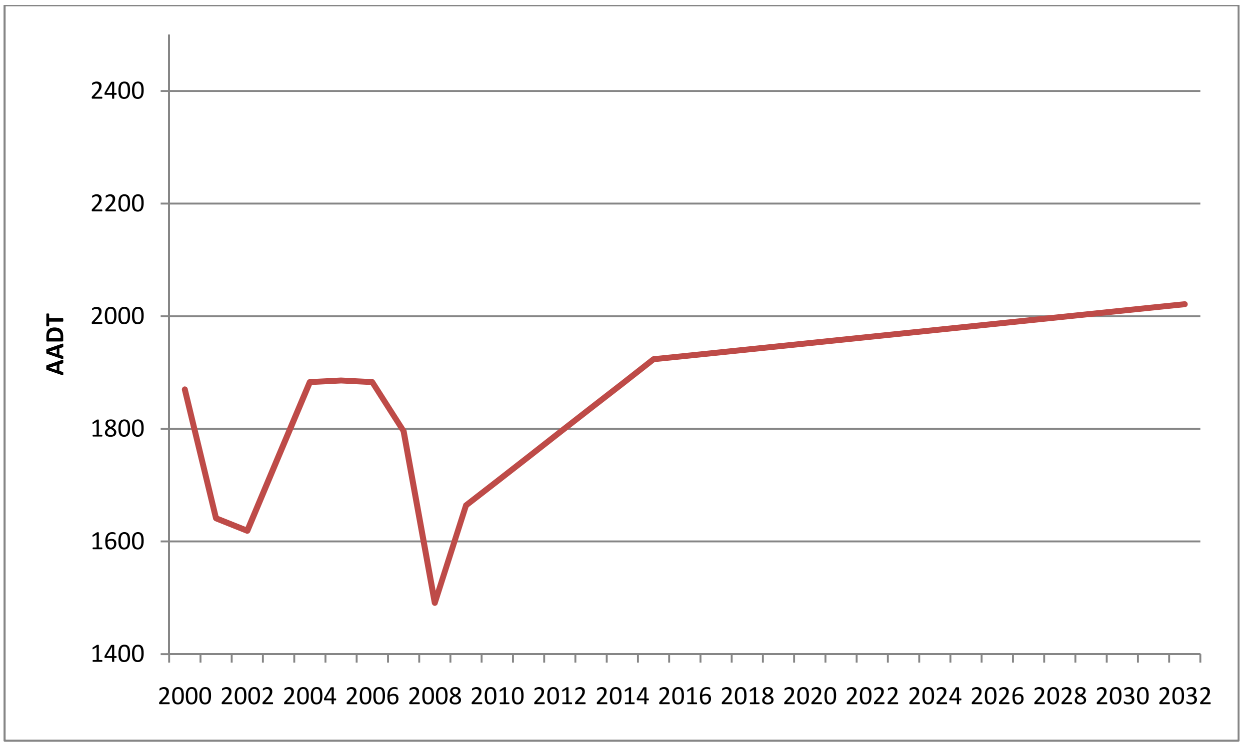


Figure 19. MT 16 (South) AADT (2000-2032)

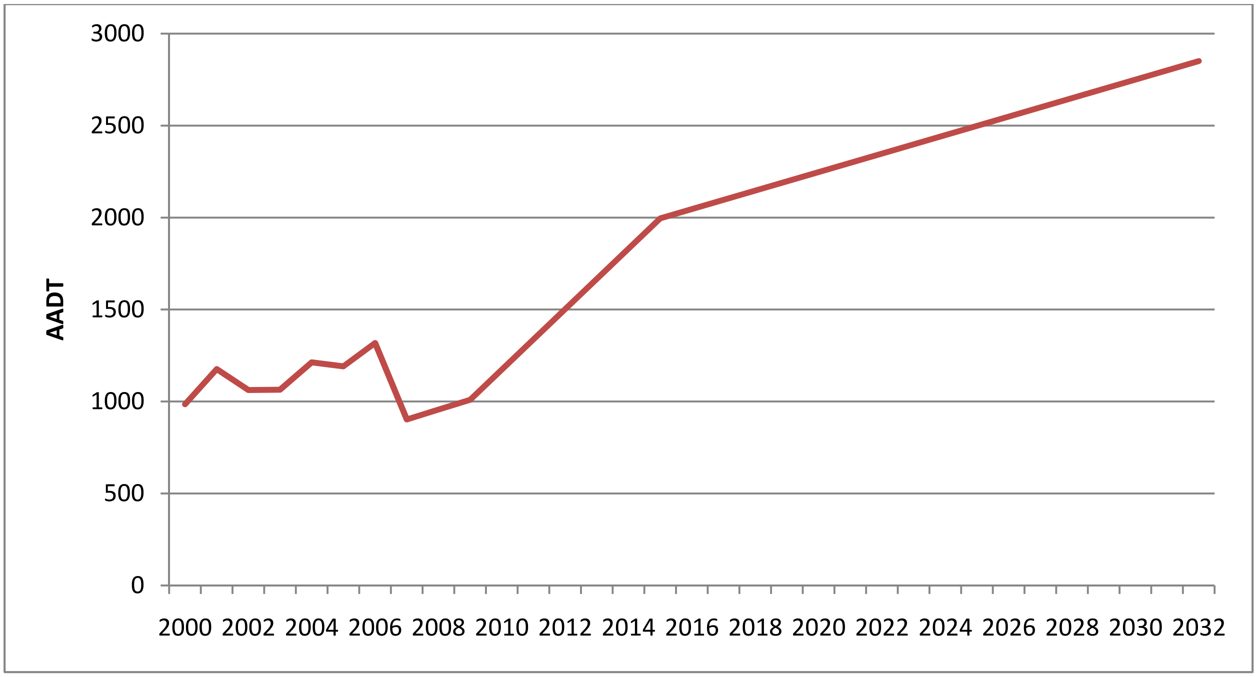
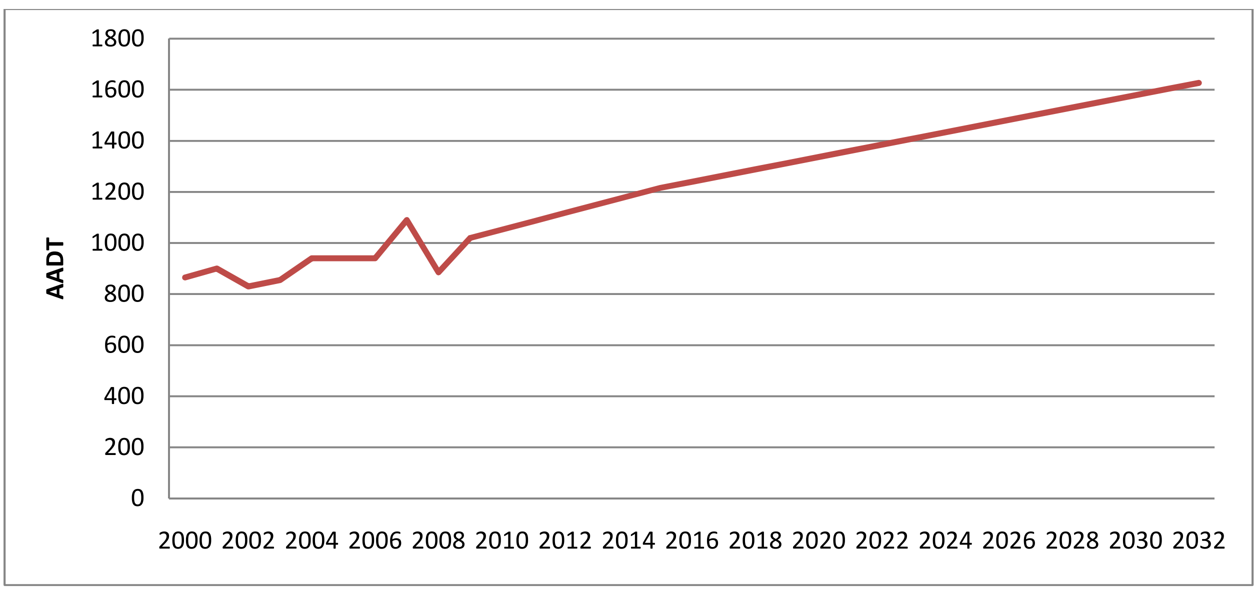


Figure 20. MT 16



After plotting the 2106 to 2032 projected AADT counts, the slope of this data was calculated using the following formula:

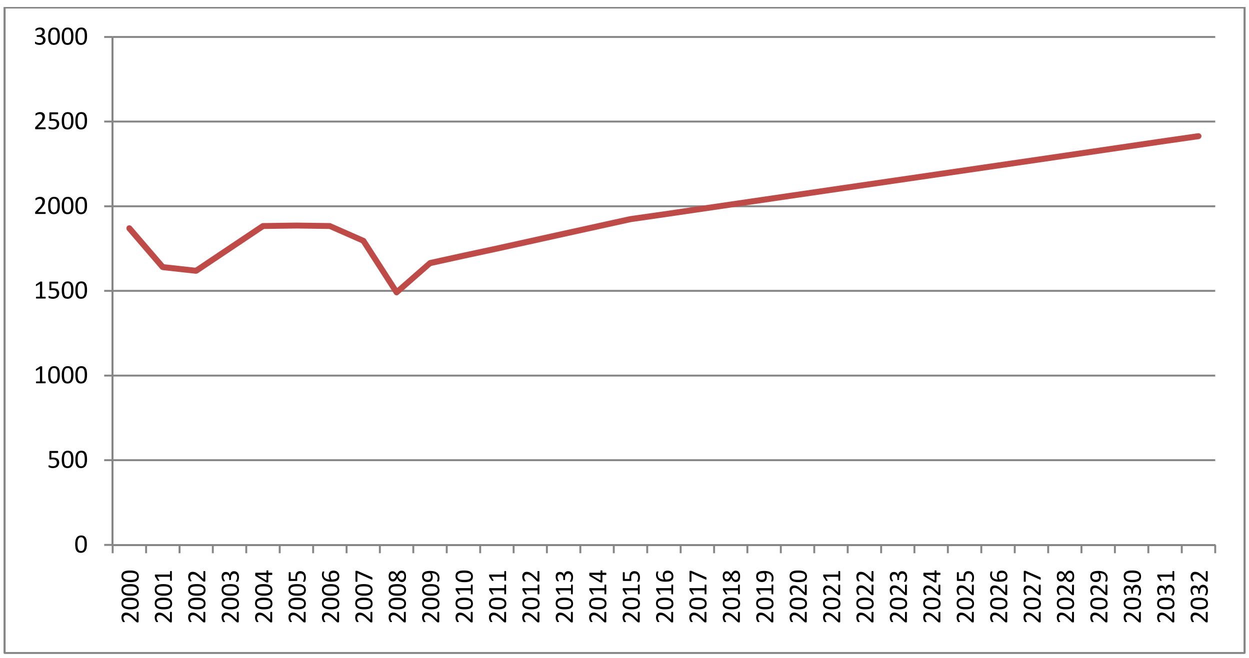
Formula 2.

$$PR = \frac{\frac{(A_{future} - A_{present})}{A_{present}} * 100}{Years}$$

Where: PR=Percent Rate
A_{future}= Future AADT
$A_{present}$= Present AADT
Years=Number of years between A_{future} and $A_{present}$

The growth rates for US 2, MT 16 (south), and MT 16 (north) are 0.32 percent, 2.52 percent, and 1.99 percent, respectively. While the analytical method to calculate traffic growth on US 2 produced a 0.32 percent growth rate, a growth rate of 1.0 percent is a typical adjustment for areas with minimal or negative historical growth. Based on the anticipated growth in the Culbertson area over the next 10 to 15 years, a 1.5 percent growth rate is being assumed. Formula 2 was used to calculate each year's AADT. Figure 21 shows the historical and projected AADT for US 2 using the 1.5 percent growth rate from 2016 to 2032.

Figure 21. Revised US 2 AADT (2000



Based on the most recent ten-year weighted AADT and the five-year growth rate (more indicative of the latest economic activity) for US 2, MT 16 (south) and MT 16 (north), the horizon-year projected growth rates for these roadways are 1.50 percent, 2.52 percent, and 1.99 percent, respectively. There is a possibility that the region may experience higher (or lower) traffic growth as a result of the Bakken oil boom. The calculated projections are best estimates based on currently available information. All other legs of the studied intersections were assumed to have 1.0 percent growth.

Projected LOS was computed using the intersection's turning movement counts during the intersection's peak hour noted in Table 6 and increased by their respective growth rates. Table 7 shows the LOS for each individual leg of the four intersections studied for the horizon year 2032. Appendix E contains more detail regarding 2032 projected LOS.

Table 7. 2032 Intersection Level of Service during Peak Hour

ID*	Intersection	EB	WB	NB	SB
1	US 2 and MT 16 (north)	A	A	B	B
2	US 2 and MT 16 (south)	A	A	B	N/A
3	MT 16 (south) and 1st Street	B	A	A	A
4	MT 16 (south) and CR 1020	A	A	A	B

**Note: ID per Figures 13 and 14 of this report.*
(Abbreviations used are as follows: EB = eastbound; WB = westbound; NB = northbound; SB = southbound; N/A = not applicable).

In summary, even though the overall traffic projections are for increased traffic through each of the four intersections, the level of service for the intersections is not projected to change over the next 20 years.

3.2 *Right-of-Way and Jurisdictions*

The existing corridors of US 2 and MT 16 within the study area are located primarily within private property. The State of Montana maintains the right-of-way on each side of the highway. BNSF Railway infrastructure and right-of-way is located parallel to US 2 within the corridor Study area. Other property within the Study area includes local government land as well as Montana State Trust Lands, as shown in Figure 22. As improvement options develop, right-of-way impacts will be minimized to the extent practicable. If a project is advanced from this study, potential right-of-way acquisition will be accomplished in accordance with applicable laws.

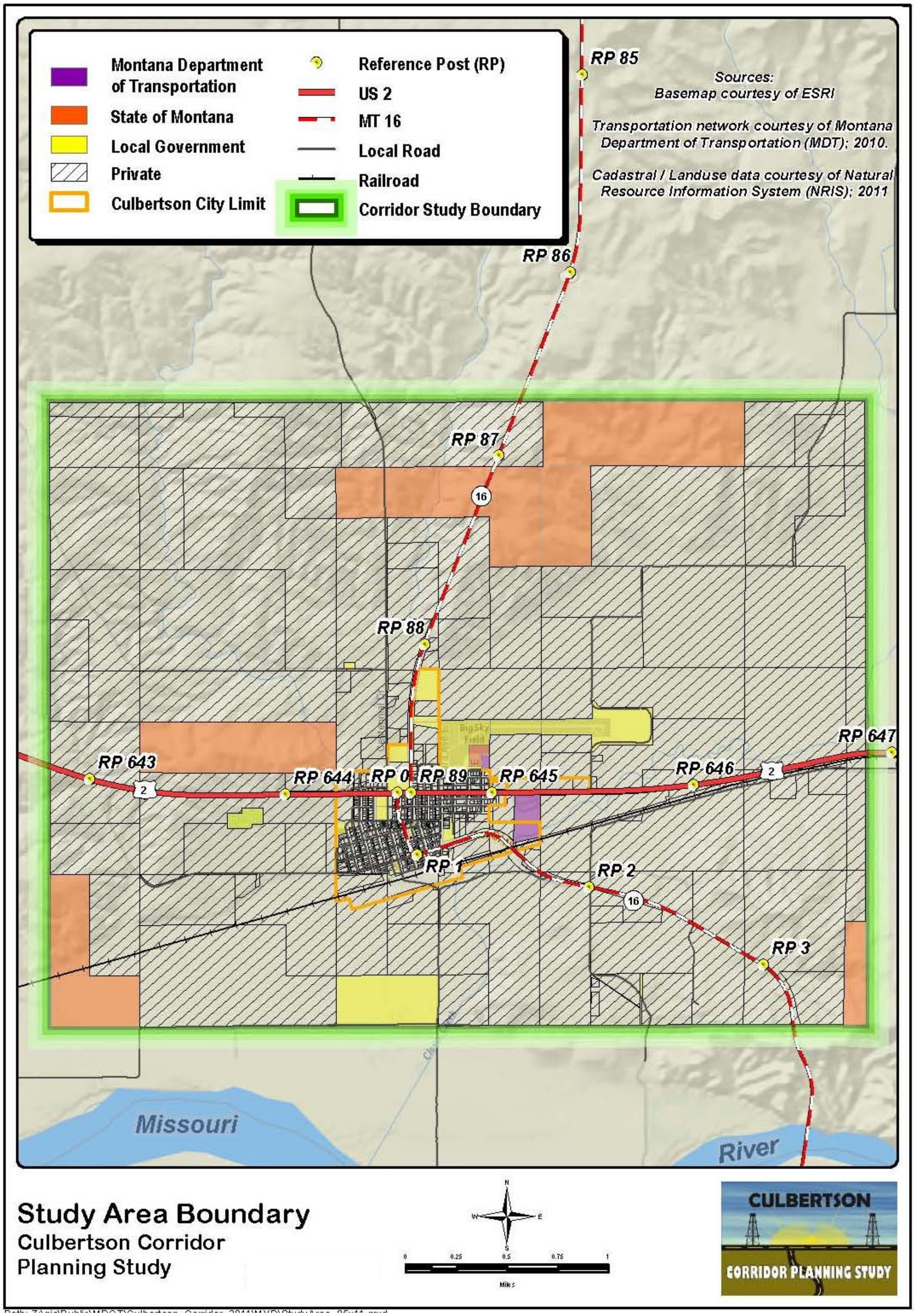


Figure 22. Land Ownership in Study Area

The right-of-way widths along US 2 and MT 16 generally vary from 33 feet to 120 feet on each side of centerline. Table 8 shows the right-of-way widths along US 2 and MT 16 according to as-built construction drawings.

Table 8. Right-of-Way Widths

Approximate RP Location	ROW Width on West/South Side from centerline	ROW Width on East/North Side from centerline
US 2 - RP 642.8 to RP 646.8 As-Built Project: FAP #F-84(20), West of Wolf Point-North		
642.48	100’	100’
642.77	100’ – 260’	80’
642.89	100’	80’
643.00	100’	120’
643.04	120’	120’
643.09	100’	100’
643.29	80’	80’
643.46	90’	120’
643.67	80’	80’
644.33	43’	33’
644.37	33’	33’
644.82	53’	53’
644.99	80’	80’
646.26	50’	80’ – 200’
646.30	50’	160’
646.61	50’	80
647.27	50’	90
647.55	50’	80
MT 16 (N-22) North of US 2 from RP 86.6 to RP 88.6 As-Built Project: FAP #F-193(9), Culbertson-Plentywood		
86.86	80’	90’
87.29	100’	90’
87.38	100’	120’
87.41	100’	80’
88.60	80’	80’
88.64	80’	33’
88.74	33’	33’
MT 16 (N-62) South of US 2 from RP 0 to RP 3 As-Built Projects: FAP #F-273(10) Sidney-Culbertson & FAP #273-A Culbertson-Sidney Hwy.		
0.00	44’	44’
0.32	33’	33’

Table 8 Right-of-Way Widths (cont.)

Approximate RP Location	ROW Width on West/South Side from centerline	ROW Width on East/North Side from centerline
0.48	40’	100’
0.73	40’ – 400’	40’
0.84	70’	50’
1.06	60’	50’ – 430’
1.32	50’	60’
1.70	40’	60’
2.18	40’	50’
2.64	60’	110’
2.91	70’	120’

3.3 *Physical Characteristics*

US 2 is a major east/west highway providing a vital national link between the states of Washington and Michigan. MT 16 is a major north/south highway providing a vital regional link between Interstate 94 and Canada. US 2 and MT 16 within the Study area are two lanes, one in each direction, with varying shoulder widths, interspersed parallel parking, and sidewalks on portions through town. Approximately one-quarter mile east of the Culbertson city limits along US 2, there are both an eastbound right turn lane and westbound left turn lane to the weigh station and rest area located on the south side of the highway. The posted speed limits along both US 2 and MT 16 through the Study area vary from 25 mph to 70 mph. Each time the posted speed limit is 75 mph, a 60 mph truck speed limit is also posted. Figure 23 shows the posted speed limits through the Study area.

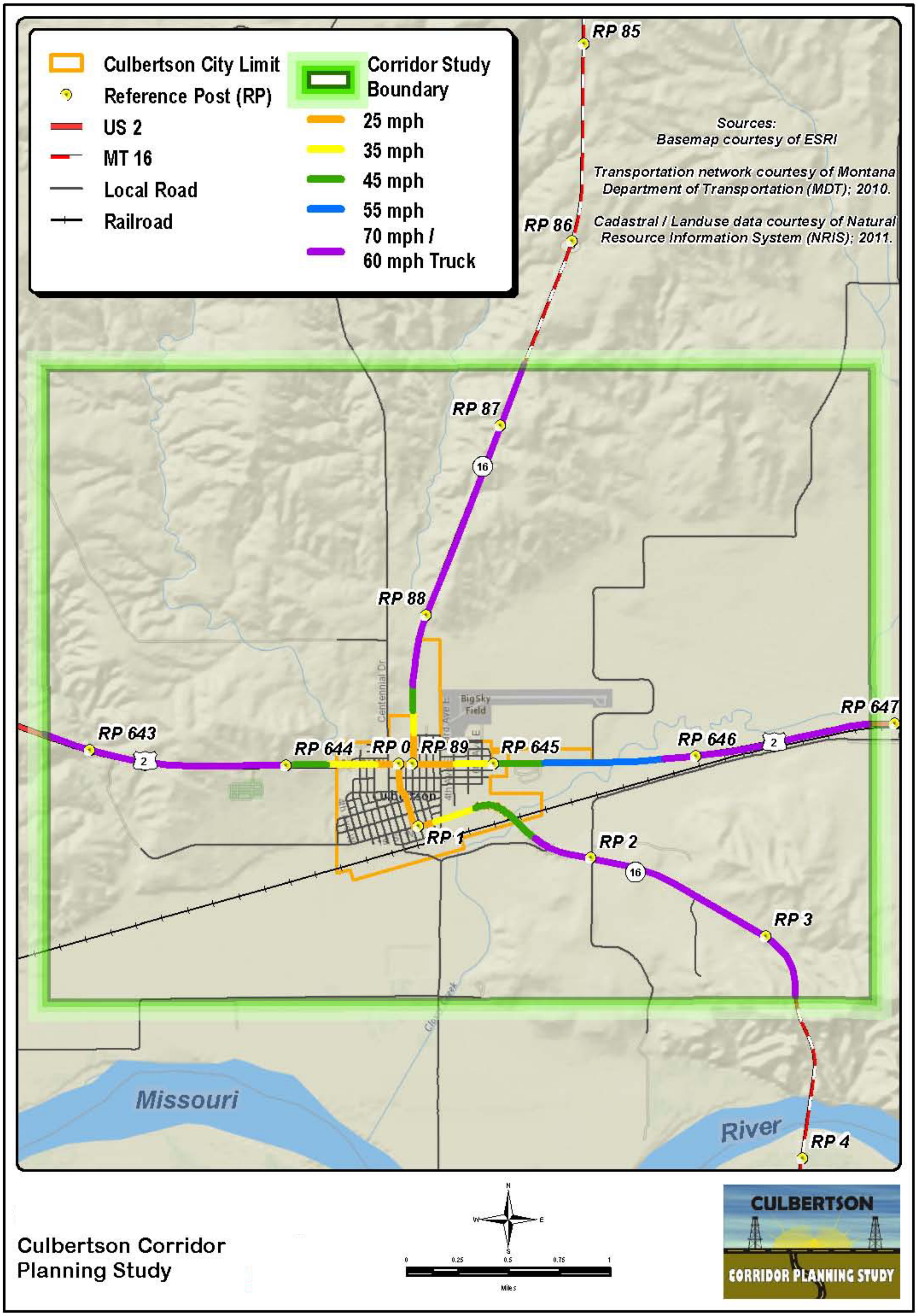


Figure 23. Posted Speed Limits

The portion of US 2 to the east of Culbertson and MT 16 north of US 2 are part of the Theodore Roosevelt Expressway. The Theodore Roosevelt Expressway is the northern third of the Ports to Plains Trade Corridor, which is a planned multimodal transportation corridor that will facilitate the efficient transportation of goods and services from Mexico to Canada.

There are two distinct sections of MT 16 through the corridor with different reference posts for each portion of MT 16 being separated by US 2. The southern section of MT 16 enters the south side of the Study area at RP 3 and continues northwest over the BNSF Railway Bridge, heads west along 1st Street, turns north on Broadway Avenue, and intersects US 2 at RP 0. MT 16 then continues east and is concurrent to US 2 for one block before heading north to begin the northern portion of MT 16 at RP 88.6 and continues north to RP 86.6.

The most recent reconstruction project within the Study area was completed in 1989 and was located on MT 16 from RP 2.79 to the Missouri River Bridge, which is located just south of the corridor Study area.

3.4 *Design Standards*

The MDT *Road Design Manual* identifies design standards which determine the overall operational characteristics of the roadway and enhance the aesthetic appearance of the highway. The geometric design standards for the Culbertson Corridor Planning Study are based on current MDT design criteria for a National Highway System (NHS) Non-Interstate Rural and Urban Principal Arterials. Through the Town of Culbertson, MDT Urban design standards apply if improvement options are further developed from this Study.

The design speed for a roadway depends on the type of terrain, anticipated operating speed, adjacent land use, and the functional classification of the highway. In rural areas such as Culbertson, topography and the functional classification are generally the controlling factors. The MDT *Road Design Manual* describes the following definitions in determining the type of terrain for a roadway:

- Level Terrain: The available stopping sight distances are generally long or can be made to be so without construction difficulty or major expense.
- Rolling Terrain: The natural slopes consistently fall below and rise above the roadway and occasional steep slopes offer some restriction to horizontal and vertical alignment.
- Mountainous Terrain: Longitudinal and traverse changes in elevation are abrupt and extensive grading is frequently needed to obtain acceptable alignments.

According to the terrain definitions, the Study area outside of the Town of Culbertson primarily occurs in level terrain (70 mph design speed) with some areas of rolling terrain (60 mph design speed). Table 9 lists the design standards for Rural and Urban Principal Arterials according to current MDT design criteria.

Table 9. Geometric Design Criteria for Rural and Urban Principal Arterials (National Highway System – Non Interstate) U.S. Customary

Design Element			Design Criteria					
Design Controls	Functional Classification		Rural Principal Arterial			Urban Principal Arterial		
						Curbed	Uncurbed	
	Design Forecast year		20 Years					
	*Design Speed	Level	70 mph			40 - 45 mph	40 - 50 mph	
		Rolling	60 mph					
		Mountainous	50 mph					
	Level of Service		Level/Rolling: B Mountainous: C			Desirable: B Minimum: C		
Roadway Elements	*Travel Lane Width		12'					
	*Shoulder Width	Outside	Varies					
	Cross Slope	*Travel Lane	2% Typical					
		Shoulder	2% Typical					
	Median Width		Varies			N/A		
	TWLTL Width		N/A			16'		
Earth Cut Sections	Ditch	Inslope	6:1 (Width: 10')			N/A	6:1 (Des\4:1 Min)	
		Width	10' Minimum			N/A	10' Min	
		Slope	20:1 towards back slope			N/A	20:1 towards back slope	
	Back Slope; Cut Depth at Slope Stake	0' - 5'	5:1					
		5' - 10'	Level/Rolling: 4:1; Mountainous: 3:1					
		10' - 15'	Level/Rolling: 3:1; Mountainous: 2:1					
		15' - 20'	Level/Rolling: 2:1; Mountainous: 1.5:1					
		> 20'	1.5:1					
Earth Fill Slopes	Fill Height at Slope Stake	0' - 10'	6:1					
		10' - 20'	4:1					
		20' - 30'	3:1					
		> 30'	2:1					
Alignment Elements	DESIGN SPEED		50 mph	60 mph	70 mph	40 mph	45 mph	50 mph
	*Stopping Sight Distance		425'	570'	730'	305'	360'	425'
	Passing Sight Distance		1835'	2135'	2480'	N/A	N/A	760'
	*Minimum Radius		760'	1200'	1810'	533'	711'	711'
	*Superelevation Rate		e_{max} = 8.0%			e_{max} = 4.0%		e_{max} = 8.0%
	*Vertical Curvature (K-value)	Crest	84	151	247	44	61	84
		Sag	96	136	181	64	79	96
	*Maximum Grade	Level	3%			6%		
		Rolling	4%			7%		
		Mountainous	7%			9%		
	Minimum Vertical Clearance		17.0'					

Source: Montana Department of Transportation Road Design Manual Chapter 12, Figures 12-3 & 12-7 "Geometric Design Criteria for Rural and Urban Principal Arterials"

*Controlling design criteria (see Section 8.8 of the MDT Road Design Manual)

3.5 *Roadway Geometrics*

The roadway geometric design elements within the Culbertson Corridor Planning Study were evaluated to identify areas of concern that do not meet current MDT design standards. This analysis was based on available as-built construction drawings. The segments of US 2 and MT 16 *within* the city limits of Culbertson were compared to current MDT design standards for Urban Principal Arterials and areas outside of the city limits are compared to Rural Principal Arterial standards.

MT 16 undergoes several directional changes within the study area, particularly at four intersections. The intersection of US 2 and MT 16 (north)/1st Avenue East, is a four-legged intersection with two-way stop control on MT 16 (north)/1st Avenue East. Lane configurations on all four-legs are currently shared left/thru/right turning movements. The intersection of US 2 and MT 16 (south)/Broadway Avenue is a T-intersection with stop control on MT 16 (south)/Broadway Avenue. The lane configurations at this intersection include a shared thru/right on US 2 eastbound, shared thru/left on US 2 westbound, and shared left/right on MT 16 (south)/Broadway Avenue. The intersection of MT 16/Broadway Avenue and 4th Street is a skewed intersection with two-way stop control on 4th Street. Lane configurations on all four legs of the intersection have shared left/thru/right turning movements. The intersection of MT 16/Broadway Avenue and 1st Street is a four-legged intersection with shared left/thru/right lane configurations. The intersection is three-way stop controlled, with no stop control on MT 16 southbound leg.

The Culbertson School District is located between US 2 and 4th Street and 2nd Avenue West and 1st Avenue West. It should be noted that the school bus loading and unloading facility is located along 4th Street West, between 2nd Avenue West and 1st Avenue West, and off the US 2 and MT 16 highway system.

The findings of the roadway geometrics within the Study area discussed in greater detail in the following sections.

3.5.1 Horizontal Alignment

The horizontal alignments of US 2 and MT 16 have a major influence on traffic operation and safety and are comprised of elements including curvature, superelevation, and sight distance. The parameters defining horizontal alignment are directly related to the type of terrain and associated design speed.

A summary of the horizontal alignment curvature for both US 2 and MT 16 is presented in Table 10. The table includes the approximate reference post (RP) location of the center of the curve, length, and radius. Two curves along MT 16, near the intersection of Broadway Avenue and 4th Street West, do not meet the current minimum MDT design standards for an Urban Principal Arterial with a design speed of 40 mph. The curve length at RP 647.80 on US 2 does not meet current standards for level terrain. Four curves along MT 16 at the south end of the study area do not meet current standards for level terrain. Cells within Table 10 shaded in blue are segments within city limits and therefore subject to urban design standards.

Table 10. Horizontal Alignment

Approximate RP of Curve Center	Radius (ft)	Length (ft)
US 2 - RP 642.8 to RP 646.8 As-Built Project: FAP #F-84(20), West of Wolf Point-North (1956)		
643.27	11,460.0	3,960.0
645.98	22,920.0	4,686.7
646.87	5,730.0	1,553.3
647.80	11,460.0	1,006.7
MT 16 (N-22) North of US 2 from RP 86.6 to RP 88.6 As-Built Project: FAP #F-193(9), Culbertson-Plentywood (1959)		
85.90	5,730.0	2,101.7
88.18	5,730.0	2,190.0
MT 16 (N-62) South of US 2 from RP 0 to RP 3 As-Built Projects: FAP #F-273(10) Sidney-Culbertson (1959) & FAP #273-A Culbertson-Sidney Hwy (1933)[1]		
0.13	134.5	94.0
0.15	185.1	179.2
0.47	2,865.0	2,000.0
0.72	636.6	864.1
0.96	1,432.5	1,153.3
1.64	5,730.0	1,825.0
2.47	1,273.3	1,405.2
2.77	1,146.0	544.3
2.97	1,432.5	798.3

**Values shown in red do not meet current MDT design standards for level terrain (outside the city limits) or urban (within city limits) design standards. (See Table 9 for standards)*
1. Approximate locations are shown as mile posts rather than reference posts.

3.5.2 Vertical Alignment

The vertical alignment is a measure of elevation change of a roadway. The length and steepness of grades directly affects the operational characteristics of the roadway. The MDT *Road Design Manual* lists recommendations for maximum grades on rural and urban principal arterials according to the type of terrain in the area. Table 11 shows the maximum grade recommendations according to terrain.

Table 11. Maximum Grade

Terrain	Maximum Grade
Level – Rural	3%
Rolling – Rural	4%
Level – Urban	6%
Rolling - Urban	7%

The grade and terrain throughout the corridor varies from level to rolling and goes from rural to urban. The alignment grades within Culbertson are relatively flat and meet maximum grade standards for urban principal arterials. However, outside the city limits, five vertical curves have grades greater than 4%, which exceeds the maximum grade for rolling terrain standards (4%). Other controlling design factors for vertical alignments include the rate of vertical curvature (K-value) and stopping sight distance, which are both dependent on the type of terrain and design speed within the Study area.

Table 12 shows vertical alignment information based on available as-built drawings. Outside the city limits of Culbertson, ten vertical curves do not meet current MDT design standards for level terrain. Vertical alignments within the city limits, shaded in blue in the table, meet current MDT design standards for Urban Principal Arterials with a design speed of 40 mph.

Table 12. Vertical Alignment

Approximate RP of Curve Center	Type of Curve	Length (ft)	Grade In (G1)%	Grade Out (G2)%	K-Value	Stopping Sight Distance (SSD) (ft)
US 2 - RP 642.8 to RP 646.8 As-Built Project: FAP #F-84(20), West of Wolf Point-North (1956)						
642.63	Crest	836	-0.990	-4.160	263.7	754.44
643.09	Sag	1,000	-4.160	1.900	165.0	673.93
643.61	Crest	1,200	1.900	-2.800	255.3	742.32
643.95	Sag	400	-2.800	-3.300	800.0	2,358.24
644.24	Sag	600	-3.300	-1.050	266.7	1,743.6
644.57	Sag	400	-1.050	0.050	363.6	-
644.74	Crest	200	0.050	-0.210	769.2	4,250.46
644.91	Sag	200	-0.210	0.110	625.0	-
645.07	Crest	200	0.110	-0.344	440.5	2,476.92
645.5	Sag	200	-0.344	0.000	581.4	-
645.68	Sag	400	0.000	0.550	727.3	-
646.15	Crest	400	0.550	0.000	727.3	2,162.04
646.6	Sag	500	0.000	0.970	515.5	-
646.84	Crest	600	0.970	-0.100	560.7	1,308.52
647.1	Crest	200	-0.100	-0.330	869.6	4,791.83

Approximate RP of Curve Center	Type of Curve	Length (ft)	Grade In (G1)%	Grade Out (G2)%	K-Value	Stopping Sight Distance (SSD) (ft)
MT 16 (N-22) North of US 2 from RP 86.6 to RP 88.6 As-Built Project: FAP #F-193(9), Culbertson-Plentywood (1959)						
86.46	Crest	1,200	4.660	0.130	264.9	756.12
86.69	Sag	800	0.120	4.660	176.2	713.89
86.99	Crest	1,400	1.980	0.120	752.7	1,274.55
87.84	Crest	1,800	4.020	1.980	882.4	1,379.97
88.12	Sag	1,000	1.220	4.020	357.1	1,520.76
88.48	Crest	400	0.792	1.220	934.6	-
MT 16 (N-62) South of US 2 from RP 0 to RP 3 As-Built Projects: FAP #F-273(10) Sidney-Culbertson (1959) & FAP #273-A Culbertson-Sidney Hwy (1933)[1]						
0.44	Crest	200	2.020	0.440	126.6	782.99
0.51	Sag	300	-0.290	2.020	129.9	970.19
0.84	Crest	200	0.660	-0.290	210.5	1,235.92
0.93	Sag	200	-0.340	0.660	200.0	-
1.13	Sag	300	-3.260	-0.340	102.7	542.56
1.27	Crest	200	-1.420	-3.260	108.7	686.48
1.41	Sag	300	-4.580	-1.420	94.9	475.74
1.55	Crest	400	1.240	-4.580	68.7	385.14
1.69	Sag	300	-3.100	1.240	69.1	327.34
1.85	Crest	200	-2.060	-3.100	192.3	1,137.62
1.96	Sag	200	-3.160	-2.060	181.8	-
2.12	Crest	700	-0.350	-3.160	249.1	734.03
2.40	Sag	300	-3.770	-0.350	87.7	425.03
2.68	Crest	500	6.000	-3.770	51.2	332.34

Values shown in red do not meet current MDT design standards for level terrain (outside the city limits) or design standards for urban sections (within city limits). Values in blue exceed the maximum grade of 4% for rolling terrain.

1. Approximate locations are shown as mile posts rather than reference posts.

3.5.3 Roadside Safety (Clear Zone)

The roadside clear zone, starting at the edge of the traveled way, is the total roadside border area available for safe use by errant vehicles. The area may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a recovery area. The desired width varies depending on traffic volumes, speeds, and roadside geometry. Clear zones are evaluated individually and based on the roadside cross section. The urban section through Culbertson has substantial development such as sidewalks, signs, buildings, utilities, and lighting; and it may be impractical to protect or remove the obstacles within the clear zone. Obstructions in the clear zone may cause sight distance issues and with the influx in truck traffic, this may pose as a safety concern as well. Current MDT standards establish clear zone guidelines in rural and urban sections. As improvement options develop, roadside clear zones should be designed, to the extent practicable, to meet current MDT urban and rural design standards.

Parallel parking is provided on both sides of MT 16 south from 4th Street to the intersection of 1st Street West and 3rd Avenue East. The portion of MT 16 from 4th Street to US 2 also has areas on both sides of the street for parking, although it is not clear whether the surface width in this section is adequate to safely accommodate both heavy vehicle traffic and parallel parking. Wide shoulders along the north side of US 2 from 1st Avenue West to 4th Avenue East provide availability for parallel parking.

3.5.4 Intersection Sight Distance

Adequate sight distance at intersection corners is important for safe vehicle access and turning movements and also based on the type of traffic control at the intersection. Sight obstructions may vary from buildings, parked or turning vehicles, trees, hedges, tall crops, or un-mowed grass. If sight obstructions exist within the sight triangle, it is suggested they be removed or modified in order to heighten driver's view of approaching vehicles. Intersection sight distance was examined at four intersections within the study area. Intersection sight distance obstructions are summarized below:

- US 2 & MT 16 (north of US 2) – the southwest, southeast, and northeast quadrants have obstructions including signs, buildings, and potential parked/turning vehicles.
- US 2 & MT 16 (south of US 2) – the southeast quadrant has obstructions including buildings, signs, gas pumps, and potential parked/turning vehicles.
- MT 16/Broadway Avenue & 4th Street – the northeast and southwest quadrants have obstructions including trees and buildings. Sight distance is also hindered due to the curve along MT 16/Broadway Ave.
- MT 16/Broadway Avenue & 1st Street – northeast and southeast quadrants have obstructions including parked/turning vehicles and buildings; southwest and northwest quadrants have building and parked vehicles obstructions.

3.6 *Surface Width and Pavement Conditions*

The 2011 *Montana Road Log,* prepared by MDT, contains the most current roadway surfacing characteristics including surface width, lane width, shoulder width, surfacing thickness, base thickness, and travel lanes. Tables 13, 14, and 15 show the existing roadway surfacing information for both US 2 and MT 16 within the Study area. Due to the presence of turning lanes and street parking within the Study area, which are not included in the Road Log, the total surface width may be greater than the sum of lane widths and shoulder widths. The route segment plan indicates a recommended surface width of 36 feet or greater for MT 16 and 40 feet or greater for US 2. However, the MDT Road Width Committee would determine the appropriate width during future project development. Due to the increase in traffic volumes, deterioration of the roadway surface may come at a higher rate. The reduction in roadway service life results in an area of concern.

Table 13. Existing Roadway Surface Width for US 2

Location Reference Post (RP)	Width (feet)			Thickness (inches)		Travel Lanes
	Surface	Lane	Shoulder	Surface	Base	
642.8 – 644.251 *Enter West Culbertson City Limits @ 644.251*	28	12	2	6.0	14.0	2
644.251 – 644.556	32	12	4	3.0	14.0	2
644.556 – 644.624 *Junction N-62 (MT 16) @ 644.556; Junction N-22 (MT 16) @ 644.624*	32	12	4	3.0	14.0	2
644.624 – 645.498 *Leave East Culbertson City Limits @ 645.498*	32	12	4	3.0	14.0	2
645.498 – 646.8	32	12	4	3.0	14.0	2

Source: *2011 MDT Road Log*, pg. 39

Table 14. Existing Roadway Surface Width for MT 16

Location Reference Post (RP)	Width (feet)			Thickness (inches)		Travel Lanes
	Surface	Lane	Shoulder	Surface	Base	
86.6 – 88.599 *Enter North Culbertson City Limits @ 88.599*	28	12	2	6.0	16.8	2
88.599 – 88.742 *Junction N-22 (MT 16) & N-1 (US 2) @ 88.742*	43	12	8	6.0	16.8	2

Source: *2011 MDT Road Log*, pg. 69

Table 15. Existing Roadway Surface Width for MT 16

Location Reference Post (RP)	Width (feet)			Thickness (inches)		Travel Lanes
	Surface	Lane	Shoulder	Surface	Base	
0.000 – 0.326 *Junction N-62 (MT 16) & N-1 (US 2)*	44	12	8	3.0	15.0	2
0.326 – 1.200 *Junction MT 16 & 1st Street @ 0.326*	44	12	8	3.0	15.0	2
1.200 – 1.517 *Leave South Culbertson City Limits @ 1.517*	36	12	6	3.0	12.0	2

Location Reference Post (RP)	Width (feet)			Thickness (inches)		Travel Lanes
	Surface	Lane	Shoulder	Surface	Base	
1.517 – 2.074	36	12	6	3.0	12.0	2
2.074 – 3.00	40	12	8	3.0	8.0	2

Source: *2011 MDT Road Log*, pg. 89

3.7 *Geotechnical*

A detailed geotechnical investigation report will not be developed for this corridor Study. The Big Muddy Creek – East project covers US 2 from RP 646.26 beyond the western edge of the Study area. The Big Muddy Creek – East Geotechnical report noted weak foundation soils in the area, which required a special provision to replace the traditional embankment construction with geotextile, geogrid and special borrow. At RP 87 on MT 16, a small shallow slope failure occurred due to heavy rainfall in the spring of 2011 and is being repaired.

3.8 *Drainage*

As stated in the Environmental Scan submitted for this Corridor Planning Study, the corridor Study area is located within the Lower Missouri River Basin, Charlie-Little Muddy Creek Sub-basin. The drainage has several unnamed streams and Clover and Diamond creeks that run through the Study area. A majority of local streets have curb and gutter which allows gravity flow to drain water away from the city limits. As a primarily agricultural corridor, there are several irrigation systems within the corridor, and consideration will be given to drainage as improvement options develop.

3.9 *Hydraulic Structures*

Table 16 shows the hydraulic structures located along US 2 and MT 16 within the corridor. A hydraulic analysis would be recommended if an improvement option is implemented as there have been historical flooding occurrences within the Study area.

Table 16. Hydraulic Structures

Approximate Location Reference Post (RP)	Size	Length	Remarks
US 2 - RP 642.8 to RP 646.8 As-Built Project: FAP #F-84(20), West of Wolf Point-North Dakota Line			
642.82	24”	58’	DRAIN
643.05*	84”	200’	DRAIN
643.33*	24”	130’	DRAIN
643.66	18”	36’	RD APP RT
643.71	24”	128’	DRAIN SKEW
643.82	24”	118’	DRAIN
643.84	4’x6’	70’	U-PASS
643.94	24”	74’	DRAIN
644.02	24”	60’	DRAIN
644.26*	72”	148’	DRAIN SKEW COVER 21’ (Diamond Creek)
644.37	18”	80’	STREET APP LT & RT
644.40	18”	22’	ALLEY APP RT
644.43	18”	40’	STREET APP RT
644.50	18”	60’	DRAIN
644.50	18”	40’	STREET APP RT
644.55	18”	67’	DRAIN
644.62	18”	120’	DRAIN DBL
644.69	18”	60’	DRAIN
644.69	18”	60’	DRAIN
644.76	18”	60’	DRAIN
644.82	18”	132’	STREET APP LT & RT
644.90	18”	60’	DRAIN
644.96	18”	51’	RD APP LT
645.42	24”	86’	DRAIN
645.66	18”	72’	RD APP LT & RT
645.77	18”	72’	FLD ENT LT & RT
646.02	24”	74’	DRAIN
646.41	30”	74’	DRAIN
646.50	24”	88’	DRAIN
646.59	24”	36’	RD APP LT
MT 16 (N-22) North of US 2 from RP 86.6 to RP 88.6 As-Built Project: FAP #F-193(9), Culbertson-Plentywood			
88.60	29”S x 18”R	62’	DRAIN – INSTALLED & MOVED TO
88.49	29”S x 18”R	62’	DRAIN

Table 16. Hydraulic Structures (cont.)

Approximate Location Reference Post (RP)	Size	Length	Remarks
88.40*	43"S x 27"R	54'	DRAIN
88.05*	12'6"S x 7'11"R	124'	DRAIN – COVER 13'
87.83	24"	76'	DRAIN
87.67	15"	40'	APP 31' RT
87.56	24"	66'	DRAIN
87.42	5'10"S x 7'7"R	80'	STOCKPASS
87.36	24"	174'	DRAIN
87.32	15"	60'	APP 47' RT
87.12	5'10"S x 7'7"R	92'	STOCKPASS
87.08	24"	176'	DRAIN
86.83*	24"	136'	DRAIN
86.71	24"	128'	DRAIN
MT 16 (N-62) South of US 2 from RP 0 to RP 3** As-Built Projects: FAP #F-273(10) Sidney-Culbertson & FAP #273-A Culbertson-Sidney Hwy.			
0.06	18"S x 11"R	68'	DRAIN
0.14	18"S x 11"R	126'	DRAIN – SKEW
0.19	18"S x 11"R	152'	DRAIN
0.25	18"S x 11"R	86'	DRAIN
0.34	15"	24'	PRIV ENT LT
0.35	15"	48'	ALLEY ENT LT & RT
0.36	15"	20'	PRIVATE ENT LT
0.38	15"	40'	PRIVATE ENT LT & RT
0.39	15"	76'	ST APP LT & RT
0.41	15"	20'	PRIVATE ENT LT
0.42	15"	48'	ALLEY ENT LT & RT
0.47	29"S x 18"R	40'	STREET APP – 93' RT
0.53	30" 30" DBL	46' 42'	NEW CMP DBL DR USE IN PLACE, LENG 26' LT & 20' RT
0.65	24"	58'	DRAIN
0.77	18"	54'	DRAIN
0.82	15"	36'	FARM ENT RT
0.94	18"	84'	FARM ENT LT & RT
0.99	18"	144'	RD APP LT & RT
1.03	18"	68'	FARM ENT LT & RT
1.22	18"	120'	DRAIN
1.30	24"	44'	DRAIN
1.65	18"	52'	DRAIN
1.71	7' x 6'	38'	DRAIN & STOCKPASS
1.79	30"	44'	DRAIN

Table 16. Hydraulic Structures (cont.)

Approximate Location Reference Post (RP)	Size	Length	Remarks
1.89	18"	32'	FARM ENT LT
1.90	18"	56'	RD APP RT
2.20	24"	58'	DRAIN
2.25	18"	42'	DRAIN
2.37*	24"	58'	DRAIN – SKEW
2.42	7' x 6'	76'	DRAIN & STOCKPASS – SKEW 35°
2.47	15"	28'	FARM ENT LT
2.59	24"	54'	DRAIN
2.65	18"	60'	DRAIN
2.68	15"	60'	FARM ENT LT & RT
2.83	24"	110'	DRAIN - SKEW
2.90	24"	100'	DRAIN
3.01	24"	190'	DRAIN – SKEW

**denotes blue line stream crossing on USGS Quad Map. Indicating the waterways may be potentially jurisdictional by U.S. Army Corps of Engineers.*

***The culvert locations for the portion of MT 16 south of US 2 are represented as actual mile locations rather than reference post locations.*

3.10 *Bridge Crossings*

Two bridge crossings are located within the corridor. They include the Clover Creek Bridge and the Clover Creek/BNSF Railway Bridge. The Clover Creek Bridge was last inspected in December 2010, and the Clover Creek/BNSF Railway Bridge was last inspected in May 2011. The assessments determined the Sufficiency Rating (SR) for each structure.

The Sufficiency Rating formula is a method of evaluating highway bridge data to obtain a numeric value indicating the sufficiency of the bridge to remain in service. The result of this method is the percentage in which 100 is an entirely sufficient bridge and 0 is an entirely deficient bridge. In order to receive funding through the Highway Bridge Replacement and Rehabilitation Program (HBRRP), structures must be *Structurally Deficient* or *Functionally Obsolete* and have an SR of 80% or below. Structures with an SR of 0 to 49.9% are eligible for replacement, and structures 50 to 80 are eligible for rehabilitation unless otherwise approved by the FHWA. The following criteria determine whether or not a structure is structurally deficient or functionally obsolete:

1. Structurally Deficient. A condition of **4 or less** for any of the following:

    Deck Rating

    Superstructure Rating

    Substructure Rating

    Or, an appraisal of 2 or less for the following:

Structure Rating

Waterway Adequacy

2. Functionally Obsolete. An appraisal of **3 or less** for the following:

Deck Geometry

Under Clearance

Approach Roadway Alignment

Or, an appraisal of 3 for the following:

Structure Rating

Waterway Adequacy

Table 17 shows the sufficiency ratings of the two bridge crossings.

Table 17. Bridge Sufficiency Rating (SR)

Structurally Deficiency SR Criteria		**Clover Creek**	**Clover Creek/BNSF**
Deck Rating	≤4	7	6
Superstructure Rating	≤4	5	5
Substructure Rating	≤4	5	7
Structure Rating	≤2	5	5
Waterway Adequacy	≤2	3	8
Functionally Obsolete SR Criteria			
Structure Rating	≠3	5	5
Deck Geometry	≤3	5	5
Under Clearance	≤3	-	3
Waterway Adequacy	≠3	3	8
Approach Roadway Alignment	≤3	8	6
Design Loading		3 MS 13.5 (HS 15)	5 MS 18 (HS 20)
Sufficiency Rating		47.7	58.5
Structure Status		Not Deficient	Functionally Obsolete – Eligible for Rehabilitation

3.10.1 Clover Creek Bridge

The Clover Creek Bridge is a two-lane structure located at RP 645.62 on US 2 approximately one mile east of Culbertson. Constructed in 1955, the bridge is 58 feet long and 30 feet wide with a bituminous surface on a timber stringer/girder three-span structure.

According to the MDT bridge inspection report; even though the sufficiency rating is 47.7, the Clover Creek Bridge has been categorized as ***not structurally deficient*** and ***not functionally obsolete***.

3.10.2 Clover Creek/BNSF Railway Bridge

The Clover Creek/BNSF Railway Bridge is located south of Culbertson along MT 16 at RP 1.57. Constructed in 1957, the four-span concrete cast-in-place bridge deck measures 268 feet long and 32 feet wide, spanning both Clover Creek and BNSF tracks. The structure is currently programmed for work to be completed in the Culbertson-South (CN 6972000) project. The proposed work includes removing asphalt from the deck, miscellaneous bridge deck repair, and resealing existing joints.

Based on the above ratings, the Clover Creek/BNSF Railway Bridge is categorized as ***functionally obsolete*** and ***eligible for rehabilitation***.

3.11 *Crash Analysis*

Safety issues are a concern along US 2 and MT 16 through the Study area. In 2011, the MDT Traffic and Safety Bureau conducted a crash analysis along MT 16 from RP 0 to 5 and from RP 86 to 88.7 and along US 2 from RP 642 to 647. This analysis was based on the most currently available ten-years of crash data from January 1, 2001 to December 31, 2010. Because the process of collecting and processing crash data takes time, the 2011 crash data has not been included in this analysis. The ten-year analysis compared the Study area with the statewide average crash rates on Non-Interstate National Highway System (NINHS) rural routes. Crash rates are defined as the number of crashes per million vehicle miles. Severity index is defined as the ratio of the sum of the level of crash degree to the total number of crashes. Severity rate is defined as the crash rate multiplied by the severity index. Table 18 describes the crash rate, severity index, and severity rate for each roadway as compared to the most recently available statewide averages for NINHS routes. The Study area crash data is based on the most recent 10-year crash data.

Table 18. Crash Statistics

	US 2 RP 642.0 to RP 647.0	MT 16 RP 86.0 to RP 88.74	MT 16 RP 0.0 to RP 5.0[1]	Statewide Average for NINHS Rural Routes[2]
All Vehicles Crash Rate	1.53	1.94	1.81	1.07
All Vehicles Severity Index	1.84	1.76	2.26	2.14
All Vehicles Severity Rate	2.82	3.41	4.09	2.29
All Vehicles Crashes	37	17	31	

Denotes above Statewide Average

1. *Source: MDT Traffic and Data Collection Analysis (Includes crash statistics outside the Study area boundary)*
2. *NINHS Route 5-year averages from 2005 through 2009 for the State of Montana*

The crash rate within the Study area is higher than the 2005 through 2009 average comparable rural routes throughout the state of Montana. Table 19 shows the total number of crashes for every quarter mile through the existing corridor Study area boundary over a ten-year period. It should be noted that green shading in Table 19 indicates those sections either partially or fully within the Culbertson city limits.

Table 19. Crashes by Location

Reference Post Location	Number of Crashes
US 2	
642.8 – 643.04	3
643.05 – 643.29	2
643.3 – 643.54	1
643.55 – 643.79	0
643.8 – 644.04	3
644.05 – 644.29	0
644.3 – 644.54	2
644.55 – 644.79	7
644.8 – 645.04	2
645.05 – 645.29	0
645.3 – 645.54	2
645.55 – 645.79	3
645.8 – 646.04	3
646.05 – 646.29	0
646.3 – 646.54	4
646.55 – 646.8	1
MT 16	
86.6 – 86.84	1
86.85 – 87.09	1
87.1 – 87.34	5
87.35 – 87.59	1
87.6 – 87.84	2
87.85 – 88.09	2
88.1 – 88.34	2
88.35 – 88.6	1
MT 16	
0.0 – 0.24	4

Table 19. Crashes by Location (cont.)

Reference Post Location	Number of Crashes
0.25 – 0.49	2
0.5 – 0.74	2
0.75 – 0.99	0
1.0 – 1.24	0
1.25 – 1.49	0
1.5 – 1.74	1
1.75 – 1.99	1
2.0 – 2.24	2
2.25 – 2.49	2
2.5 – 2.74	2
2.75 – 3.0	0
Total Crashes	**64**

The largest crash cluster is on US 2 between MP 644.55 and 644.79 with seven crashes over the ten-year period. Although seven crashes in a quarter mile over a ten-year period is not considered high, in relation to the other locations in the Study area it has the highest occurrence of crashes. This quarter mile section contains both intersections of US 2 with MT 16.

In addition to the sheer number of crashes throughout the Study area, the crash data was studied for any additional trends. Over two-thirds of the crashes in the Study area occurred during clear weather conditions and/or on dry road conditions. 17 crashes were either in the intersection or intersection related while the remaining 47 crashes were non junction related. Table 20 describes the crash breakdown for each roadway in terms of junction relation, weather conditions, and crash severity.

Table 20. Crashes by Roadway Segment

	Total Crashes	Junction Relation		Weather Conditions			Crash Severity			
		intersection related	Non junction	Clear	Cloudy	Rain, Snow, Other	Property Damage Only	Possible/Non-Incapacitating Injury	Incapacitating Injury	Fatalities
US 2 RP 642.8 to RP 646.8	33	10	23	24	4	5	26	4	2	1
MT 16 RP 86.6 to RP 88.6	15	0	15	7	5	3	11	3	1	0
MT 16 RP 0.0 to RP 3.0	16	7	9	14	2	0	10	5	1	0

The two most prevalent crash types in the Study area are those with wild animals or fixed objects. It should be noted that all wild animal crashes occurred outside the Culbertson city limits. Figure 24 shows a breakdown of the crashes by collision code.

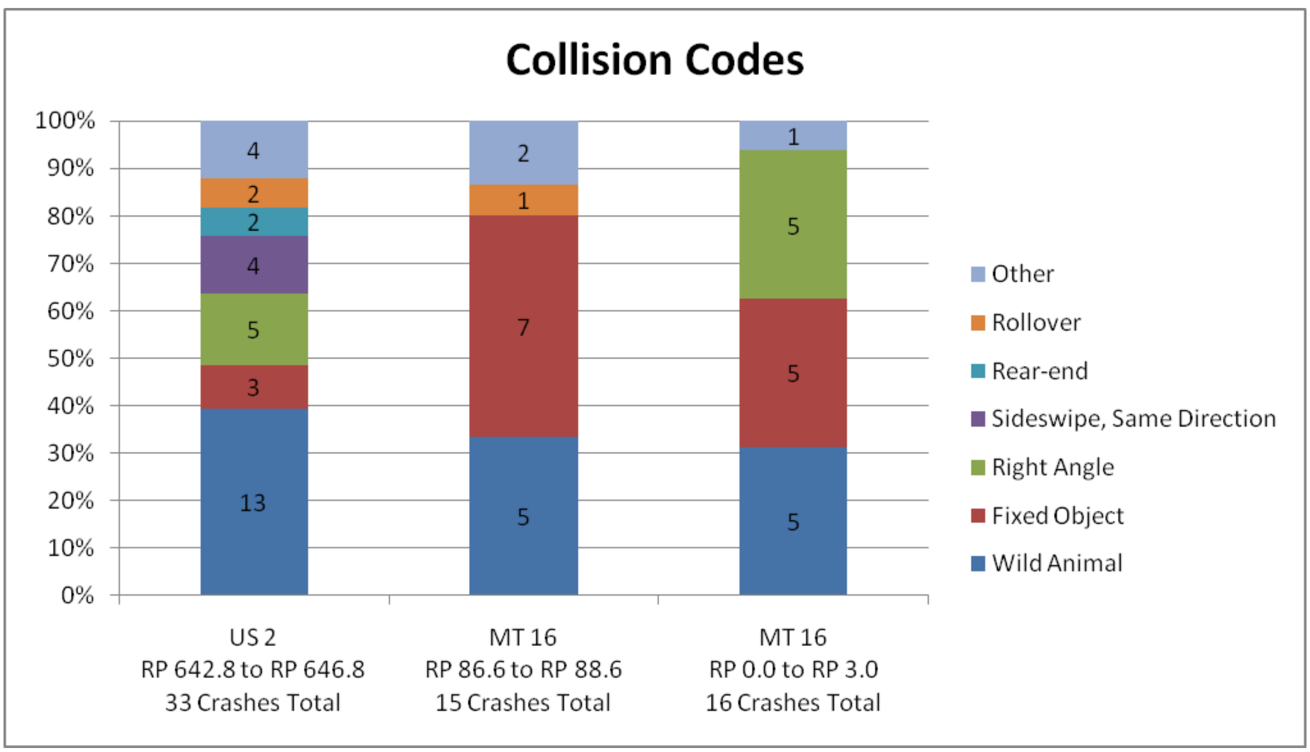


Figure 24. Crash by Collision Code

On US 2, over the ten year crash analysis period, there were five wild animal crashes west of Culbertson while the remaining eight occurred east of Culbertson. On MT 16, there were five wild animal crashes north of the Culbertson city limits and five wild animal crashes south of the Culbertson city limits. There are no clusters of wild animal/vehicle crash locations. It should be noted that wild animal crash data is developed per Montana Highway Patrol crash reports. The occurrences of wild animal crashes have the potential to be higher because not all wild animal crashes are reported. Of the 15 fixed object crashes in the Study area, the only commonality is that nine of the 12 crashes on MT 16 occurred during non-daylight hours. All three fixed object crashes on US 2 occurred during daylight hours.

3.12 *Railroad*

BNSF Railway, which runs through the middle of the corridor Study area, is a consideration in developing improvement options. The freight and passenger train speeds for the corridor are both 70 mph outside of the city limits and within the town, the speed is 60 mph for both freight and passenger trains. The system average train length is one mile. Guidelines have been established defining construction requirements and development standards near railroad facilities. As improvement options develop, consideration will be made to comply with specified railroad requirements.

3.13 *Non-Motorized Infrastructure*

Bicyclists and pedestrians, including school-aged children, walk to and from schools, parks, downtown businesses, and other community services. Current pedestrian infrastructure is inconsistent throughout the corridor as sidewalks are only adjacent to some roadways. According to the 2011 Town of Culbertson Growth Policy Update, there is limited pedestrian travel interconnectivity throughout the Town and surrounding areas. This limited interconnectivity discourages pedestrian travel or requires pedestrian use of the roadway in several portions of the Study area.

There are currently two signed and striped crosswalks located within the Study area. One crosswalk is located on US 2 between the Culbertson Public Schools and the adjacent convenient store, currently called Val-Am Stop & Go. This crosswalk is located mid-block and is primarily used by school-aged children to access the convenient store and also to access the Culbertson Schools Recreation Complex. The other crosswalk is located on Broadway parallel to 5th Street. There is currently no signed or striped crosswalk to allow children or other pedestrians within the northeast quadrant of Culbertson, located north of US 2 and east of MT 16 north, to access the school, parks, or other community services. With the percentage of trucks traversing the corridor, this has the potential to be a safety concern. As improvement options are developed, consideration shall be given to non-motorized facilities within the Culbertson community.

3.14 *Airport*

The Big Sky Field is a public general aviation airport owned jointly by Roosevelt County and the Town of Culbertson. There are seven hangers of differing sizes and one lighted runway that is 3,800 feet long and 60 feet wide. The runway has a 12,500 pounds single-wheel load capacity. The primary aircraft that use the Big Sky Field are single engine, general aviation aircraft with the exception of the air ambulance service, which uses a twin engine turbo-prop aircraft. In 2007 there were 100 air taxi operations, 700 itinerant operations, 100 Military operations, and 3,750 local operations. (WWC Engineering 2011)

3.15 *Utilities*

Several utilities exist throughout the Study area, primarily along US 2 and MT 16. Utilities include power, telephone, water, sewer, gas, and fiber optics. Culbertson's water treatment plant draws water from the Missouri River and is situated near the southeast quadrant of the Study area. Water lines run north from the water treatment plant and service not only commercial and residential properties within the City limits, but also major commercial properties outside the City limits. Water supply lines within the transportation grid are buried under the paved roadways while sewer lines run underneath alleyways. Fiber optic lines enter the Study area from the north, near MT 16. Overhead power lines service major commercial properties both within and outside the City limits.

In addition to the utilities that service the Town of Culbertson, there is also a Dry Prairie Rural Water pipeline that services northeastern Montana. This pipeline has two branches within the Study area. The Culbertson to Medicine Lake Mainline starts at the Culbertson water treatment plant then heads west where it skirts the western edge of Culbertson, crosses US 2, and then heads north. The "A" Branchline connects to the mainline north of Culbertson and then heads east. As improvement options develop, it will be important to recognize the impact options may or may not have on the utilities within the corridor. Utility adjustments and/or relocations may delay projects if they are not identified in the project development process. Consideration will be given to utilities as improvement options develop.

3.16 *Access Points*

Access points were counted using 2012 Google Earth mapping and were field verified in March 2012. Access points include driveways, alleyways, local street intersections, and any other defined entrance/exit locations. When parallel parking options exist along US 2 or MT 16, only street intersections and defined entrances/exits were counted. It should be noted that there are multiple commercial entrances throughout the Study area where there is no defined curb and gutter. Although there is no defined entrance/exit to these commercial businesses, each continuous pavement stretch was counted as a single access point.

There are currently 65 access points along US 2 (30 north and 35 south) from RP 642.8 to RP 646.8, 32 access points along MT 16 (16 west and 16 east) from RP 86.6 to RP 88.6 and 42 access points along MT 16 (22 south/west and 20 north/east) from RP 0.0 to RP 3.0. There is currently no access control implemented along either US 2 or MT 16 within the Study area. Access control is anticipated to be developed with the Culbertson to North Dakota line project. Tables 21 and 22 contain a listing of approaches by approximate half-mile increments.

Table 21. Access Points along US 2

Reference Post (RP)	North of US 2		South of US 2		Total	
	No. Accesses	Density (access/mi)	No. Accesses	Density (access/mi)	No. Accesses	Density (access/mi)
642.8 to 643.3	2	4	1	2	3	6
643.3 to 643.8	0	0	1	2	1	2
643.8 to 644.3	3	6	2	4	5	10
644.3 to 644.8	14	28	20	40	34	68
644.8 to 645.3	5	10	6	12	11	22
645.3 to 645.8	1	2	2	4	3	6
645.8 to 646.3	2	4	3	6	5	10
646.3 to 646.8	3	6	0	0	3	6

Table 22. Access Points along MT 16

Reference Post (RP)	West of MT 16		East of MT 16		Total	
	No. Accesses	Density (access/mi)	No. Accesses	Density (access/mi)	No. Accesses	Density (access/mi)
86.6 to 87.1	1	2	1	2	2	4
87.1 to 87.6	0	0	2	4	2	4
87.6 to 88.1	5	10	4	8	9	18
88.1 to 88.6	7	14	9	18	16	32
Reference Post (RP)	**South/West of MT 16**		**North/East of MT 16**		**Total**	
	No. Accesses	**Density (access/mi)**	**No. Accesses**	**Density (access/mi)**	**No. Accesses**	**Density (access/mi)**
0.0 to 0.5	5	10	5	10	10	20
0.5 to 1.0	5	10	4	8	9	18
1.0 to 1.5	6	12	7	14	13	26
1.5 to 2.0	2	4	1	2	3	6
2.0 to 2.5	1	2	1	2	2	4
2.5 to 3.0	3	6	2	4	5	10

In addition to the access points listed in the tables above, as of January 2012, MDT has two additional access point requests. If permitted, two additional access points would be added between RP 644.8 and 645.3.

Access control could be an area of concern when roadway widths are limited and when there is no widened area, such as a shoulder, for vehicles to exit the traffic stream. Access control could also be an area of concern in this corridor due to the high concentration of access points within the city limits. High concentrations of access points have the potential to increase the risk of crashes due to the proximity of vehicles concurrently entering/exiting the roadway. Although there are currently no crash trends, a lack of access control implementation coupled with the projected increase in AADT could increase the number of crashes. Access control will be considered as improvement options are developed.

3.17 *Other Planning Documents*

Other local documents are important to consider when evaluating existing and projected conditions as these local documents speak to what is planned for the area. It is also important to review these documents in order to ensure consistency with any improvement options that are developed through the corridor planning study process. Four local planning documents were consulted and are summarized in this section.

3.17.1 **Growth Policy**

As stated in the Town of Culbertson's 2011 Growth Policy Update, the 2011 Policy is intended to:

1. Update the Town's 2010 Growth Policy to be more specific to the Town's plan for growth and to ensure compliance with the Growth Policy Statute, as outlined in 76-1-601, MCA;
2. Provide effective guidance on local decisions on growth, development, and conservation over the next five to ten years;
3. Identify the tools that are needed to achieve the Towns goals;
4. Ensure that growth occurs in a manner which supports as many goals and policies as possible;
5. Provide a framework for reviewing and updating the Town's Subdivision Regulations.

There are several goals specific to transportation within the 2011 Growth Policy Update. These goals include attracting air traffic to the Big Sky Field, providing areas for pedestrians to travel that promote health and safety, and alerting motorists of the school and minimize the potential for vehicle/pedestrian accidents.

3.17.2 **Capital Improvements Plan**

The Town of Culbertson Capital Improvements Plan (CIP), adopted on December 5, 2011, contains detailed strategies for funding priority infrastructure projects for a total of $1,727,300. In addition to roadway improvements, the CIP addresses improvements to the Big Sky Field for a total of $1,202,300.

3.17.3 Transportation Regional Economic Development Study

Although the US 2/MT 16 Transportation Regional Economic Development (TRED) Study is not specific to the community of Culbertson, it does discuss regional economic issues directly related to two main arterials entering/exiting the town of Culbertson. The purpose of the TRED Study was to identify economic, regulatory, or operational changes that would result in traffic and safety conditions which in its turn would warrant building a four-lane highway on the Montana portion of the Theodore Roosevelt Expressway.

3.17.4 Culbertson – East to North Dakota Environmental Assessment

The Culbertson – East to North Dakota Environmental Assessment (EA) was consulted as part of this project due to its proposed reconfiguration of US 2 within the Study area. Future improvement options would need to consider the possibility of implementation of this proposed project.

US 2 from the North Dakota State Line to the intersection of MT 16 north is part of the Theodore Roosevelt Expressway. As stated in the February 2008 Culbertson – East to North Dakota EA the primary purpose of this project was to ensure system continuity and roadway configuration consistency with existing segments of the Theodore Roosevelt Expressway and north/south connecting corridors. The FONSI was signed August 2008. The Proposed Action identified through this EA process was a four-lane highway from the North Dakota State line to the intersection of US 2 and MT 16, which is located in the Study area. The portions of this roadway within the Culbertson City limits would consist of 5-foot sidewalks with curb and gutter, 5-foot shoulders, two 12-foot outside travel lanes, and two 11-foot inside travel lanes. As US 2 leaves the city limits the curb and gutter and sidewalks would be terminated but the roadway would remain in a four-lane undivided configuration with four 12-foot travel lanes and 8-foot shoulders. Just west of Clover Creek the roadway would transition to a divided roadway.

Chapter 4 Existing Environmental

This chapter includes a brief summary of the environmental elements within the Culbertson Corridor Planning Study area. More detailed information regarding each environmental area can be found in the full *Environmental Scan* report.

4.1 *Physical Environment*

The Study area is centered around the Town of Culbertson, located in Roosevelt County in northeastern Montana. The Missouri River is located approximately 1.5 miles south of the Town of Culbertson and outside the Study area boundary. Rolling hills parallel the river and form a break between the valley bottom and the upper glaciated plains. The general topography north of Culbertson consists of rough ridges and steep drainage ways.

4.1.1 Air Quality

The Clean Air Act of 1970, as amended in 1990, is a federal law requiring the U.S. Environmental Protection Agency (EPA) to develop and enforce regulations in order to reduce air pollution and protect air quality. The EPA has established attainment and non-attainment zones throughout the state. The state must establish a State Implementation Plan, outlining the control of air pollution, for any zones designated as non-attainment areas. The Study area is outside any non-attainment air quality zones.

4.1.2 Soil Resources and Prime Farmland

The Farmland Protection Policy Act of 1981 (Title 7 United States Code, Chapter 73) has as its purpose "to minimize the extent to which federal programs contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses, and to assure that federal programs are administered in a manner that, to the extent practicable, will be compatible with State, unit of local government, and private programs and policies to protect farmland."

Information on soils from the US Department of Agriculture, Natural Resource Conservation Service (NRCS) was obtained to determine the presence of prime and unique farmland in the Study area. The Roosevelt County soil surveys indicate that the predominant soil types within the Study area include loam, silty loams, and silty clay. Prime farmland, as well as farmland of statewide importance, exists within the Study area.

The Form NRCS-CPA-106: Farmland Conversion Impact Rating for Corridor Type Projects is a way for the NRCS to keep inventory of the Prime and Important farmlands within the state. Project activities associated with the construction of a alternative route in the Study area will likely create impacts to the soil map units with prime and important farmland status; thus it is likely required that a NRCS-CPA-106 Form be completed.

4.1.3 Land Use

According to the National Resource Information System (NRIS), the corridor Study area has been classified into 10 different categories of land use. The categories include: exempt property, agricultural rural, commercial rural, commercial urban, farmstead rural, industrial rural, residential rural, residential urban, vacant land rural, vacant land urban. The predominant corridor land use is agricultural rural.

4.1.4 Geologic Resources

The Montana Bureau of Mines and Geology has provided geological information for the Study area. According to U.S. Geological Survey (USGS), shale is the primary rock type of the Fort Union Formation, of which the Tongue River Member is part. The secondary rock type is siltstone and other rock types associated with this formation are sandstone, coal, and limestone.

The Town of Culbertson lies within the Bakken-Lodgepole Total Petroleum System within the Williston Basin Province. Due to the considerable exploration of oil and gas surrounding the Study area, oil and gas are prime economic contributors to the area.

Seismic information was reviewed for fault lines and seismic hazard areas. This geologic information can help determine any potential design and construction issues related to embankments and road design. A fault zone known as the Weldon-Brockton-Froid Fault Zone is approximately 8 miles outside the Study area, but is the closest fault zone to the Study area.

4.1.5 Water Resources

4.1.5.1. Surface Water

The study area lies within the Lower Missouri River Basin, Charlie-Little Muddy Creek Sub-basin Hydrologic Unit Code (HUC) 10060005, and Clover Creek Watershed (HUC: 1006000505). According to available geographic information system (GIS) data and a review of USGS Culbertson and McCabe West quad maps, several surface waters have been identified within the Study area.

The Lower Missouri Basin and Charlie-Little Muddy Creek Sub-basin are listed in the 2010 Integrated 303(d)/305(d) Water Quality Report for Montana by DEQ. The Charlie-Little Muddy Creek Sub-basin is listed as a Category 5 water quality, meaning that one or more applicable beneficial uses have been assessed as being impaired or threatened, and a TMDL is required to address the factors causing the impairment or threat. Beneficial uses that apply to this area include agricultural, aquatic life, warm water fisheries, drinking water sources, and industry. Probable causes of impairment include flow alteration and temperature modification by dam or impoundment impacts from hydrostructure flow regulation/modification. According to DEQ, Clover Creek and Diamond Creek are not identified as impaired water bodies on the TMDL list. If a project is forwarded from this study, potential impacts to all surface waters will need to be examined to determine if the waterways are considered waters of the U.S. and subject to jurisdiction by the U.S. Army Corps of Engineers (USACE).

4.1.5.2. Public Water Supply

According to NRIS and DEQ, three public water supplies exist within the Study area boundary. The public water supplies are summarized in Table 23.

Table 23. Public Water Supply

PWSID	Primary Name	City	Population Served (resident/non-resident)	Source Name	Source Type
MT0000192	Town of Culbertson	Culbertson	796/0	Missouri River	Surface Water
IN004	Plant Reservoir	Surface Water	-	-	-
MT0004348	Dry Prairie Rural Water Authority	Culbertson	1147/0	Consecutive Connection from 00192	Surface Water

4.1.5.1. Irrigation

Land within the southern portion of the Study area boundary is irrigated by various types of irrigation systems. The different methods include sprinkler, flood or "gravity flow", and water spreading. According to the U.S. Department of Agriculture (USDA), the predominant irrigation methods in Montana are flood and sprinkler systems. Potential impacts to the irrigation facilities should be minimized to the greatest extent practicable.

4.1.5.1. Wetlands

National Wetland Inventory (NWI) Mapping is available for the Study area. The majority of the wetlands are located near the southern portion of the study area boundary and along segments of Clover Creek. It is important to note that the NWI maps are not accurate or detailed enough for project level wetland identification and delineation. The NWI map is not intended to be a complete identification and/or delineation of wetlands present in the Study area. NWI maps are typically generated based on aerial and satellite imagery. They are generated by the U.S. Fish and Wildlife Service (USFWS), and are based on the USFWS definition of wetlands, which differs from the USACE definition of wetlands that MDT is required to use in wetland identification and delineation.

Formal wetland delineations will need to be conducted during the project development process, according to standard USACE defined procedures, if an improvement option(s) is forwarded. Jurisdictional determinations of wetlands will also be conducted during the project development process. Wetland impacts should be avoided to the greatest extent practicable. All unavoidable wetland impacts will need to be mitigated as required by the USACE. Potential mitigation sites should be investigated and constructed prior to project impacts. The USACE generally requires that compensatory mitigation occur in the same watershed as the impacts. Coordination with the USACE will be necessary to determine the appropriate location of any mitigation site.

4.1.6 Floodplains and Floodways

The Federal Emergency Management Agency (FEMA) issued flood maps have indicated Flood Zones A and AE are present within the Study area. Executive Order (EO) 11988, Floodplain Management, requires federal agencies to avoid direct or indirect support of floodplain development whenever a practicable alternative exists. EO 11988 and 23 CFR 650 Part A requires an evaluation of project alternatives to determine the extent of any encroachment into the base floodplain. Coordination with Roosevelt County should be conducted during the project development process to determine if floodplain permits are required. As improvement options are developed, consideration will be given to reduce the impact within the floodplain to the extent practicable.

4.1.7 Hazardous Substances

The NRIS database identified 13 leak sites within the Study area, and it should be noted all but 3 sites have been resolved. Two mine sites were also identified in the Study area. Additional unknown contaminated sites may be identified during the project development process and/or during construction.

If an improvement option is forwarded into project development, further evaluation may be needed at specific sites to determine if contamination will be encountered during construction. This may include reviewing DEQ files and conducting subsurface investigation activities to determine the extent of soil and groundwater contamination. If it appears that contaminated soils or groundwater could be encountered during construction, handling/disposing of the contaminated material will need to be conducted in accordance with State, Federal, Tribal, and local laws and rules.

4.2 *Biological Resources*

4.2.1 Fish and Wildlife

The Montana Fish, Wildlife & Parks owns the Culbertson Bridge Fishing Access Site; a 12.6 acre fishing access site, located south of the Study area. The closest National Wildlife Refuge is located approximately 20 miles north of the Study area at the Medicine Lake National Wildlife Refuge.

Riparian and river, stream or creek habitats should be avoided to the greatest extent practicable, including but not limited to Clover Creek and Diamond Creek. Montana Fish, Wildlife & Parks keeps a database of information on fish distribution known as the Montana Fisheries Information System (MFISH). The MFISH database notes that Clover Creek is the only waterbody in the Study area that has sufficient year-round flow to house fish. Brook Stickleback was the only species noted in Clover Creek. Encroachment into the wetted width of any waterway and the associated riparian habitat should be limited to the absolute minimum necessary for the construction of the proposed project. Soils, vegetation, and flooding data can be utilized in determining the extent of riparian habitat.

4.2.2 Threatened and Endangered Animal Species

The federal list of threatened and endangered species is maintained by the USFWS. Species on this list receive special protections under the Endangered Species Act (Title 16 United States Code, Chapter 35).

An 'endangered' species is one that is in danger of extinction throughout all or a significant portion of its range. A 'threatened' species is one that is likely to become endangered in the foreseeable future. The USFWS also maintains a list of species that are candidates or proposed for possible addition to the federal list.

In May 2011, the USFWS published a list of endangered, threatened, proposed and candidate species for each county within Montana. This list identifies the counties where one would reasonably expect the species to occur. Roosevelt County listed the endangered Pallid Sturgeon, threatened and designated critical habitat for the Piping Plover, endangered Interior Least Tern, endangered Whooping Crane, and the candidate Sprague's Pipit. Further evaluation of potential impacts to all threatened, endangered, proposed, or candidate species will need to be conducted during the project development process if an improvement option is forwarded. Updated critical habitat maps should be consulted during the project development process.

4.2.3 Animal Species of Concern

Table 24 lists the 15 animal species of concern that the Montana Natural Heritage Program (MNHP) has records of in Township 58, Sections 55 and 56. The results of a data search by the MNHP reflect the current status of their data collection efforts. These results are not intended as a final statement on sensitive species within a given area, or as a substitute for on-site surveys. On-site surveys would need to be completed during the project development process.

Table 24. Montana Animal Species of Concern

	Common Name
Mammals	Townsend's Big Eared Bat*
	Eastern Red Bat
Birds	Great Blue Heron
	Piping Plover*
	Whooping Crane
Fish**	Blue Sucker
	Iowa Darter
	Shortnose Gar
	Sturgeon Chub
	Sicklefin Chub
	Northern Redbelly Dace
	Sauger
	Pallid Sturgeon
	Pearl Dace
Reptiles	Western Hog-nosed Snake

**** Note: Although MNHP has documentation of the Townsend's Big-eared Bat and Piping Plover existing in T28N R55 and 56E, specific mapped locations of these species shows they are outside, but adjacent to the Study area.***

*****Note: Although MNHP has documentation of these fish existing in T28N R56E, Clover Creek is the only stream located within the Study area and, therefore, the stream is presumed to not have the flow necessary to sustain these fish populations.***

4.2.4 Vegetation

The Montana Natural Heritage land cover database shows that the Study area is largely comprised of lowland/prairie grassland and agriculture. The grasslands support livestock grazing, and have been tilled for small grain and hay production. The agriculture land cover category is broken into cultivated crops and pasture/hay.

4.2.4.1. Threatened and Endangered Plant Species

According to the USFWS, there are not any plant species listed as threatened, endangered, proposed, or candidate species for Roosevelt County. An evaluation of potential for and impacts to all threatened, endangered, proposed, or candidate species would need to be conducted during the project development process.

4.2.4.2. Plant Species of Concern

The MNHP does not have record of any plant species of concern within the Study area. The results of a data search by the MNHP reflect the current status of their data collection efforts. These results are not intended as a final statement on sensitive species within a given area, or as a substitute for on-site surveys. On-site surveys would need to be completed during the project development process.

4.2.4.3. Noxious Weeds

The INVADERS Database System identified six (6) noxious weeds present in Roosevelt County, Montana: Canada Thistle, Dalmatian Toadflax, Field Bindweed, Leafy Spurge, Russian Knapweed, and Spotted Knapweed. However, four (4) noxious weeds are present in the Study area boundary: Leafy Spurge, Spotted Knapweed, Russian Knapweed, and Dalmatian Toadflax. The project area will need to be surveyed for noxious weeds during the project development process.

To reduce the spread and establishment of noxious weeds and to re-establish permanent vegetation, disturbed areas will need to be seeded with desirable plant species. County Weed Control Supervisors should be contacted prior to any construction activities regarding specific measures for weed control.

4.3 *Cultural Resources*

4.3.1 Archaeological Resources

The Montana State Historic Preservation Office (SHPO) was contacted to determine the presence of any known cultural and/or historic sites within the Study area. The file search yielded one previously recorded archaeological resource site. This site is listed as a prehistoric lithic scatter. If an improvement option is forwarded into project development, on the ground fieldwork will be necessary to determine where additional cultural resources are located.

4.3.2 Historic Resources

A file search conducted by SHPO revealed four 4(f) resource sites within the Study area that are either on or eligible for inclusion in the National Register of Historic Places (NRHP) while there are 30 undetermined historic properties within the Study area.

If improvement options are forwarded from this Study and are federally-funded, a cultural resource survey of the Area of Potential Effect for this project as specified in Section 106 of the National Historic Preservation Act (Title 16 United States Code, Chapter 1; 36 CFR 800) will need to be completed. Section 106 requires Federal agencies to “take into account the effects of their undertakings on historic properties.” The purpose of the Section 106 process is to identify historic properties that could be affected by the undertaking, assess the effects of the project and investigate methods to avoid, minimize or mitigate any adverse effects on historic properties.

4.3.3 6 (f) Resources

Section 6(f) of the Land and Water Conservation Funds Act (Title 16 United States Code, Chapter 1) applies to all projects that impact public outdoor recreational lands purchased and/or improved with land and water conservation funds. The Secretary of the Interior must approve any conversion of property acquired or developed with assistance under this Act to other than public, outdoor recreation use. Several 6(f) properties have been identified within the Study area including the following:

- Culbertson Swimming Pool
- Culbertson Bicentennial Park
- Culbertson Schools Recreation Complex

4.3.4 4 (f) Resources

Section 4(f) refers to the original section within the Department of Transportation Act of 1966 (Title 49 United States Code, Chapter 3), which set the requirement for consideration of park and recreational lands, wildlife and waterfowl refuges, and historic sites in transportation project development. Prior to approving a project that “uses” a Section 4(f) resource, FHWA must find that there is no prudent or feasible alternative that completely avoids 4(f) resources. “Use” can occur when land is permanently incorporated into a transportation facility or when there is a temporary occupancy of the land that is adverse to a 4(f) resource. Constructive “use” can also occur when a project’s proximity impacts are so severe that the protected activities, features, or attributes that qualify a resource for protection under 4(f) are “substantially impacted”. 4(f) resources include any historic or archaeological sites on or eligible for inclusion in the National Register. Additionally, 4(f) resources include significant publicly-owned parks, recreational areas, and wildlife or waterfowl refuges. The following list includes potential 4(f) resources, including parks and recreational areas and sites eligible for listing on the National Register:

- Bicentennial Park
- Swimming Pool Park

- Culbertson Public Schools
- Culbertson Public School's Sports Complex
- BNSF Railway
- Charlie Jacobs House
- Oelkers Carter Service Center
- Petersen House

4.3.5 Noise

If an improvement option is forwarded into project development, a noise study would be required to determine where noise-sensitive land uses are located, what existing noise levels those areas are experiencing, and to estimate what future noise levels will be as a result of the project per MDT policy. Previous noise studies have been conducted along US 2 within the Study area for the *Culbertson East to North Dakota Environmental Assessment*. If the project is expected to change traffic volumes on other routes, then off-project routes should also be studied for noise impacts. In areas of residential development, noise impacts (existing or predicted) may need to be mitigated.

Chapter 5 Areas of Concern

This chapter includes a list of areas of concern on US 2 and MT 16 within the Culbertson Corridor Study area. These areas were determined through an analysis of as-built drawings and other available information. More detailed information regarding the areas of concern has been provided in the previous chapter and summarized in the following sections. The order in which the areas of concern are listed does not indicate one is more important nor has priority over another. All areas of concern will be considered as improvement options are developed for this Study.

5.1 *Geometrics*

Roadway geometric areas of concern include substandard horizontal and vertical curvature. The areas of concern along US 2 and MT 16 that do not meet current MDT standards are summarized in Table 25.

Table 25. Geometric Areas of Concern

Approximate Location (RP)	Design Element	Substandard Design Feature	Description
647.8 (US 2)	Horizontal	Length	Does not meet level terrain standards
0.13 (MT 16)	Horizontal	Radius & Length	Do not meet urban 40 mph standards
0.15 (MT 16)	Horizontal	Radius & Length	Do not meet urban 40 mph standards
0.96 (MT 16)	Horizontal	Radius	Does not meet level terrain standards
2.47 (MT 16)	Horizontal	Radius	Does not meet level terrain standards
2.77 (MT 16)	Horizontal	Radius & Length	Do not meet level terrain standards
2.97 (MT 16)	Horizontal	Radius & Length	Do not meet level terrain standards
642.63 – 643.09 (US 2)	Grade	Grade (4.16%)	Grade greater than rolling terrain standards (4%)
86.46 – 86.69 (MT 16)	Grade	Grade (4.66%)	Grade greater than rolling terrain standards (4%)
87.84 – 88.12 (MT 16)	Grade	Grade (4.02%)*	Grade greater than rolling terrain standards (4%)
1.41 – 1.55 (MT 16)	Grade	Grade (4.58%)	Grade greater than rolling terrain standards (4%)
2.68 – 3.00 (MT 16)	Grade	Grade (6.00%)	Grade greater than rolling terrain standards (4%)
643.09 (US 2)	Vertical	K-value & SSD	Do not meet level terrain standards
86.69 (MT 16)	Vertical	SSD	Does not meet level terrain standards
1.13 (MT 16)	Vertical	K-value & SSD	Do not meet level terrain standards
1.27 (MT 16)	Vertical	K-value & SSD	Do not meet level terrain standards
1.41 (MT 16)	Vertical	K-value & SSD	Do not meet level terrain standards
1.55 (MT 16)	Vertical	K-value & SSD	Do not meet level terrain standards
1.69 (MT 16)	Vertical	K-value & SSD	Do not meet level terrain standards
1.85 (MT 16)	Vertical	K-value	Does not meet level terrain standards
2.40 (MT 16)	Vertical	K-value & SSD	Do not meet level terrain standards
2.68 (MT 16)	Vertical	K-value & SSD	Do not meet level terrain standards

**denotes grade is at the maximum allowable grade (4%) for rolling terrain standards.*

5.2 *Intersections*

Although the four intersections studied along US 2 and MT 16 indicate there are no current capacity issues, the geometric layout of each intersection is not sufficient for proper turning movements of large trucks. As it was previously mentioned, trucks occupy two lanes of traffic in order to make the turn.

Improvements should be made to improve geometric elements to provide for semi-trucks and recreational vehicles.

5.3 *Access Points*

The number of access points and their location are a concern. In particular, the proximity of an access point to an intersection is an issue. Too many access points along the highway and ones that are located too close to an intersection create potentially unsafe conflict points.

5.4 *Non-Motorized Infrastructure*

With the location of US 2 and MT 16 right through the middle of Culbertson as well as the location of the public school, the inconsistency of bicycle and pedestrian facilities are a concern. Special attention should be given to proper locations, adequate signing and striping, as well as school zone requirements.

5.5 *Sight Distance*

The sight distance along US 2 and MT 16 through Culbertson is a concern; particularly, the sight distance for vehicles trying to enter or exit the roadway or at intersections. Hindered sight triangles with the increased traffic on these roads could pose a safety risk for the vehicles on the highway and those trying to enter/exit the highway. Several sight obstructions including buildings, signs, and parked/turning vehicles exist within quadrants at various intersections in Culbertson.

5.6 *Pavement Conditions*

With increased amounts of traffic, especially large trucks, deterioration of the existing roadway pavement is a concern. Large trucks with dual axel configurations pose the biggest threat to the pavement. Also, particular attention should be given to the roadway shoulders as these sometimes have smaller pavement sections than the travel lanes. As trucks have to pull over to the side of the road, or as rear wheels “track” onto the shoulder going through a right turn, the existing pavement can be damaged considerably. Broken up pavement, substantial cracks, and potholes reduce the service life of the roadway and pose a safety risk to the traveling public.

5.7 *Truck Traffic*

Due to the increased growth of the oil and gas industry in and around the study area, the town of Culbertson has experienced a considerable increase in truck traffic. Although there are no current or projected capacity issues within the study area, the increase in truck traffic associated with the recent boom in the area may result in functional issues in the future. Improvement options should consider anticipated economic growth, improved level of service, and updated roadway design.

5.8 *Environmental*

Assuming standard avoidance, minimization, and mitigation measures would be utilized if a project moves forward from this study, there do not appear to be any immitigable environmental resource areas.

Appendix A: 2012 Level of Service Analysis

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	47	99	6	5	111	24	4	5	1	28	3	32
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.69	0.77	0.38	0.62	0.75	0.75	0.50	0.62	0.25	0.54	0.38	0.67
Hourly flow rate (vph)	68	129	16	8	148	32	8	8	4	52	8	48
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	180			144			505	469	136	461	461	164
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	180			144			505	469	136	461	461	164
tC, single (s)	4.2			4.1			7.1	6.5	6.2	7.3	6.5	6.4
tC, 2 stage (s)												
tF (s)	2.3			2.2			3.5	4.0	3.3	3.7	4.0	3.5
p0 queue free %	95			99			98	98	100	89	98	94
cM capacity (veh/h)	1354			1450			429	468	917	452	473	831

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	212	188	20	108
Volume Left	68	8	8	52
Volume Right	16	32	4	48
cSH	1354	1450	498	569
Volume to Capacity	0.05	0.01	0.04	0.19
Queue Length 95th (ft)	4	0	3	17
Control Delay (s)	2.8	0.4	12.5	12.8
Lane LOS	A	A	B	B
Approach Delay (s)	2.8	0.4	12.5	12.8
Approach LOS			B	B

Intersection Summary			
Average Delay	4.3		
Intersection Capacity Utilization	30.7%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	94	32	64	85	33	71
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.90	0.50	0.76	0.73	0.89	0.89
Hourly flow rate (vph)	104	64	84	116	37	80
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			168		421	136
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			168		421	136
tC, single (s)			4.2		6.4	6.3
tC, 2 stage (s)						
tF (s)			2.3		3.5	3.4
p0 queue free %			94		93	91
cM capacity (veh/h)			1345		550	889

Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	168	201	117
Volume Left	0	84	37
Volume Right	64	0	80
cSH	1700	1345	744
Volume to Capacity	0.10	0.06	0.16
Queue Length 95th (ft)	0	5	14
Control Delay (s)	0.0	3.6	10.7
Lane LOS		A	B
Approach Delay (s)	0.0	3.6	10.7
Approach LOS			B

Intersection Summary			
Average Delay	4.1		
Intersection Capacity Utilization	31.1%	ICU Level of Service	A
Analysis Period (min)	15		

```
                 HCS+: Unsignalized Intersections Release 5.6

_______________________TWO-WAY STOP CONTROL SUMMARY___________________________

Analyst:              CDM Smith
Agency/Co.:           MDT
Date Performed:       6/14/2012
Analysis Time Period: PM peak
Intersection:         M-16 & 1st
Jurisdiction:
Units: U. S. Customary
Analysis Year:        2012
Project ID:  MT Corridor Study
East/West Street:     1st Street
North/South Street:   M-16
Intersection Orientation: NS                 Study period (hrs):  1.00

______________________Vehicle Volumes and Adjustments_________________________
Major Street:  Approach        Northbound              Southbound
               Movement     1      2      3     |  4      5      6
                            L      T      R     |  L      T      R
______________________________________________________________________________
Volume                                             46     35     27
Peak-Hour Factor, PHF                              0.77   0.88   0.75
Hourly Flow Rate, HFR                              59     39     36
Percent Heavy Vehicles             --     --       26     --     --
Median Type/Storage         Undivided           /
RT Channelized?
Lanes                                                 0   1    0
Configuration                                          LTR
Upstream Signal?                   No                     No
______________________________________________________________________________
Minor Street:  Approach        Westbound               Eastbound
               Movement     7      8      9     |  10     11     12
                            L      T      R     |  L      T      R
______________________________________________________________________________
Volume                      4      9      45       13     44     5
Peak Hour Factor, PHF       0.33   0.56   0.80     0.47   0.83   0.31
Hourly Flow Rate, HFR       12     16     56       27     53     16
Percent Heavy Vehicles      0      0      27       0      0      0
Percent Grade (%)                  0                      0
Flared Approach:  Exists?/Storage         No     /              No     /
Lanes                          0   1    0             0   1    0
Configuration                      LTR                    LTR
______________________________________________________________________________

__________________Delay, Queue Length, and Level of Service___________________
Approach            NB     SB        Westbound               Eastbound
Movement            1      4    |  7      8      9    |  10      11     12
Lane Config                LTR |          LTR         |          LTR
______________________________________________________________________________
v (vph)                    59             84                     96
C(m) (vph)                 1479           870                    725
v/c                        0.04           0.10                   0.13
95% queue length           0.12           0.32                   0.46
Control Delay              7.5            9.6                    10.7
LOS                         A              A                      B
Approach Delay                            9.6                    10.7
Approach LOS                               A                      B
______________________________________________________________________________
```

HCS+: Unsignalized Intersections Release 5.6

Phone: Fax:
E-Mail:

TWO-WAY STOP CONTROL(TWSC) ANALYSIS

Analyst: CDM Smith
Agency/Co.: MDT
Date Performed: 6/14/2012
Analysis Time Period: PM peak
Intersection: M-16 & 1st
Jurisdiction:
Units: U. S. Customary
Analysis Year: 2012
Project ID: MT Corridor Study
East/West Street: 1st Street
North/South Street: M-16
Intersection Orientation: NS Study period (hrs): 1.00

Vehicle Volumes and Adjustments

Major Street Movements	1	2	3	4	5	6
	L	T	R	L	T	R
Volume				46	35	27
Peak-Hour Factor, PHF				0.77	0.88	0.75
Peak-15 Minute Volume				15	10	9
Hourly Flow Rate, HFR				59	39	36
Percent Heavy Vehicles		--	--	26	--	--
Median Type/Storage	Undivided			/		
RT Channelized?						
Lanes				0	1	0
Configuration					LTR	
Upstream Signal?		No			No	

Minor Street Movements	7	8	9	10	11	12
	L	T	R	L	T	R
Volume	4	9	45	13	44	5
Peak Hour Factor, PHF	0.33	0.56	0.80	0.47	0.83	0.31
Peak-15 Minute Volume	3	4	14	7	13	4
Hourly Flow Rate, HFR	12	16	56	27	53	16
Percent Heavy Vehicles	0	0	27	0	0	0
Percent Grade (%)		0			0	
Flared Approach: Exists?/Storage			No /			No /
RT Channelized?						
Lanes	0	1	0	0	1	0
Configuration		LTR			LTR	

Pedestrian Volumes and Adjustments

Movements	13	14	15	16
Flow (ped/hr)	0	0	0	0

Lane Width (ft)	12.0	12.0	12.0	12.0
Walking Speed (ft/sec)	4.0	4.0	4.0	4.0
Percent Blockage	0	0	0	0

Upstream Signal Data

	Prog. Flow vph	Sat Flow vph	Arrival Type	Green Time sec	Cycle Length sec	Prog. Speed mph	Distance to Signal feet
S2 Left-Turn							
Through							
S5 Left-Turn							
Through							

Worksheet 3-Data for Computing Effect of Delay to Major Street Vehicles

	Movement 2	Movement 5
Shared ln volume, major th vehicles:		39
Shared ln volume, major rt vehicles:		36
Sat flow rate, major th vehicles:		1700
Sat flow rate, major rt vehicles:		1700
Number of major street through lanes:		1

Worksheet 4-Critical Gap and Follow-up Time Calculation

Critical Gap Calculation

Movement		1 L	4 L	7 L	8 T	9 R	10 L	11 T	12 R
t(c,base)			4.1	7.1	6.5	6.2	7.1	6.5	6.2
t(c,hv)		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
P(hv)			26	0	0	27	0	0	0
t(c,g)				0.20	0.20	0.10	0.20	0.20	0.10
Percent Grade				0.00	0.00	0.00	0.00	0.00	0.00
t(3,lt)			0.00	0.00	0.00	0.00	0.00	0.00	0.00
t(c,T):	1-stage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2-stage	0.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00
t(c)	1-stage		4.4	7.1	6.5	6.5	7.1	6.5	6.2
	2-stage								

Follow-Up Time Calculations

Movement	1 L	4 L	7 L	8 T	9 R	10 L	11 T	12 R
t(f,base)		2.20	3.50	4.00	3.30	3.50	4.00	3.30
t(f,HV)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
P(HV)		26	0	0	27	0	0	0
t(f)		2.4	3.5	4.0	3.5	3.5	4.0	3.3

Worksheet 5-Effect of Upstream Signals

Computation 1-Queue Clearance Time at Upstream Signal

	Movement 2		Movement 5	
	V(t)	V(l,prot)	V(t)	V(l,prot)
V prog				

Total Saturation Flow Rate, s (vph)	
Arrival Type	
Effective Green, g (sec)	
Cycle Length, C (sec)	
Rp (from Exhibit 16-11)	
Proportion vehicles arriving on green P	
g(q1)	
g(q2)	
g(q)	

Computation 2-Proportion of TWSC Intersection Time blocked	Movement 2		Movement 5	
	V(t)	V(l,prot)	V(t)	V(l,prot)
alpha				
beta				
Travel time, t(a) (sec)				
Smoothing Factor, F				
Proportion of conflicting flow, f				
Max platooned flow, V(c,max)				
Min platooned flow, V(c,min)				
Duration of blocked period, t(p)				
Proportion time blocked, p	0.000		0.000	

Computation 3-Platoon Event Periods	Result
p(2)	0.000
p(5)	0.000
p(dom)	
p(subo)	
Constrained or unconstrained?	

Proportion unblocked for minor movements, p(x)	(1) Single-stage Process	(2) Two-Stage Process Stage I	(3) Stage II
p(1)			
p(4)			
p(7)			
p(8)			
p(9)			
p(10)			
p(11)			
p(12)			

Computation 4 and 5
Single-Stage Process

Movement	1	4	7	8	9	10	11	12
	L	L	L	T	R	L	T	R
V c,x		0	210	193	0	211	175	57
s								
Px								
V c,u,x								
C r,x								
C plat,x								

Two-Stage Process

	7	8	10	11

	Stage1	Stage2	Stage1	Stage2	Stage1	Stage2	Stage1	Stage2
V(c,x)								
s		1500		1500		0		0
P(x)								
V(c,u,x)								
C(r,x)								
C(plat,x)								

Worksheet 6-Impedance and Capacity Equations

Step 1: RT from Minor St.	9	12
Conflicting Flows	0	57
Potential Capacity	1016	1015
Pedestrian Impedance Factor	1.00	1.00
Movement Capacity	1016	1015
Probability of Queue free St.	0.94	0.98

Step 2: LT from Major St.	4	1
Conflicting Flows	0	
Potential Capacity	1479	
Pedestrian Impedance Factor	1.00	1.00
Movement Capacity	1479	
Probability of Queue free St.	0.96	1.00
Maj L-Shared Prob Q free St.	0.96	

Step 3: TH from Minor St.	8	11
Conflicting Flows	193	175
Potential Capacity	706	722
Pedestrian Impedance Factor	1.00	1.00
Cap. Adj. factor due to Impeding mvmnt	0.96	0.96
Movement Capacity	677	692
Probability of Queue free St.	0.98	0.92

Step 4: LT from Minor St.	7	10
Conflicting Flows	210	211
Potential Capacity	752	750
Pedestrian Impedance Factor	1.00	1.00
Maj. L, Min T Impedance factor	0.88	0.94
Maj. L, Min T Adj. Imp Factor.	0.91	0.95
Cap. Adj. factor due to Impeding mvmnt	0.90	0.90
Movement Capacity	675	674

Worksheet 7-Computation of the Effect of Two-stage Gap Acceptance

Step 3: TH from Minor St.	8	11
Part 1 - First Stage		
Conflicting Flows		
Potential Capacity		
Pedestrian Impedance Factor		
Cap. Adj. factor due to Impeding mvmnt		
Movement Capacity		
Probability of Queue free St.		

Part 2 - Second Stage		
Conflicting Flows		
Potential Capacity		
Pedestrian Impedance Factor		
Cap. Adj. factor due to Impeding mvmnt		
Movement Capacity		
Part 3 - Single Stage		
Conflicting Flows	193	175
Potential Capacity	706	722
Pedestrian Impedance Factor	1.00	1.00
Cap. Adj. factor due to Impeding mvmnt	0.96	0.96
Movement Capacity	677	692
Result for 2 stage process:		
a		
y		
C t	677	692
Probability of Queue free St.	0.98	0.92

Step 4: LT from Minor St.	7	10
Part 1 - First Stage		
Conflicting Flows		
Potential Capacity		
Pedestrian Impedance Factor		
Cap. Adj. factor due to Impeding mvmnt		
Movement Capacity		
Part 2 - Second Stage		
Conflicting Flows		
Potential Capacity		
Pedestrian Impedance Factor		
Cap. Adj. factor due to Impeding mvmnt		
Movement Capacity		
Part 3 - Single Stage		
Conflicting Flows	210	211
Potential Capacity	752	750
Pedestrian Impedance Factor	1.00	1.00
Maj. L, Min T Impedance factor	0.88	0.94
Maj. L, Min T Adj. Imp Factor.	0.91	0.95
Cap. Adj. factor due to Impeding mvmnt	0.90	0.90
Movement Capacity	675	674
Results for Two-stage process:		
a		
y		
C t	675	674

Worksheet 8-Shared Lane Calculations

Movement	7 L	8 T	9 R	10 L	11 T	12 R
Volume (vph)	12	16	56	27	53	16
Movement Capacity (vph)	675	677	1016	674	692	1015
Shared Lane Capacity (vph)		870			725	

Worksheet 9-Computation of Effect of Flared Minor Street Approaches

Movement	7 L	8 T	9 R	10 L	11 T	12 R
C sep	675	677	1016	674	692	1015
Volume	12	16	56	27	53	16
Delay						
Q sep						
Q sep +1						
round (Qsep +1)						
n max						
C sh		870			725	
SUM C sep						
n						
C act						

Worksheet 10-Delay, Queue Length, and Level of Service

Movement	1	4	7	8	9	10	11	12
Lane Config		LTR		LTR			LTR	
v (vph)		59		84			96	
C(m) (vph)		1479		870			725	
v/c		0.04		0.10			0.13	
95% queue length		0.12		0.32			0.46	
Control Delay		7.5		9.6			10.7	
LOS		A		A			B	
Approach Delay				9.6			10.7	
Approach LOS				A			B	

Worksheet 11-Shared Major LT Impedance and Delay

	Movement 2	Movement 5
p(oj)	1.00	0.96
v(il), Volume for stream 2 or 5		39
v(i2), Volume for stream 3 or 6		36
s(il), Saturation flow rate for stream 2 or 5		1700
s(i2), Saturation flow rate for stream 3 or 6		1700
P*(oj)		0.96
d(M,LT), Delay for stream 1 or 4		7.5
N, Number of major street through lanes		1
d(rank,1) Delay for stream 2 or 5		0.3

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	4	58	1	0	64	3	2	0	1	5	0	3
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.50	0.81	0.25	0.25	0.70	0.38	0.25	0.25	0.25	0.31	0.25	0.38
Hourly flow rate (vph)	8	72	4	0	91	8	8	0	4	16	0	8
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	99			76			193	189	74	189	187	95
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	99			76			193	189	74	189	187	95
tC, single (s)	4.3			4.1			7.1	6.5	6.2	7.7	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.4			2.2			3.5	4.0	3.3	4.0	4.0	3.3
p0 queue free %	99			100			99	100	100	98	100	99
cM capacity (veh/h)	1361			1536			761	705	994	655	707	967

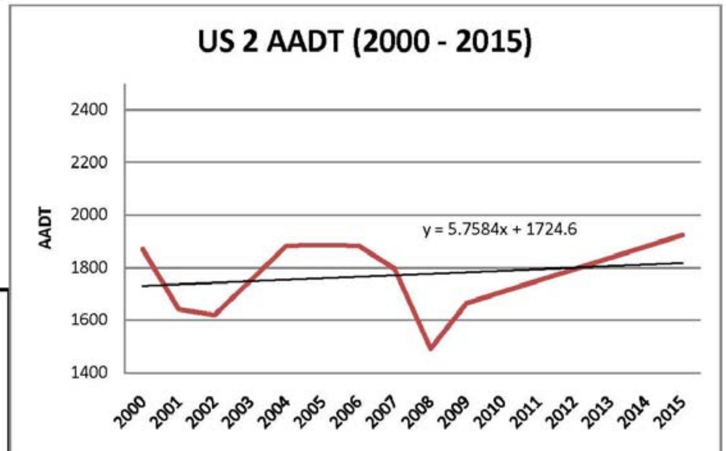
Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	84	99	12	24
Volume Left	8	0	8	16
Volume Right	4	8	4	8
cSH	1361	1536	826	732
Volume to Capacity	0.01	0.00	0.01	0.03
Queue Length 95th (ft)	0	0	1	3
Control Delay (s)	0.8	0.0	9.4	10.1
Lane LOS	A		A	B
Approach Delay (s)	0.8	0.0	9.4	10.1
Approach LOS			A	B

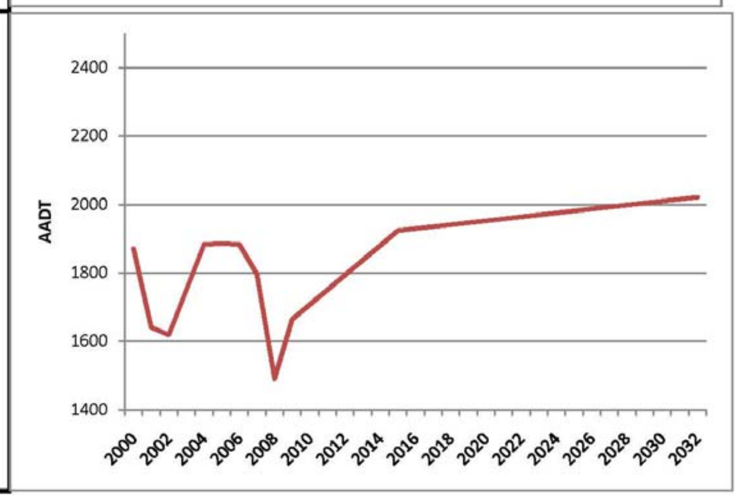
Intersection Summary			
Average Delay	1.9		
Intersection Capacity Utilization	16.4%	ICU Level of Service	A
Analysis Period (min)	15		

Appendix B: US 2 Calculations

US 2

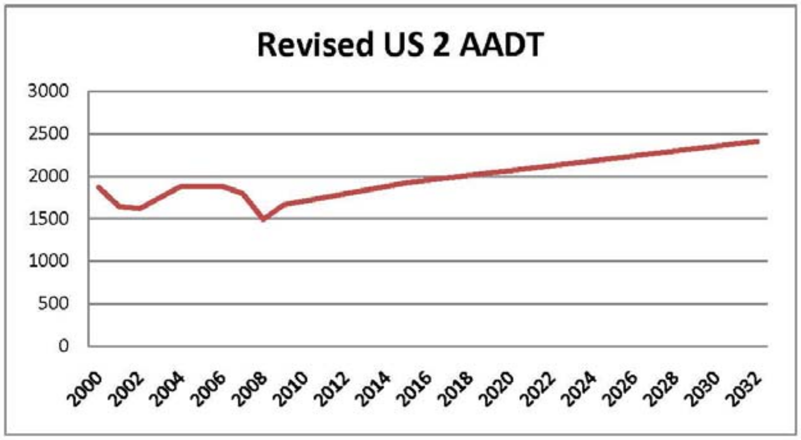
Year	AADT		Growth Rate
2000	1870	Weighted AADTs as shown in Table 5 of the *Existing and Projected Conditions Report.*	
2001	1641		
2002	1619		
2003	1751		
2004	1883		
2005	1886		
2006	1883		
2007	1796		
2008	1491		
2009	1664		
2010	1707	MDT provided a 5-year growth rate of 2.6% for US 2.	2.60
2011	1751		
2012	1794		
2013	1837		
2014	1880		
2015	1924		
2016	1929	The regression line equation was added to the 2015 AADT. In this case, the equation for 2016 to 2032 is y=5.7584(n-2015) + 1924, where n is the year's AADT to be calculated.	0.320
2017	1935		
2018	1941		
2019	1947		
2020	1952		
2021	1958		
2022	1964		
2023	1970		
2024	1975		
2025	1981		
2026	1987		
2027	1993		
2028	1998		
2029	2004		
2030	2010		
2031	2016		
2032	2021		





Revised US 2 Projections

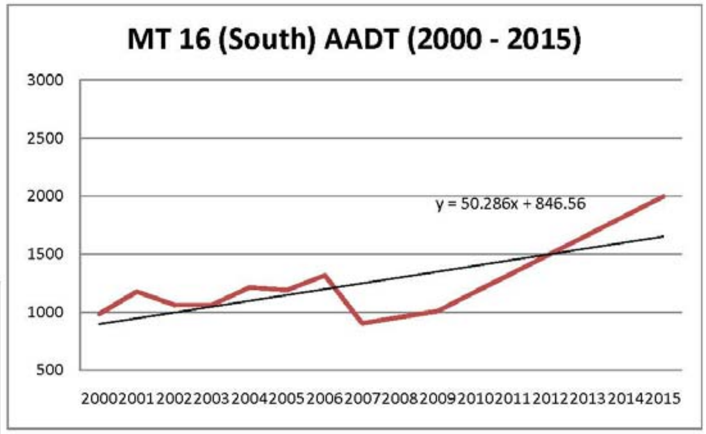
Year	AADT	Growth Rate
2000	1870	same
2001	1641	same
2002	1619	same
2003	1751	same
2004	1883	same
2005	1886	same
2006	1883	same
2007	1796	same
2008	1491	same
2009	1664	same
2010	1707	same
2011	1751	same
2012	1794	same
2013	1837	same
2014	1880	same
2015	1924	same
2016	1952	1.50
2017	1981	
2018	2010	
2019	2039	
2020	2068	
2021	2097	
2022	2126	
2023	2154	
2024	2183	
2025	2212	
2026	2241	
2027	2270	
2028	2299	
2029	2328	
2030	2356	
2031	2385	
2032	2414	

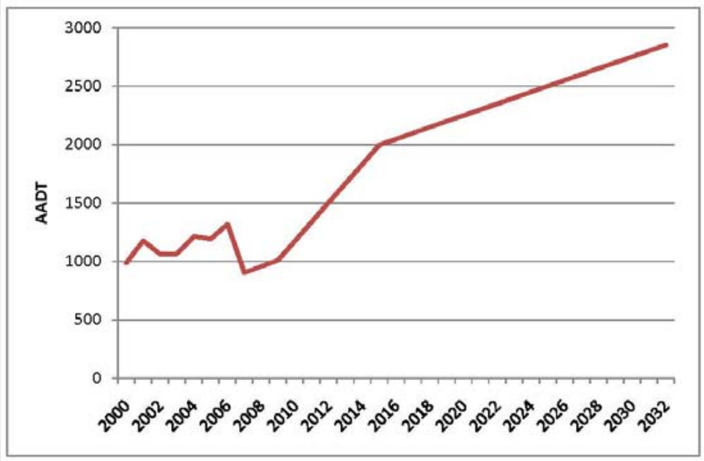


Appendix C: MT 16 (South) Calculations

MT 16 (South)

Year	AADT		Growth Rate
2000	985	Weighted AADTs as shown in Table 5 of the *Existing and Projected Conditions Report.*	
2001	1176		
2002	1062		
2003	1064		
2004	1213		
2005	1191		
2006	1318		
2007	902		
2008	956		
2009	1009		
2010	1173	MDT provided a 5-year growth rate of 16.3% for MT 16 (S).	16.30
2011	1338		
2012	1502		
2013	1667		
2014	1831		
2015	1996		
2016	2046	The regression line equation was added to the 2015 AADT. In this case, the equation for 2016 to 2032 is y=50.286 (n-2015) + 1996, where n is the year's AADT to be calculated.	2.52
2017	2096		
2018	2147		
2019	2197		
2020	2247		
2021	2298		
2022	2348		
2023	2398		
2024	2448		
2025	2499		
2026	2549		
2027	2599		
2028	2650		
2029	2700		
2030	2750		
2031	2800		
2032	2851		

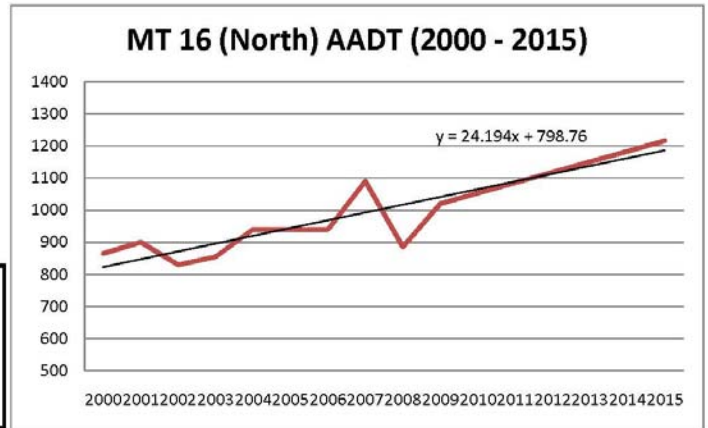


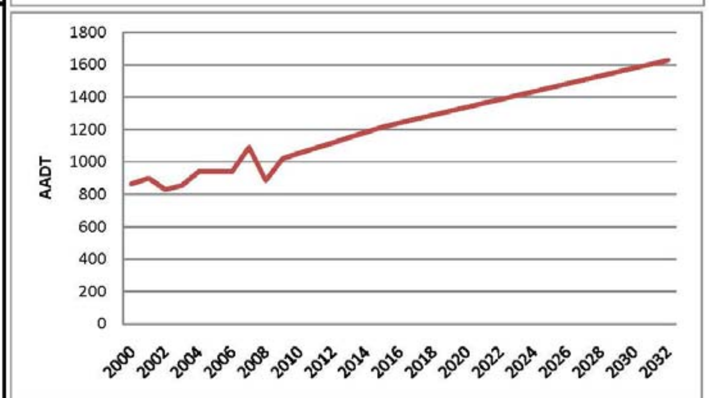


Appendix D: MT 16 (North) Calculations

MT 16 (North)

Year	AADT		Growth Rate
2000	865	Weighted AADTs as shown in Table 5 of the *Existing and Projected Conditions Report.*	
2001	900		
2002	830		
2003	855		
2004	940		
2005	940		
2006	940		
2007	1090		
2008	885		
2009	1020		
2010	1053	MDT provided a 5-year growth rate of 3.2% for MT 16 (N).	3.20
2011	1085		
2012	1118		
2013	1151		
2014	1183		
2015	1216		
2016	1240	The regression line equation was added to the 2015 AADT. In this case, the equation for 2016 to 2032 is y=24.194 (n-2015) + 1216, where n is the year's AADT to be calculated.	1.99
2017	1264		
2018	1288		
2019	1313		
2020	1337		
2021	1361		
2022	1385		
2023	1409		
2024	1434		
2025	1458		
2026	1482		
2027	1506		
2028	1530		
2029	1555		
2030	1579		
2031	1603		
2032	1627		





Appendix E: 2032 Level of Service Analysis

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✥			✥			✥			✥	
Volume (veh/h)	56	119	7	6	133	29	5	6	1	34	4	38
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.69	0.77	0.38	0.62	0.75	0.75	0.50	0.62	0.25	0.54	0.38	0.67
Hourly flow rate (vph)	81	155	18	10	177	39	10	10	4	63	11	57
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	216			173			604	561	164	551	551	197
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	216			173			604	561	164	551	551	197
tC, single (s)	4.2			4.1			7.1	6.5	6.2	7.3	6.5	6.4
tC, 2 stage (s)												
tF (s)	2.3			2.2			3.5	4.0	3.3	3.7	4.0	3.5
p0 queue free %	94			99			97	98	100	84	97	93
cM capacity (veh/h)	1313			1416			357	409	886	387	414	796

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	254	226	24	130
Volume Left	81	10	10	63
Volume Right	18	39	4	57
cSH	1313	1416	421	502
Volume to Capacity	0.06	0.01	0.06	0.26
Queue Length 95th (ft)	5	1	4	26
Control Delay (s)	2.9	0.4	14.1	14.7
Lane LOS	A	A	B	B
Approach Delay (s)	2.9	0.4	14.1	14.7
Approach LOS			B	B

Intersection Summary			
Average Delay	4.8		
Intersection Capacity Utilization	34.7%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	113	38	77	102	40	85
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.90	0.50	0.76	0.73	0.89	0.89
Hourly flow rate (vph)	126	76	101	140	45	96
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			202		506	164
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			202		506	164
tC, single (s)			4.2		6.4	6.3
tC, 2 stage (s)						
tF (s)			2.3		3.5	3.4
p0 queue free %			92		91	89
cM capacity (veh/h)			1307		484	858

Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	202	241	140
Volume Left	0	101	45
Volume Right	76	0	96
cSH	1700	1307	688
Volume to Capacity	0.12	0.08	0.20
Queue Length 95th (ft)	0	6	19
Control Delay (s)	0.0	3.7	11.6
Lane LOS		A	B
Approach Delay (s)	0.0	3.7	11.6
Approach LOS			B

Intersection Summary			
Average Delay	4.3		
Intersection Capacity Utilization	35.3%	ICU Level of Service	A
Analysis Period (min)	15		

HCS+: Unsignalized Intersections Release 5.6

TWO-WAY STOP CONTROL SUMMARY

Analyst: CDM Smith
Agency/Co.: MDT
Date Performed: 6/14/2012
Analysis Time Period: PM peak
Intersection: M-16 & 1st
Jurisdiction:
Units: U. S. Customary
Analysis Year: 2032
Project ID: MT Corridor Study
East/West Street: 1st Street
North/South Street: M-16
Intersection Orientation: NS   Study period (hrs): 1.00

Vehicle Volumes and Adjustments

Major Street: Approach	Northbound			Southbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume				55	42	32
Peak-Hour Factor, PHF				0.77	0.88	0.75
Hourly Flow Rate, HFR				71	47	42
Percent Heavy Vehicles		--	--	26	--	--
Median Type/Storage	Undivided			/		
RT Channelized?						
Lanes				0	1	0
Configuration					LTR	
Upstream Signal?		No			No	

Minor Street: Approach	Westbound			Eastbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume	5	11	54	16	53	6
Peak Hour Factor, PHF	0.33	0.56	0.80	0.47	0.83	0.31
Hourly Flow Rate, HFR	15	19	67	34	63	19
Percent Heavy Vehicles	0	0	27	0	0	0
Percent Grade (%)		0			0	
Flared Approach: Exists?/Storage			No /			No /
Lanes	0	1	0	0	1	0
Configuration		LTR			LTR	

Delay, Queue Length, and Level of Service

Approach	NB	SB	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Config		LTR		LTR			LTR	
v (vph)		71		101			116	
C(m) (vph)		1479		842			682	
v/c		0.05		0.12			0.17	
95% queue length		0.15		0.41			0.61	
Control Delay		7.6		9.9			11.4	
LOS		A		A			B	
Approach Delay				9.9			11.4	
Approach LOS				A			B	

HCS+: Unsignalized Intersections Release 5.6

Phone: Fax:
E-Mail:

TWO-WAY STOP CONTROL(TWSC) ANALYSIS

Analyst: CDM Smith
Agency/Co.: MDT
Date Performed: 6/14/2012
Analysis Time Period: PM peak
Intersection: M-16 & 1st
Jurisdiction:
Units: U. S. Customary
Analysis Year: 2032
Project ID: MT Corridor Study
East/West Street: 1st Street
North/South Street: M-16
Intersection Orientation: NS Study period (hrs): 1.00

Vehicle Volumes and Adjustments

Major Street Movements	1 L	2 T	3 R	4 L	5 T	6 R
Volume				55	42	32
Peak-Hour Factor, PHF				0.77	0.88	0.75
Peak-15 Minute Volume				18	12	11
Hourly Flow Rate, HFR				71	47	42
Percent Heavy Vehicles		--	--	26	--	--
Median Type/Storage	Undivided			/		
RT Channelized?						
Lanes				0	1	0
Configuration					LTR	
Upstream Signal?		No			No	

Minor Street Movements	7 L	8 T	9 R	10 L	11 T	12 R
Volume	5	11	54	16	53	6
Peak Hour Factor, PHF	0.33	0.56	0.80	0.47	0.83	0.31
Peak-15 Minute Volume	4	5	17	9	16	5
Hourly Flow Rate, HFR	15	19	67	34	63	19
Percent Heavy Vehicles	0	0	27	0	0	0
Percent Grade (%)		0			0	
Flared Approach: Exists?/Storage			No /			No /
RT Channelized?						
Lanes	0	1	0	0	1	0
Configuration		LTR			LTR	

Pedestrian Volumes and Adjustments

Movements	13	14	15	16
Flow (ped/hr)	0	0	0	0

Lane Width (ft)	12.0	12.0	12.0	12.0
Walking Speed (ft/sec)	4.0	4.0	4.0	4.0
Percent Blockage	0	0	0	0

Upstream Signal Data

		Prog. Flow vph	Sat Flow vph	Arrival Type	Green Time sec	Cycle Length sec	Prog. Speed mph	Distance to Signal feet
S2	Left-Turn							
	Through							
S5	Left-Turn							
	Through							

Worksheet 3-Data for Computing Effect of Delay to Major Street Vehicles

	Movement 2	Movement 5
Shared ln volume, major th vehicles:		47
Shared ln volume, major rt vehicles:		42
Sat flow rate, major th vehicles:		1700
Sat flow rate, major rt vehicles:		1700
Number of major street through lanes:		1

Worksheet 4-Critical Gap and Follow-up Time Calculation

Critical Gap Calculation

Movement		1 L	4 L	7 L	8 T	9 R	10 L	11 T	12 R
t(c,base)			4.1	7.1	6.5	6.2	7.1	6.5	6.2
t(c,hv)		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
P(hv)			26	0	0	27	0	0	0
t(c,g)				0.20	0.20	0.10	0.20	0.20	0.10
Percent Grade				0.00	0.00	0.00	0.00	0.00	0.00
t(3,lt)			0.00	0.00	0.00	0.00	0.00	0.00	0.00
t(c,T):	1-stage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2-stage	0.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00
t(c)	1-stage		4.4	7.1	6.5	6.5	7.1	6.5	6.2
	2-stage								

Follow-Up Time Calculations

Movement	1 L	4 L	7 L	8 T	9 R	10 L	11 T	12 R
t(f,base)		2.20	3.50	4.00	3.30	3.50	4.00	3.30
t(f,HV)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
P(HV)		26	0	0	27	0	0	0
t(f)		2.4	3.5	4.0	3.5	3.5	4.0	3.3

Worksheet 5-Effect of Upstream Signals

Computation 1-Queue Clearance Time at Upstream Signal

	Movement 2		Movement 5	
	V(t)	V(l,prot)	V(t)	V(l,prot)
V prog				

Total Saturation Flow Rate, s (vph)
Arrival Type
Effective Green, g (sec)
Cycle Length, C (sec)
Rp (from Exhibit 16-11)
Proportion vehicles arriving on green P
g(q1)
g(q2)
g(q)

Computation 2-Proportion of TWSC Intersection Time blocked

	Movement 2 V(t)	Movement 2 V(l,prot)	Movement 5 V(t)	Movement 5 V(l,prot)
alpha				
beta				
Travel time, t(a) (sec)				
Smoothing Factor, F				
Proportion of conflicting flow, f				
Max platooned flow, V(c,max)				
Min platooned flow, V(c,min)				
Duration of blocked period, t(p)				
Proportion time blocked, p	0.000		0.000	

Computation 3-Platoon Event Periods

Computation 3-Platoon Event Periods	Result
p(2)	0.000
p(5)	0.000
p(dom)	
p(subo)	
Constrained or unconstrained?	

Proportion unblocked for minor movements, p(x)	(1) Single-stage Process	(2) Two-Stage Process Stage I	(3) Two-Stage Process Stage II
p(1)			
p(4)			
p(7)			
p(8)			
p(9)			
p(10)			
p(11)			
p(12)			

Computation 4 and 5

Single-Stage Process

Movement	1 L	4 L	7 L	8 T	9 R	10 L	11 T	12 R
V c,x		0	251	231	0	253	210	68
s								
Px								
V c,u,x								
C r,x								
C plat,x								

Two-Stage Process

	7	8	10	11

	Stage1	Stage2	Stage1	Stage2	Stage1	Stage2	Stage1	Stage2
V(c,x)								
s		1500		1500		0		0
P(x)								
V(c,u,x)								
C(r,x)								
C(plat,x)								

Worksheet 6-Impedance and Capacity Equations

Step 1: RT from Minor St.	9	12
Conflicting Flows	0	68
Potential Capacity	1016	1001
Pedestrian Impedance Factor	1.00	1.00
Movement Capacity	1016	1001
Probability of Queue free St.	0.93	0.98

Step 2: LT from Major St.	4	1
Conflicting Flows	0	
Potential Capacity	1479	
Pedestrian Impedance Factor	1.00	1.00
Movement Capacity	1479	
Probability of Queue free St.	0.95	1.00
Maj L-Shared Prob Q free St.	0.95	

Step 3: TH from Minor St.	8	11
Conflicting Flows	231	210
Potential Capacity	672	691
Pedestrian Impedance Factor	1.00	1.00
Cap. Adj. factor due to Impeding mvmnt	0.95	0.95
Movement Capacity	638	656
Probability of Queue free St.	0.97	0.90

Step 4: LT from Minor St.	7	10
Conflicting Flows	251	253
Potential Capacity	707	704
Pedestrian Impedance Factor	1.00	1.00
Maj. L, Min T Impedance factor	0.86	0.92
Maj. L, Min T Adj. Imp Factor.	0.89	0.94
Cap. Adj. factor due to Impeding mvmnt	0.87	0.88
Movement Capacity	618	618

Worksheet 7-Computation of the Effect of Two-stage Gap Acceptance

Step 3: TH from Minor St.	8	11
Part 1 - First Stage		
Conflicting Flows		
Potential Capacity		
Pedestrian Impedance Factor		
Cap. Adj. factor due to Impeding mvmnt		
Movement Capacity		
Probability of Queue free St.		

Part 2 - Second Stage		
Conflicting Flows		
Potential Capacity		
Pedestrian Impedance Factor		
Cap. Adj. factor due to Impeding mvmnt		
Movement Capacity		
Part 3 - Single Stage		
Conflicting Flows	231	210
Potential Capacity	672	691
Pedestrian Impedance Factor	1.00	1.00
Cap. Adj. factor due to Impeding mvmnt	0.95	0.95
Movement Capacity	638	656
Result for 2 stage process:		
a		
y		
C t	638	656
Probability of Queue free St.	0.97	0.90

Step 4: LT from Minor St.	7	10
Part 1 - First Stage		
Conflicting Flows		
Potential Capacity		
Pedestrian Impedance Factor		
Cap. Adj. factor due to Impeding mvmnt		
Movement Capacity		
Part 2 - Second Stage		
Conflicting Flows		
Potential Capacity		
Pedestrian Impedance Factor		
Cap. Adj. factor due to Impeding mvmnt		
Movement Capacity		
Part 3 - Single Stage		
Conflicting Flows	251	253
Potential Capacity	707	704
Pedestrian Impedance Factor	1.00	1.00
Maj. L, Min T Impedance factor	0.86	0.92
Maj. L, Min T Adj. Imp Factor.	0.89	0.94
Cap. Adj. factor due to Impeding mvmnt	0.87	0.88
Movement Capacity	618	618
Results for Two-stage process:		
a		
y		
C t	618	618

Worksheet 8-Shared Lane Calculations

Movement	7 L	8 T	9 R	10 L	11 T	12 R
Volume (vph)	15	19	67	34	63	19
Movement Capacity (vph)	618	638	1016	618	656	1001
Shared Lane Capacity (vph)		842			682	

Worksheet 9-Computation of Effect of Flared Minor Street Approaches

Movement	7	8	9	10	11	12
	L	T	R	L	T	R
C sep	618	638	1016	618	656	1001
Volume	15	19	67	34	63	19
Delay						
Q sep						
Q sep +1						
round (Qsep +1)						
n max						
C sh		842			682	
SUM C sep						
n						
C act						

Worksheet 10-Delay, Queue Length, and Level of Service

Movement	1	4	7	8	9	10	11	12
Lane Config		LTR		LTR			LTR	
v (vph)		71		101			116	
C(m) (vph)		1479		842			682	
v/c		0.05		0.12			0.17	
95% queue length		0.15		0.41			0.61	
Control Delay		7.6		9.9			11.4	
LOS		A		A			B	
Approach Delay				9.9			11.4	
Approach LOS				A			B	

Worksheet 11-Shared Major LT Impedance and Delay

	Movement 2	Movement 5
p(oj)	1.00	0.95
v(il), Volume for stream 2 or 5		47
v(i2), Volume for stream 3 or 6		42
s(il), Saturation flow rate for stream 2 or 5		1700
s(i2), Saturation flow rate for stream 3 or 6		1700
P*(oj)		0.95
d(M,LT), Delay for stream 1 or 4		7.6
N, Number of major street through lanes		1
d(rank,1) Delay for stream 2 or 5		0.4

HCM Unsignalized Intersection Capacity Analysis
40: MT 16 & County Rd

6/14/2012

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	5	70	1	0	77	4	2	0	1	6	0	4
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.50	0.81	0.25	0.25	0.70	0.38	0.25	0.25	0.25	0.31	0.25	0.38
Hourly flow rate (vph)	10	86	4	0	110	11	8	0	4	19	0	11
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	121			90			234	229	88	228	226	115
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	121			90			234	229	88	228	226	115
tC, single (s)	4.3			4.1			7.1	6.5	6.2	7.7	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.4			2.2			3.5	4.0	3.3	4.0	4.0	3.3
p0 queue free %	99			100			99	100	100	97	100	99
cM capacity (veh/h)	1336			1517			712	669	975	614	672	943

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	100	121	12	30
Volume Left	10	0	8	19
Volume Right	4	11	4	11
cSH	1336	1517	783	700
Volume to Capacity	0.01	0.00	0.02	0.04
Queue Length 95th (ft)	1	0	1	3
Control Delay (s)	0.8	0.0	9.7	10.4
Lane LOS	A		A	B
Approach Delay (s)	0.8	0.0	9.7	10.4
Approach LOS			A	B

Intersection Summary			
Average Delay	1.9		
Intersection Capacity Utilization	17.9%	ICU Level of Service	A
Analysis Period (min)	15		