

Combined Traffic Reports

Billings Bypass

August 2013

NCPD 56 (55) Control Number 4199

Section 1 - Preliminary Traffic Study

Section 2 - Geometric Design Report

Section 3 - Traffic Signal Warrant Study

Section 4 - Lighting Warrant Study

Section 5 - FEIS Traffic Study Report













er.			



BILLINGS BYPASS EIS

SECTION 1 Preliminary Traffic Study Report

Billings Bypass April 2012







BILLINGS BYPASS EIS NCPD 56(55)CN 4199

Intentionally Blank Page.

Table of Contents	Page
INTRODUCTION	1
PROJECT BACKGROUND	1
PROJECT LOCATION AREA DESCRIPTION	1
EXISTING ROADS & STREETS OPERATIONS	7
Traffic Volumes	7
Trucks and Thru Traffic	9
Capacity and Level of Service	12
Crash History	13
COMMITTED FUTURE PROJECTS	15
PROPOSED ALTERNATIVE ALIGNMENTS	16
Mary Street Alignment Option 1	17
Mary Street Alignment Option 2	17
Five Mile Road Alignment	18
FUTURE TRAFFIC PROJECTION METHODS	19
NO-BUILD ALTERNATIVE SYSTEM IMPACTS	22
Traffic Volume Projections	22
Capacity and Level of Service	25
Crash Projections	26
BUILD ALTERNATIVE ALIGNMENT SYSTEM IMPACTS	27
Year 2035 Alternative Alignment Traffic Projections	27
Year 2035 Alternative Alignments Vehicle Miles Travel	34
Year 2035 Alternative Alignments Capacity & LOS	35
Crash Projections	38
ALTERNATIVE ALIGNMENT INTERSECTIONS	40
Johnson Lane/Coulson Road Intersections	40
Mary Street Alignment Intersections	42
Option 1 & Five Mile Road	42
Option 2 & Five Mile Road	42
Options 1 & 2 & Hawthorne Lane	45
Five Mile Road Alignment Intersections	45
Five Mile Road and Mary Street	45



Table of Contents - continued	Page
Mary Street & Bitterroot Drive Secondary Improvements	48
Mary Street & Hawthorne Lane Secondary Improvements	48
US87/HWY 312 Secondary Improvements	48
Five Mile Road & Dover Road	51
ALTERNATIVE INTERCHANGE/INTERSECTION DESIGN OPTIONS	51
Johnson Lane Interchange	51
Design Option Descriptions	52
Option 1 – Modified Diamond with Roundabouts	52
Option 2 – Single-Point Urban Interchange	53
Option 3 – Single-Point Urban Interchange with Roundabou	ts 54
Option 4 – Double Crossover Diamond with Traffic Signals	54
Option 5 – Double Crossover Diamond with Roundabouts	55
Capacity Comparisons	55
Corridor Travel Speeds	57
Mary Street Alignments - US 87/ Old Hwy 312 Intersection	59
Design Options Descriptions	59
Option 1 - Main Street Roundabout with Access to	
Mary St/Bench Blvd T-intersections	59
Option 2 – Primary & Secondary Roundabouts	60
Option 3 - Dual Roundabouts	61
Capacity Comparisons	61
Five Mile Road/Old Hwy 312	62
Design Options Descriptions	63
Option A	63
Option B	64
Mary Street/Bitterroot Drive	64
Design Options Descriptions	64
Option A – Signal	64
Option B – Roundabout	65
Option C – Signal	65
Option D – Raised Median Bitterroot	65
Option E - Grade Separation	66



Table of Cont	ents - continued	Page
Opt	ion F – Signal Northwest	67
Opt	ion G – Mary Street Termination	67
Capacity		67
SUMMARY & CC	DNCLUSIONS	69
APPENDIX A -	Traffic Volume Variations	
APPENDIX B -	Existing Roads & Street Capacity Calculations	
APPENDIX C -	No-Build Alternative Capacity Calculations	
APPENDIX D -	Mary Street Option 1 Alignment Street System Imp	oact
	Capacity Analysis	
APPENDIX E -	Mary Street Option 2 Alignment Street System Imp	oact
	Capacity Analysis	
APPENDIX F -	Five Mile Road Alignment Street System Impact C Analysis	apacity
APPENDIX G -	Alternative Alignment Intersections Capacity Analy	/sis
APPENDIX H -	Johnson Lane Interchange Design Options Figure	
7 Z., Z., Z., Z., Z., Z., Z., Z., Z.,	Capacity Analysis	.
APPENDIX I -	US 87/Old Hwy 312 Intersection Design Options F	iggures &
	Capacity Analysis	
APPENDIX J -	Five Mile Road/Old Hwy 312 Intersection Design (Options
	Figures & Capacity Analysis	•
APPENDIX K -	Mary Street Alignment /Bitterroot Drive Intersection	n Design



Options Figures & Capacity Analysis

List of Fig	jures	Page
Figure 1.	Project Location/Existing Road & Street System Map	3
Figure 2.	Existing (2010) Traffic Volume on Potentially	8
	Impacted System	
Figure 3.	O-D Percentages of All Traffic	11
Figure 4.	O-D Percentages of Commercial Trucks	11
Figure 5.	Mary Street Option 1 Alignment	17
Figure 6.	Mary Street Option 2 Alignment	17
Figure 7.	Five Mile Road Alternative Alignment	18
Figure 8.	Distribution of Existing (2010) trips -	20
	Billings Heights & Lockwood	
Figure 9.	Year 2035 ADT Volumes on No-Build System	23
Figure 10.	No-Build Alternative Year 2035 Traffic at	
	Critical Intersections	24
Figure 11.	Mary Street Option 1 Alignment – Year 2035 ADT Volumes	28
Figure 12.	Mary Street Option 1 Alignment – Year 2035	
	PM Design Hour Traffic	29
Figure 13.	Mary Street Option 2 Alignment – Year 2035 ADT Volumes	30
Figure 14.	Mary Street Option 2 Alignment – Year 2035	
	PM Design Hour Traffic	31
Figure 15.	Five Mile Road Alignment – Year 2035 ADT Volumes	32
Figure 16.	Five Mile Road Alignment – Year 2035 Design Hour Traffic	33
Figure 17.	Johnson Lane/Coulson Road-Proposed Arterial Intersections	41
Figure 18.	Mary Street Option 1Alignment - Five Mile Road Intersection	43
Figure 19.	Mary Street Option 2Alignment - Five Mile Road Intersection	44
Figure 20.	Mary Street Option 1 & 2 Alignments –	
	Hawthorne Lane Intersection	46
Figure 21.	Five Mile Road Alignment – Mary Street Intersection	47
Figure 22.	Five Mile Road Alignment – Mary & Bitterroot	
	Secondary Improvements	49
Figure 23.	Five Mile Road Alignment US 87-312-Bench-Mary	
	Secondary Intersection Improvements	50



List of Ta	bles	Page
Table 1.	Commercial Truck Traffic on Existing (2010)	10
14515 11	Road & Street System	.0
Table 2.	Existing (2010) Intersection Capacity Summary	12
Table 3.	Crash Statistics on Existing (2010) Road & Street System	14
	1/1/2006 to 12/31/2010	
Table 4.	Project Specific Demographic Areas – Years 2002 to 2035	21
	From 2009 Plan Update	
Table 5.	No-Build Alternative (2035) Intersection Capacity Summary	25
Table 6.	No-build Alternative Crash Projections on Existing Road &	26
	Street System Year 2035	
Table 7.	Alternative Alignments Vehicle Miles Travel Comparison	35
Table 8.	Mary Street Option 1 Alignment – Existing Street System	36
	Capacity	
Table 9.	Mary Street Option 2 Alignment – Existing Street System	37
	Capacity	
Table 10.	Five Mile Road Alignment – Existing Street System Capacity	37
Table 11.	Alternative Alignments Annual Crash Projections on	
	Existing Road & Street System Year 2035	39
Table 12.	Johnson Lane Interchange Design Options	
	Capacity Summary	56
Table 13.	Johnson Lane Corridor Travel Speeds Through Interchange	58
Table 14.	Mary Street Alignments US 87/Old Hwy 312 Capacity	62
Table 15.	Mary Street Alignment – Bitterroot Drive Design Options	
	Capacity Summary	68



er.			

INTRODUCTION

This report was prepared in fulfillment of Activity 112 (Preliminary Traffic) for the Billings Bypass Project NCPD 56(55) CN 4199. General descriptions of the preliminary project alignments and potentially impacted existing street system are presented within this report. Summaries of the existing street system are provided as baseline traffic conditions. Future design year (2035) traffic projections for the No-build and preliminary alignment alternatives are presented along with traffic analysis results associated with existing and proposed alternative roadways and intersections.

An extensive number of alternative alignments and intersections were screened within the project's Environmental Impact Statement (EIS) process. This report presents a summary of the traffic operations that would be associated with each of the alternatives that have been advanced through to the final screening process. All of the design alternatives presented within this report would provide acceptable traffic operating conditions in the design year. Since there are a number of considerations other than traffic operations that need to be considered in final design, this report summarizes the potential safety and efficiency associated with each alternative, but does not make recommendations to identify preferred alternatives.

PROJECT BACKGROUND

The project was originally intended to be a bypass route north of Billings between Interstate 90 (I-90) and Montana Route 3 (MT 3) and was to be part of the Camino Real International Trade Corridor route from Canada to Mexico. The bypass was to skirt congested urban routes within Billings and provide a direct connection between MT 3 and I-90. Funding constraints eventually resulted in a re-scoping of the project to focus on the eastern segment of the proposed project between the interstate and Old Hwy 312. A review of the transportation needs in the eastern portion of Billings, coupled with input from local plans and documents, revealed that physical barriers (Yellowstone River, MRL Railroad, Rimrocks, and Interstate 90) limit access and connectivity within and through the area for both local travel and truck/commercial vehicles. MDT coordinated with local, state, and federal agencies and the public on revising the project purpose and need to address these transportation issues. The project purpose and need, as detailed in the EIS, were used as prime screening criteria in development of the alternative alignments that were analyzed and summarized within this report.

PROJECT LOCATION AREA DESCRIPTION

The City of Billings has an extensive system of internal streets and has eight highways that enter the urban area. These highways include: Interstates 90 and 94; Primary Highways MT 3, US 87, old US 87 to Hardin, and old US 312; and a Secondary Highway to Pryor, south of Billings. This regional highway system is important in terms of commercial and through traffic within the Billings urban



area. Also, smaller towns in the region tend to act as bedroom communities with substantial numbers of persons working in Billings and living in the outlying areas.

Key physical characteristics of Billings include the "Rimrocks", which are 300' high sandstone bluffs which rise on the northern boundary of Billings Proper. Billings Heights, which contains approximately 25% to 30% of the urban population, is located on bench-land north and northeast of the Rimrocks. Access between Billings and Billings Heights is confined to one of three routes: Main Street, which provides a narrow passage around the east edge of the Rimrocks just west of the Yellowstone River; North 27th Street, which is a roadway cut diagonally into the face of the Rimrocks north of downtown (CBD); and Zimmerman Trail, which is a steep winding roadway that follows a natural drainage way on the west end of Billings. All of these routes eventually converge at a point between the Rimrocks and the Yellowstone River, where Main Street is forced to carry all north-south external area traffic and a large portion of the urban area traffic.

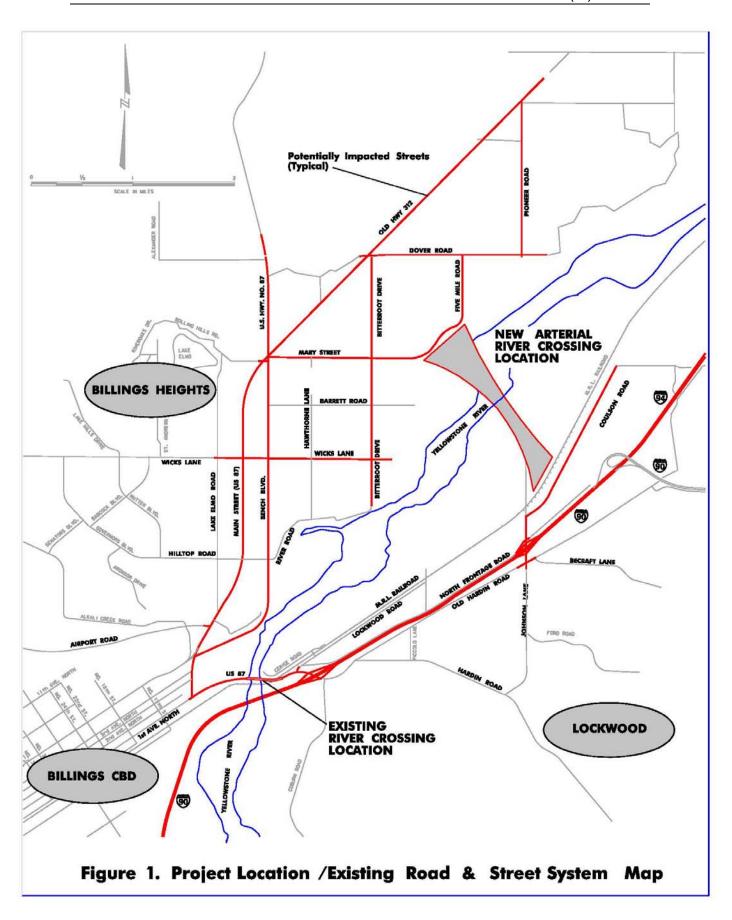
The Yellowstone River is another physical feature of the Billings area that has determined the location and function of transportation systems in Billings. Lockwood and the South Hills are the two major urbanized areas located on the south side of the Yellowstone River. There are only three crossings of the Yellowstone within the concentrated urban area: US 87 at the Lockwood (I-90) Interchange; the I-90 River Bridge west of Lockwood; and the South Billings Boulevard River Bridge, located south of the Billings CBD.

These two important physical characteristics create a great deal of traffic demand on urban arterial streets by forcing traffic with external origins and destinations to utilize local urban streets. External traffic on all routes northeast of Billings has no other option than to utilize portions of Main Street.

Interstate 90, which runs east—west along the southern boundary of the urbanized area, is the major carrier of external area traffic. Interstate 94 begins at an intersection with I-90 on the eastern edge of the urbanized area at the Pinehills Interchange. US 87 begins at an intersection with I-90, on the western edge of Lockwood and heads north to access communities north and east of Billings. Old Highway 312 parallels the alignment of I-94 on the north side of the Yellowstone River and provides access to a number of bedroom communities northeast of Billings, including the town of Huntley, which is also served by an interchange with Interstate 94.

A number of street and highway routes were identified as having the greatest potential for changes in traffic demand associated with the proposed arterial road river crossing. Traffic modeling efforts completed as a part of this project were instrumental in the identification of key corridors which would be sensitive to the proposed project alignments. Figure 1 provides an illustration of the select system routes for which existing traffic conditions have been compiled and evaluated within this report.





The principal roads and streets that have the potential for impacts resulting from the construction of a new arterial roadway between Billings Heights and Lockwood would be Main Street (US 87), Bench Boulevard, Old Highway 312, US 87 River Crossing between Main Street, Interstate 90, and Interstate 94.

Main Street is a principal arterial street within the City of Billings that is coincident with US 87 between 1st Avenue North, on its southern terminus, and the US 87/Old Highway 312 junction, on its northern terminus. Main Street is approximately 90 feet in width, carries three thru-lanes in each direction, and has a raised median with left-turn lanes along its entire length. Constructed in 1965, Main Street has numerous driveways and median openings to commercial businesses between 1st Avenue North and Wicks Lane. The segment of Main Street north of Wicks Lane was reconstructed in 1983 and has fewer driveway approaches and median openings with much greater access control. Main Street has the highest traffic volumes of any roadway in the state of Montana, with approximately 50,000 vehicles per day just north of a junction with Airport Road. It is at this point that most of the traffic between Billings Proper, Lockwood and Billings Heights is funneled, due to physical barriers (the Rimrocks, the Yellowstone River, and the railroad). There are a total of 10 signalized intersections on Main Street, with one additional traffic signal being planned at the present time. For the purposes of impact evaluation within this study, four of these intersections are considered to be key intersections that are most representative of overall operations on Main Street. Those intersections are at 1st Avenue North, Airport Road, Wicks Lane, and US 87/HWY 312.

Bench Boulevard is a principal arterial street that parallels Main Street between US 87/HWY 312 and Lake Elmo Drive south of Hilltop Road. Bench is currently a 24 foot wide, two-lane roadway that was the original US 10 highway to Miles City. When Main Street was constructed in 1965, it reverted to being a county road, and in the late 1980s it became a City of Billings street when the Billings Heights was annexed into the City of Billings. Bench Boulevard is surrounded by residential development along its length and there is limited access to Main Street. Where those access streets do exist, some commercial development exists on side street lots east of Main Street. There are numerous driveways that access Bench Boulevard along its length, and the majority of traffic is localized with origins and destinations on Bench Boulevard or on side streets east of Bench Boulevard. At the time this report was written, a construction project was completed that extended Bench Boulevard from Lake Elmo Road over a new Alkali Creek bridge to 6th Avenue North at Main Street. In addition, two subsequent MDT projects that will improve Bench Boulevard from the north end of the new Alkali Creek Bridge to US 87/HWY 312 are currently undergoing final design. Those projects will create a new three lane roadway with improved horizontal geometry and access control. One of the purposes of those projects is to create a facility that would take some of the operational pressure off on Main Street. Bench Boulevard's function as a parallel facility to Main Street would be realized by a third project that involves a grade separation between Main Street and the Bench Boulevard/6th Avenue North roadway.



Old Highway 312 was previously the primary highway connection between Billings and Miles City, but was reclassified as a Secondary state highway after Interstate 94 was constructed in the 1960's. It provides access to residential subdivisions and small communities northeast of Billings, and its terminus is I-94 near Pompey's Pillar. It is currently classified as a Yellowstone County road and is maintained by Yellowstone County. It is approximately 28 feet wide for the majority of its length. Approximately four years ago, MDT reconstructed Old Highway 312 from its junction with US 87/Main Street to a point approximately one mile northeast of Dover Road. The newly constructed portion of Old Highway 312 has a width that varies between 64 feet and 80 feet and provides two travel lanes in each direction and a two-way-left-turn-lane along the majority of its length.

The segment of *US 87* that runs between the Lockwood I-90 interchange and the Main Street/First Avenue North intersection ranges in width between 68 feet and 80 feet. There are only two street accesses within this segment of US 87. There is an access to the City of Billings' sewage treatment facility and METRA Park fairgrounds to the North, and another northern access to Lockwood Road/North Frontage Road near the Lockwood Interchange. This segment of US 87 features an elevated crossing of both the Yellowstone River and the Montana Rail Link Railroad. It is the main entry to Billings for traffic with origins and destinations east of Billings on I-90 and I-94. It is also the only direct access between Billings and Lockwood, and between Billings Heights and Lockwood. The only other river crossing between Billings Heights and Lockwood is approximately ten miles northeast at the Huntley-Interstate 94 (I-94) Interchange. This segment also serves as a connection between Billings Heights and large commercial attractions on the extreme west end of Billings. In addition, this US 87 segment carries all external and through traffic from US 87, north of Billings to and from Old US 87, I-90, and I-94.

Interstate 90 skirts the southern edge of Billings, south of the Yellowstone River, west of US 87, and crosses the Yellowstone River west of the Lockwood Interchange. I-90 was constructed south of the industrial area along the Yellowstone River and south of what was in 1966 sparse residential areas in Lockwood. It now bisects the community of Lockwood from the Yellowstone River Bridge to its junction with I-94, at a small community known as Pinehills, on the eastern edge of Lockwood. The I-90/I-94 junction is commonly known as the Pinehills Interchange. The Pinehills Interchange is a Trumpet style interchange that requires eastbound I-90 traffic to exit on a single lane ramp. Its geometrics are considered to be substandard, according to current AASHTO geometric criteria and guidelines.

Two I-90 interchanges would potentially be impacted by this project. The **Johnson Lane Interchange** is located approximately 1.3 miles southwest of the Pinehills Interchange and 2.5 miles northeast of the Lockwood Interchange. This interchange provides access to Johnson lane, which is a principal north-south arterial roadway in Lockwood. Johnson Lane begins at an intersection with old US 87 on the south and extends through the community of Lockwood, under I-90, crosses the MRL railroad, and dead-ends near the Yellowstone River. Jus



south of the railroad tracks, Johnson Lane intersects Coulson Road. Coulson Road is a rural roadway south of and parallel to the railroad tracks. It accesses properties to the northeast, and provides a secondary access to the Pinehills community. Johnson Lane also intersects with the I-90 North Frontage Road immediately north of the I-90 westbound interchange ramps. North Frontage road begins at an intersection with Lockwood Road near the Lockwood Interchange and parallels I-90 to its intersection with Johnson Lane. North frontage continues one mile northeast of Johnson Lane and terminates at an access to private property near the Pinehills Interchange. The North Frontage Road intersection with Johnson Lane currently operates with stop control on the North Frontage Road.

The Johnson Lane Interchange is a standard diamond interchange. The eastbound and westbound ramp intersections with Johnson Lane are separated by a distance of approximately 750 feet. The westbound ramps intersection is stop controlled while the eastbound ramps are controlled by a traffic signal. There are two traffic lanes on the eastbound off-ramp approach to Johnson lane. All other ramps have single lanes. Johnson Lane has single through lanes and marked left-turn lanes at intersections with the I-90 ramps.

South of the eastbound I-90 ramps, Johnson Lane intersects Old Hardin Road, which is a principal arterial street located south of and parallel to I-90. Old Hardin Road extends from its western terminus at an intersection with Old US 87, near the Lockwood Interchange, to its eastern terminus within the community of Pinehills. The intersection of Old Hardin Road and Johnson Lane has multiple approach lanes and operations are controlled by a traffic signal.

The Johnson Lane Interchange was constructed in 1984 to serve the eastern portion of Lockwood and was the first project in Montana that was constructed using a combination of local and federal funds. The Lockwood Transportation District was created to provide the local share of Interstate matching funds necessary to create the federal project. Growth in Lockwood and associated traffic volumes have increased substantially since its construction such that operational problems have begun to develop on the Johnson Lane crossroad.

The *Lockwood Interchange* was constructed as a part of the original I-90 construction project in 1965. The Lockwood interchange provides access to the Billings CBD from origins and destinations east of Billings. It also is the primary access for traffic to and from the Billings Heights area and for external traffic on US 87 and Highway 3. Prior to the Johnson Lane Interchange construction, it was the only access to the entire community of Lockwood. The interchange is standard diamond type with single lane ramps and a five lane crossroad (US 87). The US 87 roadway has two traffic lanes in each direction and left turns lanes within a raised median section at the ramp intersections. Both eastbound and westbound ramps were signalized approximately ten years ago and a right-turn lane was added to the eastbound off-ramp in 2010. A third traffic signal at the Lockwood Road intersection, west of I-90 operates in coordination with the ramp signals. Current traffic volumes on the US 87 crossroad create periodic congestion due to vehicle queues exceeding available storage.



EXISTING ROADS & STREETS OPERATIONS

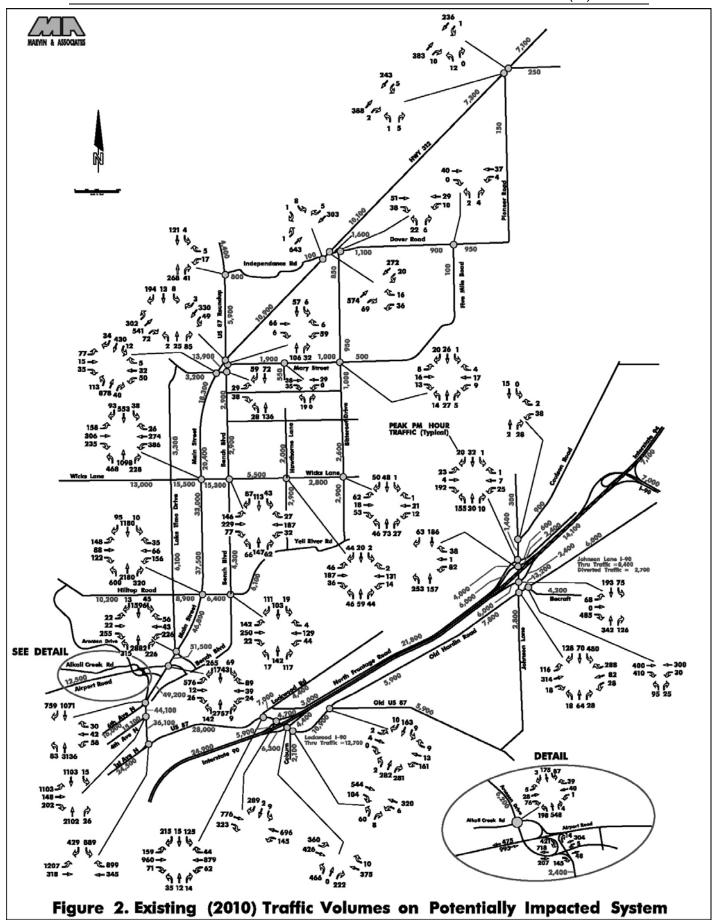
Traffic Volumes

Existing (2010) traffic count data was requested from and supplied by MDT, the City of Billings, and Yellowstone County. In addition, data was extracted from the Lockwood Transportation Plan. In order to supplement data that was incomplete or out-dated, additional peak hour traffic movement counts were taken at a number of intersections in 2010 and 2011. Traffic count data was composed of road tube data summarized by hourly volume variations, and peak hour turning movement data summarized by 15 minute count periods. Average Daily Traffic (ADT) counts were calculated by factoring 24 hour count data by day of the week and month of the year where 24-hour count data was available. At locations where 24 hour count data was not available, turning movement counts were used to estimate ADT based on average hourly variations for the type and location of each facility. MDT has a number of permanent traffic count stations in the Billings area that record one-hour volumes continuously on a number of different facilities. Statistics gathered from those permanent count stations are published on the MDT Web Site. Appendix A in this report presents the daily and monthly variation factors used to estimate ADT volumes. Other statistics in the MDT reports were used to determine peak design hour traffic volumes.

There were three specific locations where turning movement counts were collected at successive intersections on different days and in some cases different months. As a result, departure traffic volumes from one intersection did not match approach traffic volumes at the next intersection. Those locations involved four intersections at both the Lockwood and Johnson Lane interchanges and on Main Street, between 1st Avenue North and Airport Road. In order to resolve the differences and present a more accurate accounting of traffic volumes at these locations, a traffic balancing spreadsheet was created to ensure that traffic demand at individual intersections agreed with the daily and peak hour traffic passing through each individual corridor.

Figure 2 illustrates the existing (2010) traffic volumes for Average Daily Traffic (ADT) and peak PM hour design traffic. Throughout the study process, it was determined that the PM peak hour traffic volumes are considerably higher than the AM hour volumes and that operational measures of efficiency are worse during the PM hour. Therefore, the PM design hour volumes were used for evaluation of operational differences within this study.





Trucks and Through Traffic

In addition to ADT for all vehicles, commercial vehicle traffic (trucks) data was extracted from MDT's "Traffic by Section" report for 2010, previous traffic classification counts by Marvin & Associates, and extrapolations between segments. Table 1 includes a summary of the existing system road and street segments; the segment length, year 2010 ADT, commercial (truck) ADT, and percentage of total ADT that includes trucks. The highest volume and percentage of trucks are on the Interstate 90 and 94 corridors, ranging from 14.6% on I-94 to 22.1% on I-90 east of Johnson Lane. Truck traffic on Johnson Lane, within the interchange area, also has a high percentage of trucks that ranges between 11.7% and 16.3% because of two large truck plazas that exist on each side of I-90 at that interchange.

Both Main Street and US 87 carry a substantial volume of commercial vehicle traffic, which ranges between 300 and 550 ADT. Because Main Street has such a high volumes of overall traffic, the relative percentage of trucks is actually less than 1% of total ADT. On US 87 north of the Old Highway 312 junction, the relative percentage of trucks is 5.2% of ADT. One hour counts were taken at the intersections of US 87/HWY 312/Main Street, Main Street/Airport Road, and 1st Avenue N/Main/US 87 to determine the percentage of trucks that were local or short-haul trucks as opposed to interstate or long-haul trucks. It was determined that the percentage of total trucks that were local ranged between 65% and 85%. Thus, it appears that on the average, 75% of truck traffic on the Main Street/US 87 corridor is local or short- haul vehicles while the remaining 25% of truck traffic is represented by interstate or long- haul vehicles.

The lowest volume of truck traffic occurs on the east-west roads and streets that feed into the Main Street or I-90 corridors. The county roads, represented by Dover Road, Five Mile Road and Pioneer Road, are primarily rural with a small number of farm trucks and, in the case of Dover Road, gravel trucks. Because the total volume of traffic on those roads is so small, the percentage of truck traffic appears to be high.

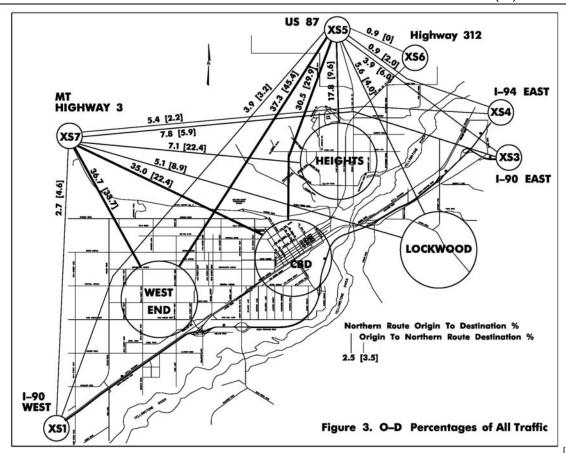
Through traffic demand (external to external origins and destinations) data and estimates used within this study are based on an Origin-Destination Study completed in the year 2000 as a part of the North Bypass Feasibility Study. Figures 3 and 4 illustrate the percentage of external trips to and from external and internal origins and destinations, based on origin-destination (OD) studies on Highway 3 and US 87. Figure 3 is a summary for all vehicles and Figure 4 presents percent distributions for commercial traffic (trucks). While the study is ten years old, the percentages of total traffic could be applied to the year 2010 traffic volumes to reflect current conditions.

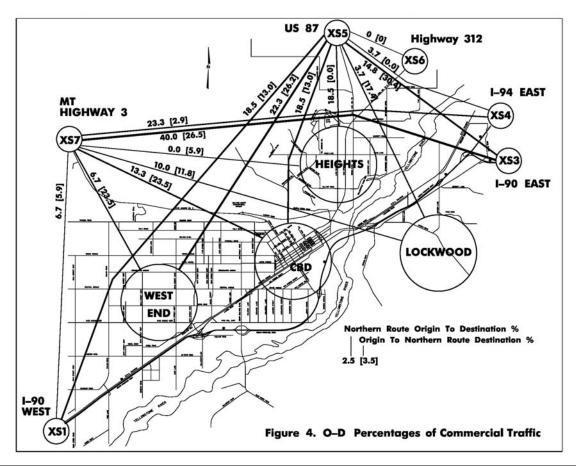


Table 1. Commercial Truck Traffic on Existing (2010) Road & Street System

	EXIST	TING STREET LINK SEGN	IENTS	Length	2010		nercial affic
	ROUTE NAME	from	to	(miles)	ADT	ADT	% Total
I-94	Interstate 94	Pinehill Interchange	Huntley Interchange	6.21	7000	1020	14.6%
06-1	Interstate 90	Johnson Lane	Lockwood	1.27	21400	3150	14.7%
31	Interstate 90	Pinehill Interchange	Johnson Lane	2.45	14000	3100	22.1%
County	Johnson Lane	I-90 Interchange	Coulson Road	0.29	4600	750	16.3%
U-1032	Johnson Lane	Old Hardin Road	I-90 Interchange	0.17	12000	1400	11.7%
U-1028	(Old US 87)	Lockwood Interchange	Jct Old Hardin Road	0.58	10700	450	4.2%
	Highway 87	I-90 Lockwood Interchng	1st Avenue N	1.25	27500	550	2.0%
	Main Street	1st Avenue N	6th Avenue N	0.35	39300	500	1.3%
US 87 N-16	Main Street	6th Avenue N	Airport Road	0.37	48500	450	0.9%
87 1	Main Street	Airport Road	Hilltop Road	0.64	50400	300	0.6%
SN	Main Street	Hilltop Road	Wicks Lane	1.02	35000	300	0.9%
	Main Street	Wicks Lane	HWY 312/Bench	1.00	19300	300	1.6%
	Highway 87	HWY 312/Bench	HWY 312/Bench 1.00 19300 300 ndependence Road 0.96 5800 300 Main Street 0.24 15200 20 Bench Boulevard 0.24 15000 50		300	5.2%	
12	Wicks Lane	Lake Elmo	Main Street	0.24	15200	20	0.1%
U-1012	Wicks Lane	Main Street	Bench Boulevard	0.24	15000	50	0.3%
,	Wicks Lane	Bench Boulevard	Bitterroot Drive	1.00	2800	10	0.4%
City	Mary Street	Bench Boulevard	Five Mile Road	1.67	1500	10	0.7%
788	Highway 312	US 87 (N16)	Dover Road	1.32	10700	100	0.9%
CO56788	Highway 312	Dover Road	Pioneer Road	2.20	7100	50	0.7%
၁	Highway 312	Pioneer Road	S-522 Huntley	5.43	6000	50	0.8%
U-1036	Bench Boulevard	Wicks Lane U-1012	US 87 (N16)	1.03	2900	5	0.2%
County	Dover Road	HWY 312 CO56788	Pioneer Road	1.56	1200	50	4.2%
County	Bitterroot Drive	Wicks (U-1012)	Mary Street	1.00	1300	5	0.4%
,	Bitterroot Drive	Mary Street	Dover Road	0.96	1000	5	0.5%
County	5 Mile Road	Mary Street	Dover Road	0.65	150	10	6.7%
County	Pioneer Road	Dover Road	HWY 312 CO56788	1.50	200	15	7.5%
S-522	Huntley Main Street	I-94 Huntley Interchange	CO56788 (HWY 312)	2.37	3700	50	1.4%
			Total =	37.73	13491	481	3.6%
					Avg	Avg	Avg







For the OD study on Highway 3, it was determined that approximately 15% of all traffic was through traffic, with an origin and destination external to the Billings area. The remaining traffic (85%) either originated in Billings or was destined to stop in Billings. On US 87, only 10.5% of the total traffic could be classified as through traffic. The percentage of through traffic for commercial (truck) traffic was substantially different, with through traffic accounting for approximately 53% of Highway 3 traffic, and 40% of US 87 traffic.

Capacity and Level of Service

Operational data for key intersections along the existing roads and streets that have the most probable impacts was gathered, and capacity analysis for existing (year 2010) conditions was performed for 18 separate intersections. In addition, capacity analysis was performed on three sections of Interstate-90 and the ramps at the Lockwood and the Johnson Lane Interchanges. All of the Interstate segments and ramps currently operate at Level-of-Service (LOS) "C" or better. The traffic analysis summaries can be found in Appendix B of this report.

Table 2. Existing (2010) Intersection Capacity Summary

			Inte	ersectio	n Appro	ach		
	N	IB	S	В	E	В	W	/B
Intersection	LOS	Delay (s/v)	LOS	Delay (s/v)	LOS	Delay (s/v)	LOS	Delay (s/v)
		· , ,	200	(0,1)	200	(0,1)		
Highway 312 & Dover	С	15					A	9
Dover & Bitterroot	Α	10					Α	7
Dover & Five Mile Road	Α	9					Α	7
Mary & Bitterroot	В	11	Α	10	Α	7	Α	7
Mary & Hawthorne	Α	10					Α	8
Mary & Bench			Α	8	В	12	В	12
US87/Main/HWY 312/Bench	Е	38	С	22	Α	9	Α	9
Main & Wicks Lane	D	44	D	35	Е	58	D	44
Main & Airport Road	D	38	В	15	Е	70	F	114
Main/1st Ave N/US 87			В	16	С	33	С	35
Lockwood US87/WB Ramps			С	33	С	24	В	12
Lockwood US87/EB Ramps	В	18			В	18	С	29
Johnson Lane EB Ramps	В	19	В	14	С	27		
Johnson Lane WB Ramps	Α	9					F	51
Johnson Lane & N Frontage	Α	8	Α	7	В	11	С	22
Johnson Lane & Coulson Road			Α	7			Α	9
Johnson Lane & Old Hardin Rd	С	34	В	15	С	25	В	20
Old Hardin Rd & Becraft	Е	41					В	11
		= LOS E) & E			= LOS F		



Table 2 presents a summary of LOS and delay, in terms of seconds per vehicle, for each intersection approach. Only five of the 18 intersections have approaches that operate below a LOS "C". The northbound approach to the US 87/HWY 312/Main/Bench intersection currently operates at LOS "E" with 38 seconds per vehicle delay in the PM design hour. Signalization of that intersection is currently under design.

Two key intersections on Main Street have approaches that operate at a LOS less than "C". The NB and SB approaches at Wicks Lane operate at LOS "D", while the EB approach has the most delay and operates at LOS "E". At the Airport Road intersection with Main Street, the NB movement operates at LOS "D" while accommodating in excess of 3,000 vehicles during the peak PM hour period. However, the lower volume Airport Road approaches suffers more delay with a LOS "E" on the EB approach and LOS "F" on the WB approach. Because Main Street is operating on a coordinated system and the majority of traffic flows in the northbound direction during the PM hour, there is more side street delay during that time. Operations at these intersections are much better at off-peak hours of the day.

The Johnson Lane WB Off-ramp operates at LOS "F" during the PM design hour due mainly to the high volume of truck movements on the ramp and on Johnson Lane, and the number of turning movements within the intersection. Fortunately the ramps' volumes are so low that only four or five vehicles are in the storage queues.

The intersection of Becraft Lane and Old Hardin Road is located within 300 feet of the Johnson Lane and Old Hardin Road intersection. The NB Becraft Lane approach to the intersection is stop controlled and currently operates at LOS "E" with 41 seconds per vehicle delay during the PM design hour traffic. While the approach volume is fairly low (200 vehicles) in the PM hour, it is double that in the AM hour. Thus, the Becraft approach operations are poor during most heavy traffic periods of the day. Signalizing this intersection would be difficult since its operations would then interfere with the existing signal at Johnson Lane and Old Hardin Road. The Lockwood Transportation Plan presents a method of relocating Becraft to enable coordinated operations on Old Hardin Road. However, there are no projects currently being planned at this intersection.

Crash History

The MDT Traffic Safety Section provided collision data for the select system routes for a five-year time period between January 1, 2006 and December 31, 2010. The collision data was divided into a number route segments and statistics were compiled for each route segment. Table 3, on the following page, presents a summary of collision statistics. As a comparison, the 2006 to 2010 statewide average crash rates for Urban Interstate routes was 1.18 crashes per million vehicle miles of travel (mvm) and the average severity rate was 2.11/mvm. For NHS routes & primary highways within city limits the average crash rate was 4.86 crashes/mvm and the average severity rate was 8.16/mvm. No other statewide urban crash statistics are available for city streets.



Table 3. Crash Statistics on Existing (2010) Road & Street System - 1/1/2006 to 12/31/2010

	EXIC	TING STREET LINK SEGM	MENTS				RASH HI	STORY	No. Fatal No.		STORY PAST 5 YEARS			
				Length	2009	No.	Crash	Injury			No.		Severity	
	ROUTE NAME	from	to	(miles)	ADT	Acc.	Rate	Crash	Inury	Crash	Fatal	Index	Rate	
I-94	Interstate 94	Pinehill Interchange	Huntley Interchange	6.21	7000	79	1.00	18	23	0	0	1.41	1.40	
1-90	Interstate 90	Johnson Lane	Lockwood	1.27	21400	74	1.49	20	32	0	0	1.49	2.22	
<u> </u>	Interstate 90	Pinehill Interchange	Johnson Lane	2.45	14000	7	0.11	1	1	0	0	1.26	0.14	
County	Johnson Lane	I-90 Interchange	Coulson Road	0.29	4600	20	8.22	3	5	0	0	1.27	10.43	
U-1032	Johnson Lane	Old Hardin Road	I-90 Interchange	0.17	12000	10	2.69	2	5	0	0	1.36	3.65	
U-1028	(Old US 87)	Lockwood Interchange	Jct Old Hardin Road	0.58	10700	17	1.50	8	15	0	0	1.85	2.77	
	Highway 87	I-90 Lockwood Interchng	1st Avenue N	1.25	27500	176	2.81	50	73	0	0	1.51	4.24	
, a	Main Street	1st Avenue N	6th Avenue N	0.35	39300	146	5.82	45	65	0	0	1.55	9.04	
87 N-16	Main Street	6th Avenue N	Airport Road	0.37	48500	107	3.27	34	56	0	0	1.57	5.14	
2 2	Main Street	Airport Road	Hilltop Road	0.64	50400	335	5.69	115	186	0	0	1.62	9.21	
ns 8	Main Street	Hilltop Road	Wicks Lane	1.02	35000	290	4.45	110	170	2	2	2.02	8.99	
-	Main Street	Wicks Lane	HWY 312/Bench	1.00	19300	146	4.15	31	0	0	0	1.38	5.73	
	Highway 87	HWY 312/Bench	Independence Road	0.96	5800	35	3.44	8	13	0	0	1.41	4.86	
12	Wicks Lane	Lake Elmo	Main Street	0.24	15200	19	2.85	4	4	0	0	1.38	3.94	
U-1012	Wicks Lane	Main Street	Bench Boulevard	0.24	15000	45	6.85	16	19	0	0	1.64	11.23	
Ď	Wicks Lane	Bench Boulevard	Bitterroot Drive	1.00	2800	33	6.46	6	9	0	0	1.33	8.57	
City	Mary Street	Bench Boulevard	Five Mile Road	1.67	1500	9	1.97	0	0	0	0	1.00	1.97	
788	Highway 312	US 87 (N16)	Dover Road	1.32	10700	20	0.78	3	3	1	1	3.72	2.89	
CO56788	Highway 312	Dover Road	Pioneer Road	2.20	7100	51	1.79	21	31	1	1	2.70	4.83	
ဗ	Highway 312	Pioneer Road	S-522 Huntley	5.43	6000	96	1.61	38	63	1	1	2.22	3.59	
U-1036	Bench Boulevard	Wicks Lane U-1012	US 87 (N16)	1.03	2900	60	11.01	21	27	0	0	1.63	17.94	
County	Dover Road	HWY 312 CO56788	Pioneer Road	1.56	1200	6	1.76	1	1	0	0	1.30	2.28	
County	Bitterroot Drive	Wicks (U-1012)	Mary Street	1.00	1300	17	7.17	3	5	0	0	1.32	9.44	
County	Bitterroot Drive	Mary Street	Dover Road	0.96	1000	0	0.00	0	0	0	0	0.00	0.00	
County	5 Mile Road	Mary Street	Dover Road	0.65	150	1	5.62	1	1	0	0	2.80	15.74	
County	Pioneer Road	Dover Road	HWY 312 CO56788	1.50	200	5	9.13	3	3	0	0	2.08	19.00	
S-522	Huntley Main Street	I-94 Huntley Interchange	CO56788 (HWY 312)	2.37	3700	29	1.81	14	16	0	0	1.87	3.39	
		Totals =		37.73	13491	1833	3.83	576	826	5	5	1.66	6.39	
ı					Avg		Avg					Avg	Avg	

There were a total of 1,833 reported crashes on 37.73 miles of roads and streets during the 5 year reporting period. These crashes produced 826 injuries and 5 fatalities, while 1,002 crashes involved property damage only. The average crash rate on all roadway segments was approximately 3.83 crashes per million vehicle miles of travel (mvm) and the average severity rate was 6.39/mvm.

The highest crash rate on any one route segment was 11.01/mvm on Bench Boulevard between Main Street and Wicks Lane. However, it should be noted that the majority of those crashes occurred at either the US 87 intersection or at the Wicks Lane intersection located on either end of the route segment. The second highest crash rate (9.13) was on Pioneer Road, which has a very low volume of traffic and the five crashes on that route elevate the crash rate, though it is suspected that most of the crashes involved the nearby intersection with Highway 312. This segment also had the highest severity rate (19.0) with three of the five crashes resulting in injuries. The third highest crash rate (8.22) was on Johnson Lane between the I-90 interchange and Coulson Road. Since the crash rate on the south side of the interchange is substantially lower, it is possible that some of the crashes may have been located on the south side rather than the north. The high volumes and restrictive geometry at the Johnson Lane interchange, along with heavy truck traffic and major turning movements, tend to make this interchange area congested and may overload drivers' perception skills.



Some crash trends relative to the route class can also be seen. The interstate segments experienced the lowest overall crash rates, ranging between 0.11 and 1.49 crashes/mvm. Crash rates on the Highway 312 corridor were also fairly low, ranging between 0.78 and 1.79. However, it should be noted that the section of Highway 312 east of US 87 was recently rebuilt to provide multiple lanes and wide shoulders. The value of the reconstruction project can be seen when comparing the 0.78 crash rate in that section to the 1.79 rate east of the new project.

The average collision rate on urban arterial segments of the select system routes averaged about 5.0/mvm. However, it should be noted that the collision rates on urban arterials can be somewhat skewed to the higher end because of the number of intersections which involve side street traffic in the collision numbers, yet side street traffic volumes are not always in the calculation.

The crash rate on the rural county roads (Pioneer Road, 5 Mile Road, and Bitterroot Drive) were the highest, probably because of increasing traffic on older substandard roadways.

COMMITTED FUTURE PROJECTS

Future transportation improvement projects that have been committed for within the Billings Urban Area Transportation Plan that would interact with the Billings Bypass Project are: the 6th Avenue North – Bench Boulevard grade separation at Main Street, and the Billings Inner Belt Loop connecting Wicks Lane to Highway 3. Although both of these projects would decrease dependence on Main Street to satisfy travel demand, each project targets different areas of Billings Heights and thusly, would have distinct differences with regard to interaction with the study project.

The 6th Avenue North - Bench Boulevard Grade Separation Project is considered to be Phase 2 of the Bench Boulevard – 4th and 6th Avenues North connection project that was recently constructed (not currently in operation). That project connected Bench Boulevard, at its current Lake Elmo Drive termini, directly to Main Street via a new bridge over Alkali Creek. The new roadway passes adjacent to and north of the METRA Park Rimrock Auto Arena, and will serve as the main access to the building's parking lots. The connection to Main Street was made at an existing signalized intersection at 6th Avenue North and The newly constructed intersection features a slip ramp for northbound vehicles on Main Street. This ramp will allow access to Bench Boulevard for all northbound vehicles, and all eastbound vehicles entering Main Street on 4th Avenue North that have destinations in Billings Heights east of Main Street. Southbound traffic on Bench Boulevard would stop at the Main Street traffic signal. Because southbound traffic on Bench Boulevard would compete for green time at the signal with traffic on Main Street, it is anticipated that northbound traffic on the Bench Boulevard connection road will far exceed southbound traffic volumes. The Phase 2 grade separation project is expected to equalize the directional disparity when it is implemented. For the purposes of



this study, it was assumed that the Phase 2 project would be in-place and operating by the year 2035 design year.

The Billings Inner Belt-Loop Project involves a new connector route that would begin at a point near the existing termini of Wicks Lane west of Main Street, intersect with Alkali Creek Road, and connect to Highway 3 west of the Billings Logan Airport near Zimmerman Trail. Contained in various transportation planning documents for a number of decades, this segment of the Inner Belt-Loop would complete a connection between Interstate 90 at Shiloh Road and US 87 (Main Street). Preliminary design of this segment of roadway was undertaken by the City of Billings in 2010 and construction of the first two-lane phase recently was delayed until the year 2013 or 2014. The project would provide an alternate route between Billings Heights and the west end of Billings. This route would satisfy travel demand in the western and northern portions of Billings Heights. For purposes of this project, it was assumed that the Inner Belt-Loop would be inplace in the design year 2035. It was also assumed that the Inner Belt-Loop would reduce traffic demand on Wicks Lane west of Main Street to a measured degree, and that a coordinated system of future streets in the outlying northern area would reduce traffic demand on US 87, just north of Main Street.

PROPOSED ALTERNATIVE ALIGNMENTS

After an extensive screening process, multiple alternative project alignments were screened out and three alternatives are being carried forward in the Environmental Impact Statement (EIS) process. This study addresses specific traffic operations associated with alignment design operations and impacts on the potentially impacted street system. Descriptions of the three alternative alignments can be found in the EIS Alternatives Report and in the following narratives and illustrations.

A connection to the Johnson Lane Interchange and a segment of the alignment south of the Yellowstone River is common to all alternative alignments. This segment is approximately 2.4 miles long and extends through land zoned for industrial and agricultural use. The Johnson Lane connection to I-90 would require reconstruction of the existing interchange to accommodate the anticipated traffic patterns.

The alignment would proceed north from I-90 along Johnson Lane and follow the existing Coulson Road alignment northeast for approximately 0.3 miles. At this point, the alignment would veer off of that existing road alignment and continue northeast roughly along the boundaries of parcels with industrial use. The alignment would proceed north and then west over Coulson Road and the Montana Rail Link railroad toward the Yellowstone River traversing agricultural land.

This alignment would include an at-grade connection with Coulson Road approximately 0.35 miles northeast of Johnson Lane. The existing segment of Coulson Road between Johnson Lane and this new connection would be removed.



Mary Street Alignment Option 1

This alignment would provide a 2.51-mile long connection from Old Hwy 312 across the Yellowstone River through land zoned for residential, agricultural, and commercial use. The connection to Old Hwy 312 would be located near

the intersection of Old Hwy 312 and Mary Street, requiring the reconstruction of the existing at-grade intersection.

The alignment would proceed east directly north of Mary Street for approximately 1.6 miles, and would be bordered by land with agricultural and residential uses along this section. The alignment would veer south across Mary Street and proceed southeast across an undeveloped parcel before crossing the Yellowstone River.

This alignment would include at-grade connections to Mary Street at four locations; Bench Boulevard, Hawthorne Lane, Bitterroot Drive, and approximately 1.6 miles east of Old Hwy 312 where the alignment would cross Mary Street. Mary Street would be used as a frontage road for local resident access.



Mary Street Alignment Option 2

This alignment would provide a 2.76-mile long connection from Old Hwy 312 across the Yellowstone River through land zoned for residential, agricultural, and commercial use, as well as a tract of future park land.

This alignment would be identical to the Mary Street Alignment - Option 1 from Old Hwy 312 to approximately 0.5 miles before the Yellowstone River. At this point, it would veer to the north across Five Mile Creek and Five Mile Road. The alignment would then proceed southeast through a tract of future park land and continue across the Yellowstone River.

This alignment would include connections to Mary Street at three locations: Bench Boulevard, Hawthorne Lane, and Bitterroot Drive. The alignment would also connect with Five Mile Road north of Five Mile



Creek. Mary Street would be used as a frontage road for local resident access.

Five Mile Road Alignment

For this alternative, there are two connection location options at Old Hwy

312. Depending on the location of its connection with Old Hwy 312, the Five Mile Road alignment would provide either a or 2.23-mile 2.13 long connection from Old Hwy 312 across the Yellowstone River. It would cross land zoned for agricultural, commercial, residential use, as well as a tract of future park land.

Either connection to Old Hwy 312 would be located approximately 1 mile north of Dover Road, requiring construction of a new at-grade intersection. The alignment would proceed south to the existing intersection of Five Mile Road and Dover Road. From that location, the alignment would continue south along the Five alignment before Mile Road southeast through veering planned future park land and crossing the Yellowstone River.



FUTURE TRAFFIC PROJECTION METHODS

Traffic projections for future design year volumes were based upon an approved methodology established specifically for this project. As with all transportation models, the traffic projection methods employed do not result in volumes that can be stated with any discrete level of accuracy, but have produced reasonable traffic volume estimates necessary to make informed planning decisions and also provide a realistic representation of traffic demand that was used to develop concept geometry and traffic controls for the alternative alignments.

The proposed traffic projection methodology is based on the following assumptions.

- The existing Billings traffic model was created for system-wide planning level projections within the urban area, while the proposed Bypass alternative alignment projections were based on a corridor level analysis.
- ☐ The Bypass corridor would provide an alternate route to serve both initial and future travel demand between Billings Heights and Lockwood. The corridor would also serve external travel demands by using the Bypass corridor as an alternate route to existing street system routing.
- ☐ The Bypass corridor alternatives will intersect and connect to a number of existing streets between the two termini connections in Billing Heights and Lockwood.
- Bypass corridor traffic projections were made by redistributing existing and future road system traffic based on shortest travel time routing.
- There was sufficient existing and easily obtained traffic data available to perform calculations required for redistribution of existing traffic.
- Future traffic projections were completed by using projected land use growth scenarios contained within the Billings Urban Area Transportation Plan 2009 Update.
- For the purposes of estimating future trips, Billings Heights and Lockwood were considered to be production centers, while other portions of the urban area such as the CBD and the west end commercial areas are considered to be trip attractors. It was assumed that the number of trips produced in each area having external origins and destinations will be in the proportion to the existing ratio of internal/external traffic.
- Origin-destination results from the Origin-Destination Study completed in 2000 are still valid with current and future land uses.



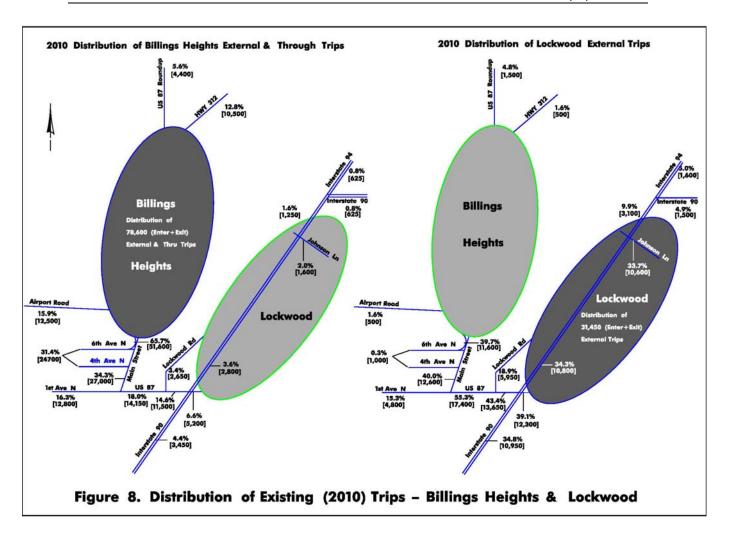


Figure 8 illustrates the relative boundaries of the Billings Heights and Lockwood communities and the roadway system entering and exiting each community. The only substantial external accesses to and from Billings Heights are Airport Road, Main Street, US 87, and Highway 312. The only external accesses to Lockwood are US 87 and I-90, and the only reasonable connection between the two communities is the US 87 Yellowstone River Crossing. Thus, in terms of travel demand, the Bypass corridor is essentially an alternate river crossing and the demand for travel on the route can be calculated by examining the directional traffic demand on the existing US 87 river crossing.

Figure 8 also shows the 2010 average daily traffic (ADT) volumes at key count stations and the relative percentage of external trips produced in Billings Heights and Lockwood, plus external traffic passing through each community. Through trip data was obtained by applying the Origin-Destination Study data detailed in Figures 3 and 4. The number of trips generated in each area that enter or leave the area's boundaries is determined by adding all of the cordon count station volumes and subtracting the external to external through traffic. It is important to note that the number of external trips produced in the Billings Heights area represents approximately 40% of the total number of trips produced within that area, while the number of external trips produced in Lockwood represents



approximately 65% of the total trip production in Lockwood. This disparity illustrates the fact that Billings Heights has developed a higher level of diversity in terms of residential and commercial land use, whereas Lockwood has a land use mix with a higher proportion of residential uses. Thus, one component of the traffic projections involves redistribution of trips between Lockwood and the west end of Billings to the Billings Heights commercial areas, since a new connection would reduce travel times for commercial trip purposes.

Data from the previous O-D study was used to determine external-external traffic, including commercial (truck) traffic that would use the new arterial route. In addition, the new arterial route would have an impact on traffic that currently uses the Huntley I-94 interchange to connect the residential developments and small communities northeast of the project site along Old Highway 312. Travel times savings associated with the new alignment would divert a portion of the traffic that currently uses the Huntley Interchange and traffic flow on a portion of Highway 312 would be reversed, thus reducing traffic on I-94 and I-90 east of the Johnson Lane Interchange.

An analysis of travel times was completed for the alternative alignments based upon average travel speeds along route segments and average intersection delays using the average HCM delays associated with existing intersection movement levels-of-service (LOS). It was determined that the areas of Billings for which the new alternative alignments would reduce travel time are Billings Heights East & West, Outlying North, Outlying Northeast, and the West End Commercial Areas. It was determined that none of the alternative alignments would reduce travel time to and from the CBD, Central Billings, or large areas of the Billings West end that are not immediately adjacent to I-90.

The data from this study was used to develop travel time contour mapping in order to delineate the specific areas of Billings Heights and Lockwood that would experience a travel time advantage by using each Bypass alternative. Demographic data within these smaller areas combined with the percentage of external trips on each route was used to determine the number of trips to and from each area for each alternative alignment. Table 4 presents the land use growth projections, extracted from the 2009 Update to the Billings Area Urban Transportation Plan, that were used to project growth within the travel time contour areas.

Table 4. Project Specific Demographic Areas - Years 2002 to 2035 From 2009 Plan Update

	Yea	Year 2002 Year 3035			2035 - 2002 Difference		
ZONE NAME	D U s	Employment	D U s	Employment	DUs	Employment	
Outlying North	834	20	3000	500	2166	480	
Heights West	5957	2988	10457	5488	4500	2500	
West End	6074	4264	8574	11764	2500	7500	
Outlying Northeast	356	111	476	361	120	250	
Lockwood	1717	2011	2917	3511	1200	1500	
Heights East	2040	265	3640	1015	1600	750	
Totals =	16978	9659	29064	22639	12086	12980	
Population Estimates	42445		72660		30215		



The zones listed in Table 4 are associated with distinct areas contained in the Billings Urban Area Transportation plan. The Outlying North area is a large area that is north of the US 87/Old HWY 312 intersection and straddles US 87. The Outlying Northeast area encompasses land the fans out from the US 87/Old Hwy 312 intersection and it bisected by Old Hwy 312. The Height East and West areas encompass the developed areas of Billings Heights that are located on either side of Main Street. The Lockwood area encompasses all of the land south of the Yellowstone River between the Lockwood Interchange and Pinehills (including the Pinehills Community). The West End area encompasses a large area of land that includes residential and commercial developments within the western portion of Billings' City Limits.

NO-BUILD ALTERNATIVE SYSTEM IMPACTS

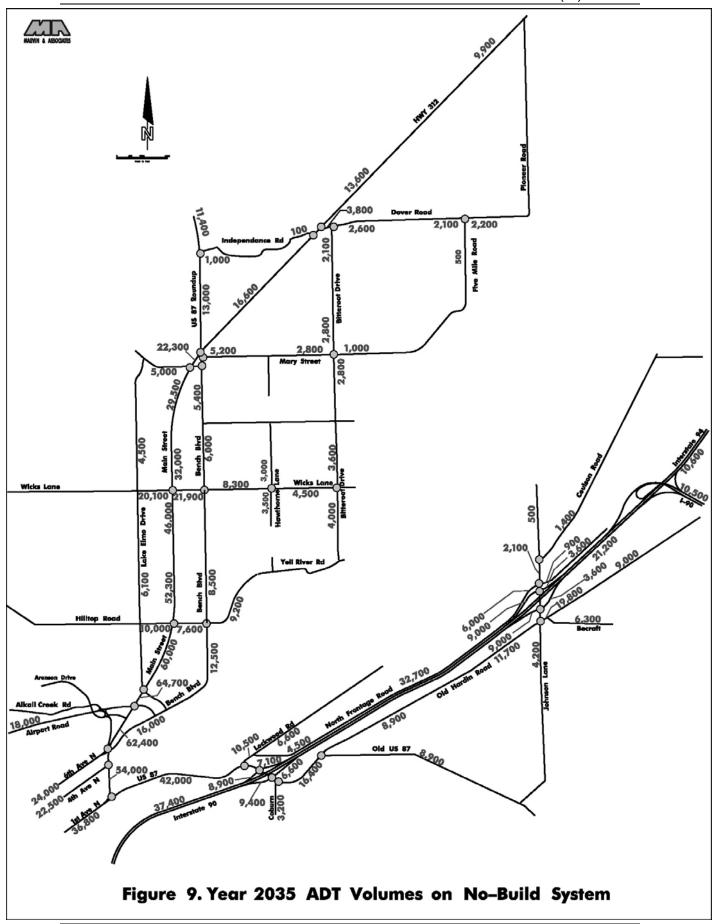
This section of the study report deals with year 2035 traffic projections and resultant traffic operations that could be expected on the existing plus committed (E+C) street system, if this project were not built. The existing system consists of the streets and roadways indicated in Figure 1 and as described in subsequent narratives. The committed system consists of the projects described in the "Committed Future Projects" section of this report.

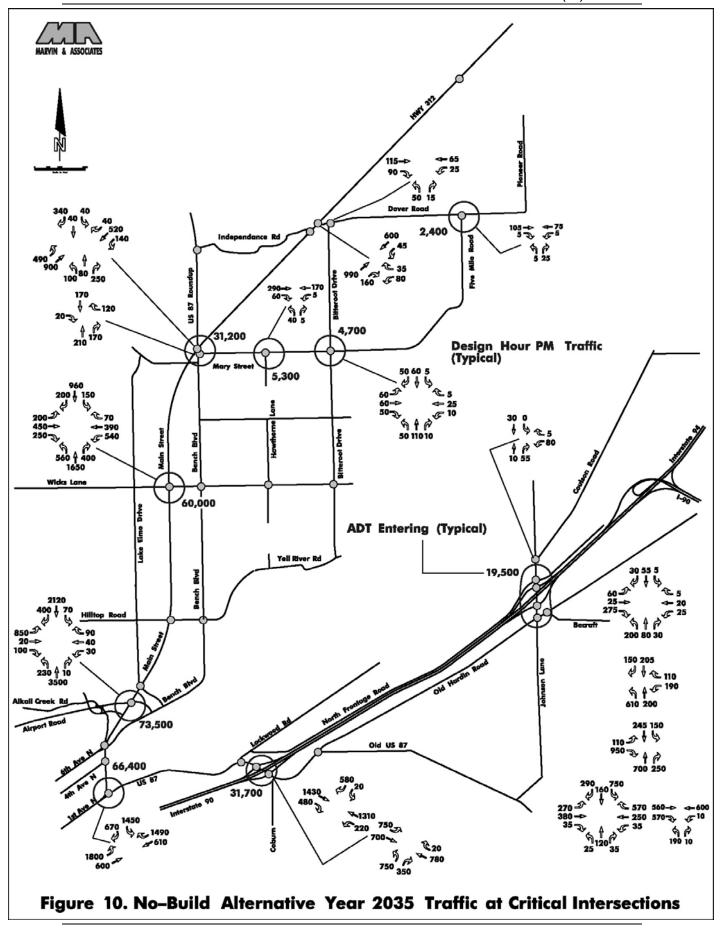
Traffic Volume Projections

Figure 9 presents a summary of year 2035 ADT volumes on the study's road and street system. Traffic projections were based upon the relative land use changes described in the "Future Traffic Projections" section of this report and by calculating future traffic volumes using historic records on facilities with a substantial volume of traffic external to the study area, such as the Interstate roadway system. It was determined that the majority of roadways would have ADT increases of approximately 50% in excess of the current year 2010. Committed projects, such as the Bench Boulevard – 6th Avenue North grade separation and Bench Boulevard reconstruction projects, were also factored into the estimates. The Inner Belt-loop project would result in reduced traffic on Wicks Lane west of Main Street and on Airport Road. In addition, the Inner Belt-loop Road would also reduce the overall traffic demand on US 87 north of Main Street, when local streets are constructed in a configuration that would encourage use of the Belt-loop.

Figure 10 presents the No-build Alternative year 2035 PM design hour traffic volumes at critical intersections along the E+C street system. These volumes reflect the ADT traffic growth based on existing peak hour traffic counts and redistribution of traffic due to land use changes and committed project influences. The peak hour volumes shown in Figure 10 represent the baseline conditions used for alternative alignment projections and are used in capacity calculations to determine measures of effectiveness (MOEs) and crash projections.







Capacity and Level of Service

Capacity calculations along existing roads and streets were completed for the No-Build system based upon the year 2035 traffic at critical intersections illustrated in Figure 10. In addition, capacity analysis was performed on three sections of Interstate-90 and on all ramps at the Lockwood and the Johnson Lane Interchanges. All I-90 freeway segments and interchange ramps would still operate at LOS "C" or better in the year 2035. The capacity analysis calculations for each location can be found in Appendix C of this report.

Table 5 presents a summary of level-of-service (LOS) and delay (sec/vehicle) for each intersection approach. Only one of the 17 intersections would have all approaches that operate at LOS "C" or better. Ten of the intersections would have at least one approach that would operate at LOS "F". It should be noted that the eastbound approach to the US 87/HWY 312/Main/Bench intersection would only operate at LOS "F" when pedestrian crossings occur, which is currently a rare occurrence.

Table 5. No-Build Alternative (2035) Intersection Capacity Summary

		Inte	ersectio	n Appro	ach				
N	_	S	SB			W	/B		
LOS	Delay (s/v)	LOS	Delay (s/v)	LOS	Delay (s/v)	LOS	Delay (s/v)		
F	194					В	13		
В	12					Α	8		
Α	9					Α	8		
С	19	В	13	Α	7	Α	8		
В	14					Α	8		
В	18	В	18	F	110	D	40		
F	115	D	40	F	148	F	116		
F	175	D	45	F	109	F	148		
		D	42	F	100	F	203		
		F	209	F	101	С	26		
F	157			F	222	D	43		
F	89	F	357	D	37				
В	12					F	2421		
Α	8	Α	8	С	16	D	35		
		Α	8			Α	10		
F	137	D	44	D	40	D	54		
F	1141					В	14		
	LOS F B A C B F F F F A	F 194 B 12 A 9 C 19 B 14 B 18 F 115 F 175 F 157 F 89 B 12 A 8	NB S Delay (s/v) LOS F 194 B 12 A 9 C 19 B 14 B 18 B 15 D 175 D F F 157 F 89 B 12 A 8 A A F 137 D D	NB SB Delay (s/v) Delay (s/v) F 194 B 12 A 9 C 19 B 14 B 18 D 40 F 175 D 42 F 209 F 157 F 89 F 357 B 12 A 8 A 8 A 8 F 137 D 44	NB SB E Delay (s/v) Los (s/v) Los F 194 Image: square squ	Delay (s/v) Delay (s/v)	NB SB EB W Delay (s/v) Delay (s/v) Delay (s/v) Los F 194 B B B 12 A A A 9 A A A C 19 B 13 A 7 A B 14 A A A A B 14 B B F 110 D F 115 D 40 F 148 F F 175 D 45 F 109 F F 175 D 42 F 100 F F 209 F 101 C C F 89 F 357 D 37 F B 12 F 4 A A A F 137 D 44 D 40 D </th		

= LOS D & E



= LOS F

Crash Projections

Table 6 represents a projection of future crash statistics that would be associated with the No-Build alternative if current crash and severity rates were applicable in the design year 2035. It is recognized that a number of improvements could be made to the existing system during the next 24 years and there are a number of driver and vehicle variables that could occur during that period of time, however existing baseline conditions extrapolated into future conditions provides a common baseline in comparisons between the No-Build and the project alignment conditions. The values shown in Table 6 represent the best estimates that can be made given the limitations of available information and uncertain future conditions.

Table 6. No-build Alternative Crash Projections on Existing Road & Street System Year 2035

EXISTING STREET LINK SEGMENTS					Annual Crash Projections				
		to	Length	2035 ADT	No.	Injury	No.	Fatal	No.
			(miles)		Crash	Crash	Inury	Crash	Fatals
Interstate 94	Pinehill Interchange	Huntley Interchange	6.21	10600	23.6	5.4	6.9	0.0	0.0
Interstate 90	Johnson Lane	Lockwood	1.27	32700	22.2	6.0	9.6	0.0	0.0
Interstate 90	Pinehill Interchange	Johnson Lane	2.45	21200	2.1	0.3	0.3	0.0	0.0
Johnson Lane	I-90 Interchange	Coulson Road	0.29	6900	6.0	0.9	1.5	0.0	0.0
Johnson Lane	Old Hardin Road	I-90 Interchange	0.17	18000	3.0	0.6	1.5	0.0	0.0
(Old US 87)	Lockwood Interchange	Jct Old Hardin Road	0.58	16400	5.1	2.4	4.5	0.0	0.0
Highway 87	I-90 Lockwood Interchng	1st Avenue N	1.25	42000	53.8	15.3	22.3	0.0	0.0
Main Street	1st Avenue N	6th Avenue N	0.35	54000	40.1	12.4	17.9	0.0	0.0
Main Street	6th Avenue N	Airport Road	0.37	62400	27.5	8.7	14.4	0.0	0.0
Main Street	Airport Road	Hilltop Road	0.64	62400	83.0	28.5	46.1	0.0	0.0
Main Street	Hilltop Road	Wicks Lane	1.02	49100	81.4	30.9	47.7	0.6	0.6
Main Street	Wicks Lane	HWY 312/Bench	1.00	30700	46.4	9.9	0.0	0.0	0.0
Highway 87	HWY 312/Bench	Independence Road	0.96	13000	15.7	3.6	5.8	0.0	0.0
Wicks Lane	Lake Elmo	Main Street	0.24	21000	5.3	1.1	1.1	0.0	0.0
Wicks Lane	Main Street	Bench Boulevard	0.24	21900	13.1	4.7	5.5	0.0	0.0
Wicks Lane	Bench Boulevard	Bitterroot Drive	1.00	6400	15.1	2.7	4.1	0.0	0.0
Mary Street	Bench Boulevard	Five Mile Road	1.67	4500	5.4	0.0	0.0	0.0	0.0
Highway 312	US 87 (N16)	Dover Road	1.32	16600	6.2	0.9	0.9	0.3	0.3
Highway 312	Dover Road	Pioneer Road	2.20	13600	19.5	8.0	11.9	0.4	0.4
Highway 312	Pioneer Road	S-522 Huntley	5.43	9000	28.8	11.4	18.9	0.3	0.3
Bench Boulevard	Wicks Lane U-1012	US 87 (N16)	1.03	5800	24.0	8.4	10.8	0.0	0.0
Dover Road	HWY 312 CO56788	Pioneer Road	1.56	2300	2.3	0.4	0.4	0.0	0.0
Bitterroot Drive	Wicks (U-1012)	Mary Street	1.00	4000	10.5	1.8	3.1	0.0	0.0
Bitterroot Drive	Mary Street	Dover Road	0.96	2500	0.0	0.0	0.0	0.0	0.0
5 Mile Road	Mary Street	Dover Road	0.65	500	0.7	0.7	0.7	0.0	0.0
Pioneer Road	Dover Road	HWY 312 CO56788	1.50	400	2.0	1.2	1.2	0.0	0.0
Huntley Main Street	I-94 Huntley Interchange	CO56788 (HWY 312)	2.37	5500	8.6	4.2	4.8	0.0	0.0
Totals =			37.7	19756	551.3	170.3	241.8	1.6	1.6
				Avg					

To compare the projected crash statistics in Table 6 to the existing conditions in Table 3, they must be converted to an annual rate. Thus, the existing number of crashes (1,539) on the road and street system is divided by five (years) to arrive at 307.8 annual average crashes. Year 2035 No-build projections in Table 6 are 443.4, or approximately 135 more crashes per year than on the existing system. Similar increases in the number of injury crashes, number of injuries, and number of fatalities would increase in a similar manner, since existing crash rates and



severity rates were used to project future statistics. The only variable that would change in the year 2035 would be the traffic volumes on each street segment.

BUILD ALTERNATIVE ALIGNMENTS' SYSTEM IMPACTS

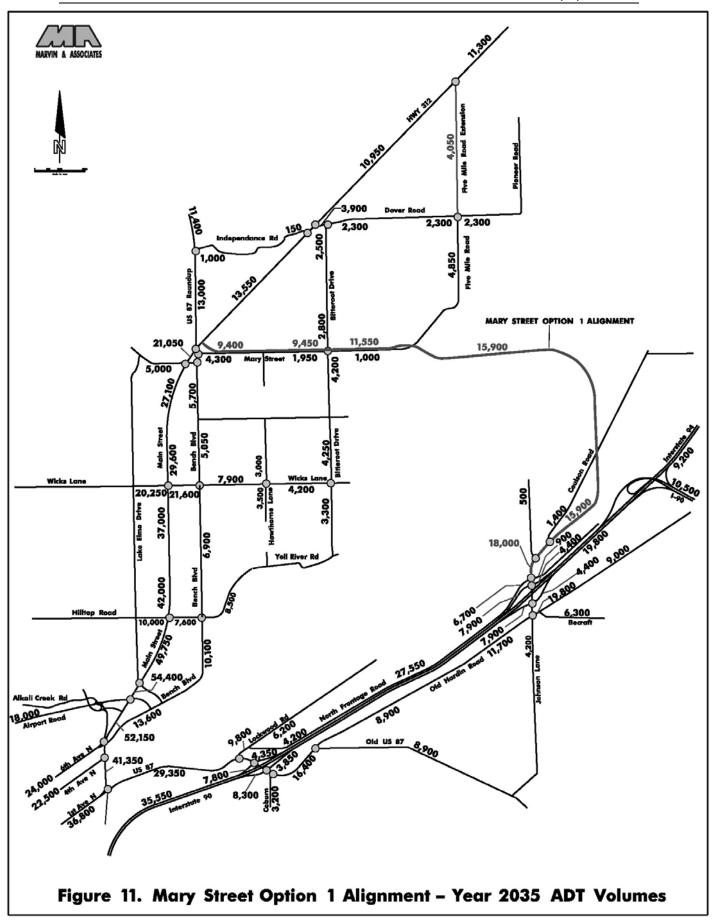
This section of the traffic study report presents the traffic volume projections for the three alternative alignments carried forward in the EIS. Year 2035 capacity and LOS for the existing system roads and streets are summarized. Crash projections for each alternative alignment are calculated in a similar manner as completed for the No-build alternative and comparisons between all alternatives are made. Individual intersections along the new alignments are not addressed within this section. Subsequent report sections address individual intersection design recommendations. At some of the alignment intersections, there are a number of design options that would provide acceptable operations for year 2035 conditions, and each option is evaluated and summarized.

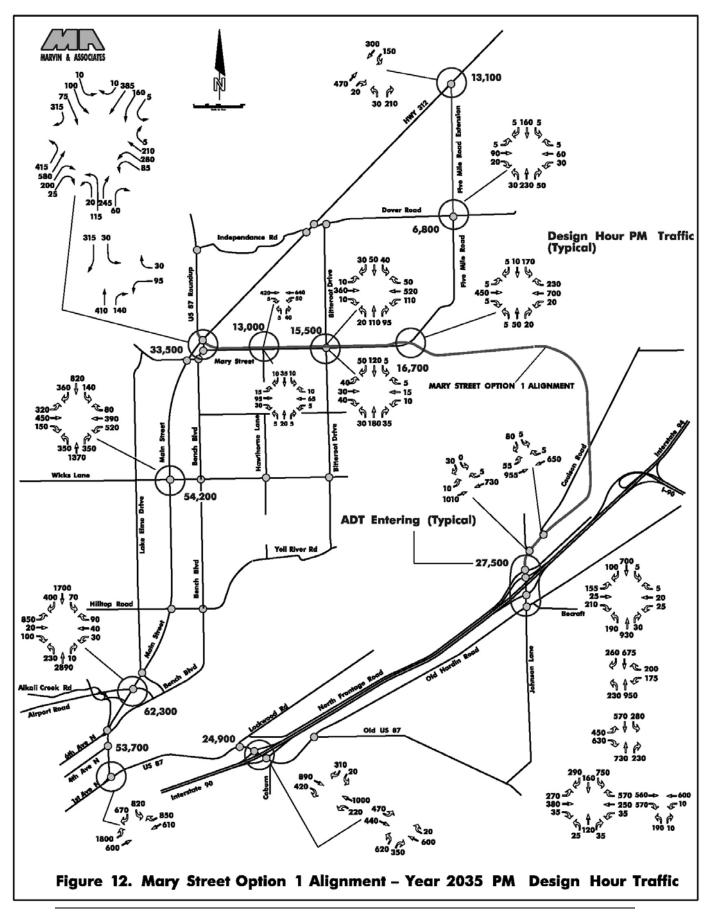
Year 2035 Alternative Alignment Traffic Projections

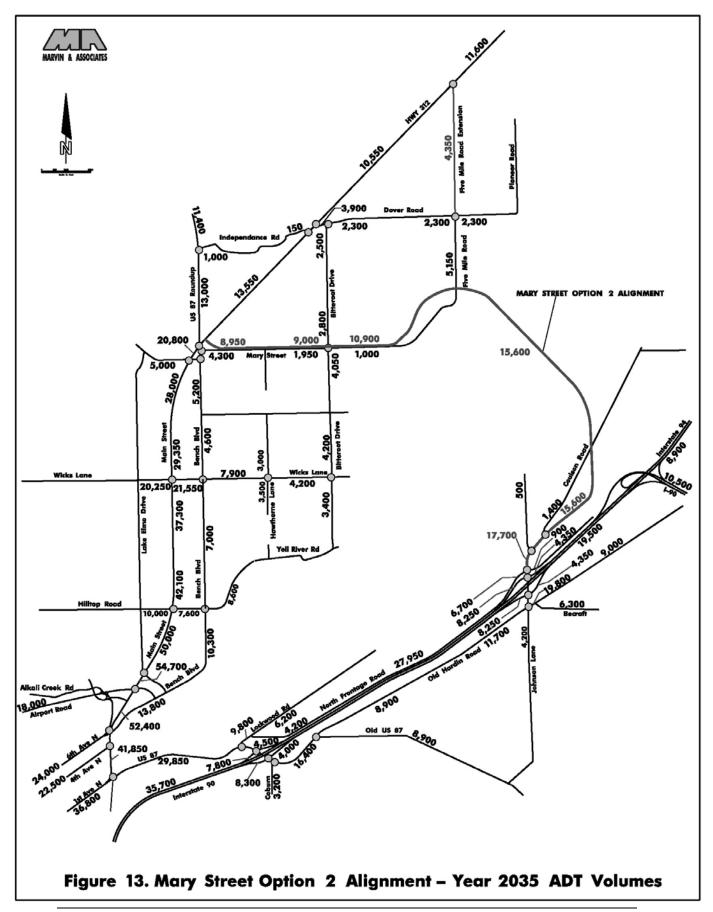
Traffic projection methodologies (previously detailed) were utilized for each of the alternative alignments. Initial traffic projections revealed that traffic demand from and to various areas of Billings Heights would result in substantial traffic demand on connecting roadways. In particular, Pioneer Road would have significant traffic increases due to reduced travel times from outlying northeast areas along Old Highway 312 and redistribution of I-94 Huntley Interchange traffic. This condition was found to exist for both of the Mary Street alignments. Since it was determined that there were a number of conditions on Pioneer Road, such as: multiple approach legs at Old Highway 312; a 90 degree curve between Pioneer Road and Dover Road; an elementary school complex located within the curve area; and substandard roadway geometrics, it was evident that impact mitigation on Pioneer Road would be very difficult. Traffic projections determined that an extension of the Five Mile Road alignment would better serve outlying northeast travel demand than Pioneer Road. Traffic demand to and from the Billings Heights and Outlying North areas would also use the existing Mary Street corridor to access the new river crossing associated with the Five Mile Road alternative. In that case, improvements would also be needed to Mary Street as a part of the Five Mile alignment implementation. The screening process led to the conclusion that each of the three alignments would require additional secondary improvements. An extension of Five Mile Road to Old Highway 312 from Dover Road would be necessary for both of the Mary Street Alignment alternatives, and the Five Mile Alignment alternative would require reconstruction of Mary Street.

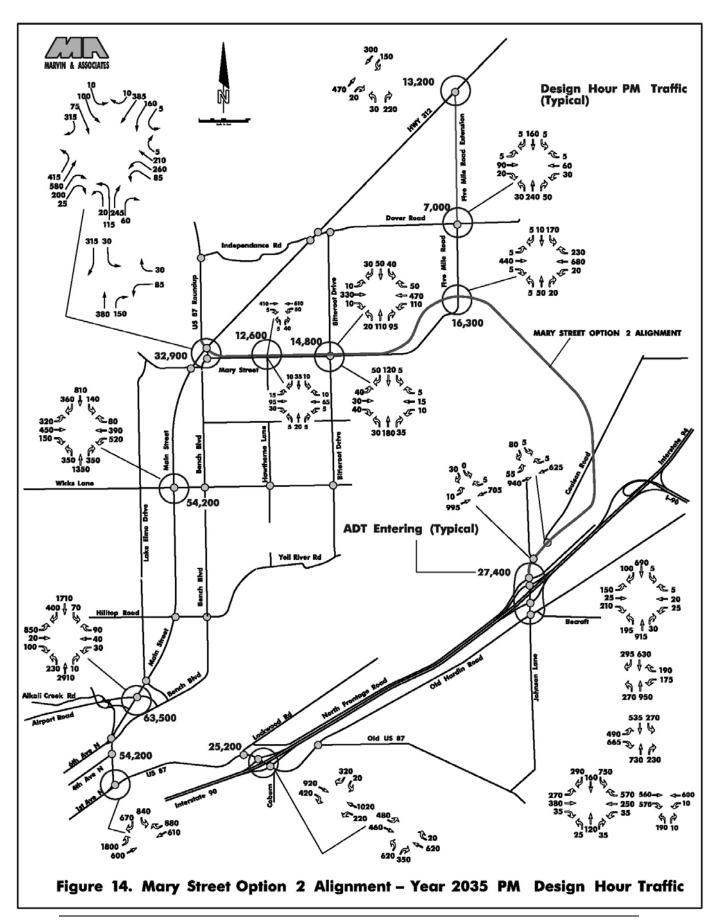
The traffic model was revised to include the Five Mile Road connection for both of the Mary Street Alignments and to reflect improved geometry on Mary Street as a part of the Five Mile Road Alignment alternative. Figures 11 through 16, on the following pages, present a summary of year 2035 ADT and PM design hour traffic volumes on the existing system and at proposed intersections along each alternative alignment. Comparisons between No-Build ADT and alternative alignment ADT indicate that substantial traffic reductions on Main Street, US 87 between Main Street and I-90, and on I-90 could be realized.

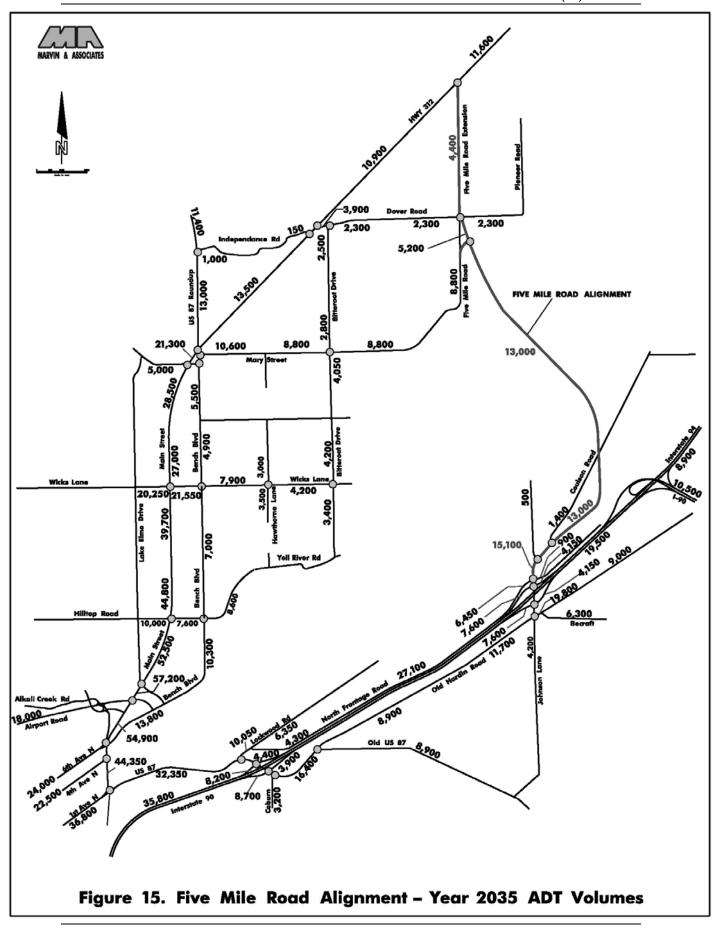


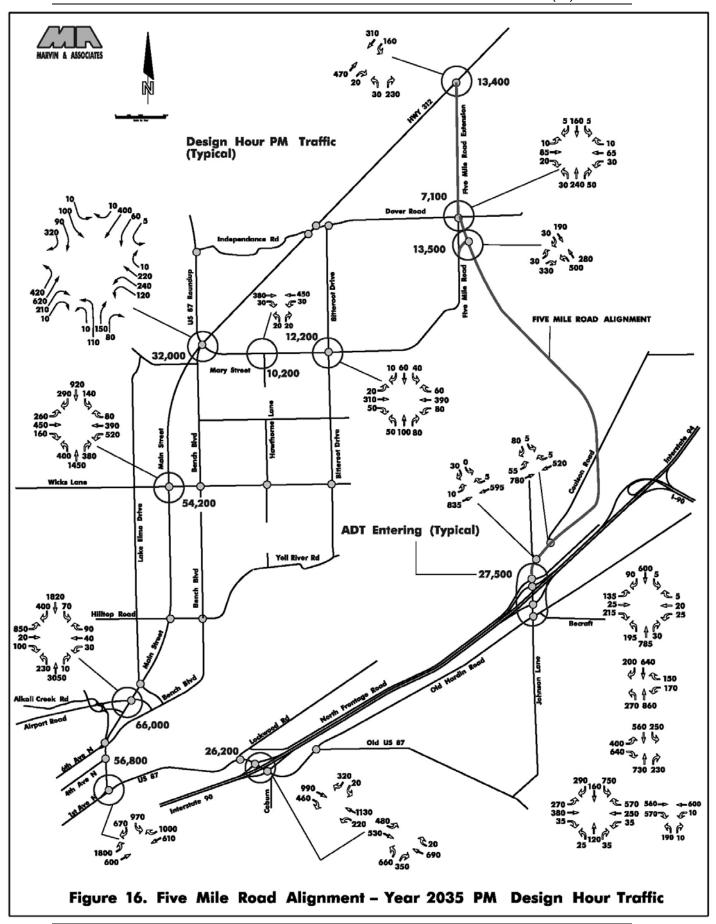












Year 2035 Alternative Alignments Vehicle Miles Travel

Table 7 presents a summary of vehicle miles travel (VMT) for each of the alternative alignments, including the No-Build alternative. VMT are based on ADTs projected for each alternative route segment. The No-Build alternative would experience approximately 667,000 VMT in the year 2035, while each of the Build alternative alignments would have higher VMT totals. The reason why the alternative alignments have a higher VMT is because the alternative alignments have shorter travel times and while there are more miles traveled, the overall vehicle hours of travel (VHT) are less.

It is important to note that the Mary Street Option 1 Alignment would have the highest ADT, but the total VMT for that alternative would be less than the Five Mile Road Alignment. The smallest increase in VMT would be for Mary Street Option 2 Alignment with approximately 3,500 VMT more than the No-Build alternative.

The most significant values shown in Table 7 are the VMT savings on Main Street, US 87, and on I-90. Comparing the No-Build Alternative on the Main Street corridor south of Wicks Lane with the Mary Option 1 Alignment, an approximate savings of 25,000 VMT on an average daily basis could be realized. The segment of US 87 between Main Street and the Lockwood Interchange would save 16,000 VMT. Both of these corridors would be highly congested, whereas the new alignment corridors would be relatively free-flow conditions.

It has been determined that the average travel time savings for all traffic that would use the alternative alignments ranges between 4 and 6 minutes. If an average travel time savings of 5 minutes was applied to year 2035 traffic projections for the alternative alignments, the approximate travel time savings for each of the alignments would be:

Mary Street Option 1 Alignment	480,000 VHT Saving
Mary Street Option 2 Alignment	475,000 VHT Savings
Five Mile Road Alignment	395,000 VHT Saving

The above noted VHT savings is significant when the economic value of time is considered. Current federal guidelines value the cost of time in excess of thirteen dollars per hour. Even if a reduced value of ten dollars per hour was used, the annual travel time savings associated with the alternatives would be between four and five million dollars.



Table 7. Alternative Alignment Vehicle Miles Travel Comparison

	Li	nk	Existing	Length	Alterna	atives' Vel	nicle Miles	Travel
Route	From	То	ADT	Miles	No-Build	Mary 1	Mary 2	Five Mile
	US 87	Dover Road	10900	1.32	21912	17886	17886	17820
Highway 312	Dover Road	Five Mile Road	8700	1.47	17346	16097	15509	16023
	Five Mile Road	S-522 Huntley	6500	6.16	56056	64680	66528	66528
US 87 North	Highway 312	Independence Lane	5900	0.96	12480	12480	12480	12480
	1st Avenue N	4th/6th Avenues North	36100	0.32	17280	13232	13392	14192
	4th/6th Avenues North	Airport Road	49200	0.40	24960	20860	20960	21960
Main Street	Airport Road	Hilltop Road	42200	0.64	38400	31840	32000	33600
	Hilltop Road	Wicks Lane	35200	1.02	50184	40290	40494	43095
	Wicks Lane	US 87/312	19350	1.00	31300	28350	28650	27750
	US 87	Wicks Lane	2900	1.03	5871	5511	5047	5356
Bench Boulevard	Wicks Lane	Hilltop Road	4300	1.01	8585	6969	7070	7070
	Hilltop Road	Main Street	na	1.36	19380	16116	16388	16388
Bitterroot Drive	Dover Road	Mary Street	900	0.96	2400	2544	2544	2544
Ditterroot Drive	Mary Street	Wicks Lane	1800	1.00	3200	4250	4100	4100
Mary Street	Bench Boulevard	Bitterroot Drive	1450	1.00	4000	3100	3100	9700
mary otreet	Bitterroot Drive	5 Mile Road	500	1.15	1150	1150	1150	10120
5 Mile Road	Mary Street	Dover Road	100	0.65	325	3153	3348	5720
Dover Road	HWY 312	Bitterroot Drive	1600	0.08	304	312	312	312
Dovor Roda	Bitterroot Drive	5 Mile Road	1000	1.00	2400	2300	2300	2300
	Lake Elmo Road	Main Street	15500	0.24	4824	4860	4860	4860
Wicks Lane	Main Street	Bench Boulevard	15300	0.24	5256	5184	5172	5172
	Bench Boulevard	Bitteroot Drive	4100	1.00	6400	6050	6050	6050
Hilltop Road	Lake Elmo Road	Main Street	8900	0.24	2400	2400	2400	2400
	Main Street	Bench Boulevard	6400	0.24	1824	1824	1824	1824
Johnson Lane	Old Hardin Road	Johnson Interchange	12500	0.17	3196	3196	3196	3196
	Johnson Interchange	Coulson Road	1400	0.29	609	5220	5133	4379
US 87	Lockwood Interchange	Old Hardin Road	10900	0.58	9512	9512	9512	9512
	1st Avenue N/Main	Lockwood Interchange	28000	1.25	52500	36688	37313	40438
I-94	Huntley Interchange	Pinehill Interchange	7100	6.21	65826	57132	55269	55269
	S. 27th St. Interchange	Lockwood Interchange	24900	2.76	103224	98118	98532	98808
I-90	Lockwood Interchange	Johnson Ln Interchange	21800	1.27	41529	34989	35497	34417
	Johnson Ln Interchange	Pinehill Interchange	14100	2.45	51940	48510	47775	47775
	Highway 312	Bitterroot Drive	0	0.97	0	9118	0	0
Mary Street Option 1	Bitterroot Drive	Five Mile Road	0	0.65	0	7508	0	0
	Five Mile Road	Johnson Lane	0	3.08	0	48972	0	0
	Highway 312	Bitterroot Drive	0	0.97	0	0	8730	0
Mary Street Option 2	Bitterroot Drive	Five Mile Road	0	1.18	0	0	12862	0
	Five Mile Road	Johnson Lane	0	2.75	0	0	42900	0
	Highway 312	Dover Road	0	0.93	0	0	0	4092
Five Mile Road Align.	Dover Road	Five Mile/Mary	100	0.45	225	0	0	2340
	Five Mile/Mary	Johnson Lane	0	2.82	0	0	0	36660
	ADT = Average Daily Traffic Alor	ng Entire Link	Totals =		666798	670398	670281	674250

Differences between No-Build = 3600

3483 7

Year 2035 Alternative Alignment Capacity & LOS

Capacity calculations along existing roads and streets that have the most probable impacts were completed for the alternative alignments based upon year 2035 traffic at critical intersections illustrated in Figures 11 through 16. Capacity analysis was not performed on the three sections of Interstate-90 and the associated interchange ramps, since all of the alternative alignments would result in traffic volumes that would be lower than the No-Build alternative. Because all capacity calculations on I-90 and interchange ramps for the year 2035 No-Build alternative indicated that the LOS would be at "C" or better, it can be assumed that the alternative alignments' LOS would be measurably better than the No-



Build alternative. The capacity analysis calculations for each location can be found in the Appendix of this report.

Unlike the No-Build Alternative, there are only seven intersections on the existing system that would be impacted by the new alignments. The remaining intersections would be included as improvements integral to construction of the alternative alignments. Table 8 presents a LOS and delay (sec/vehicle) summary for each of the seven intersections associated with the Mary Street Option 1 Alignment alternatives. In comparing these intersections to the same intersections in Table 5 (No-Build alternative), it can be seen that the alternative alignment would provide significant improvements to the intersection of Main Street/1st Avenue N./US 87. That intersection would still operate at relatively acceptably LOS "C" – "D", whereas the No-Build alternative would have both EB and WB approaches operating at LOS "F". In a similar manner, the I-90 Lockwood Interchange EB and WB ramps would have substantial improvements over the No-Build Alternative LOS "F" operations.

Since there would be very minimal changes in total traffic volumes at the intersections along Dover Road, the No-Build capacity calculations would also apply to all of the new alternative alignments. It was assumed that the unacceptable LOS for the Dover Road approach to Old Highway 312, shown in Table 5, would require alternative traffic control features be built well in advance of the year 2035.

Table 8. Mary Street Option 1 Alignment - Existing Street System Capacity

		Inte	ersectio	n Appro	ach		
N	В	S	В	Е	В	W	/B
LOS	Delay (s/v)	LOS	Delay (s/v)	LOS	Delay (s/v)	LOS	Delay (s/v)
F	194					В	13
В	12					Α	8
F	105	D	45	D	45	F	100
F	81	C	34	F	93	F	177
		C	26	C	29	D	48
		С	29	С	29	В	16
D	54			D	43	Е	64
	LOS F B F F	EOS (s/v) F 194 B 12 F 105 F 81	NB S Delay LOS (s/v) LOS	NB SB Delay (s/v) LoS Delay (s/v) F 194 User (s/v) Delay (s/v) B 12 User (s/v) Delay (s/v) Delay (s/v) F 194 User (s/v) Delay (s/v)	NB SB E Delay (s/v) LOS (s/v) LOS F 194 B 12 F 105 D 45 D F 81 C 34 F C 26 C C 29 C	Delay (s/v) Delay (s/v) Delay (s/v) Delay (s/v) F 194 12 12 F 105 D 45 D 45 F 81 C 34 F 93 C 26 C 29 C 29 C 29	NB

* Minimal Difference from No-Build Alt.

= LOS D & E = LOS F

Table 9 is the capacity summary for the Mary Street Option 2 Alignment. In comparing this table to Table 8, it can be seen that there is very little if any difference in LOS or delay measures. Only minor changes in delay would be evident at most of the intersections since the differences in traffic volume reductions on the Main Street corridor are very minor in comparison to total traffic demand.



Table 9. Mary Street Option 2 Alignment - Existing Street System Capacity

			Inte	ersection	n Appro	ach		
	N	IB	S	В	E	В	W	/B
Intersection	LOS	Delay (s/v)	LOS	Delay (s/v)	LOS	Delay (s/v)	LOS	Delay (s/v)
Highway 312 & Dover*	F	194					В	13
Dover & Bitterroot*	В	12					Α	8
Main & Wicks Lane	F	100	D	45	D	45	F	100
Main & Airport Road	F	84	C	35	F	93	F	178
Main/1st Ave N/US 87			С	27	С	29	D	49
Lockwood US87/WB I-90 Ramps			С	30	С	30	В	17
Lockwood US87/EB I-90 Ramps	D	50			D	46	Е	68

^{*} Minimal Difference from No-Build Alt.

= LOS D & E = LOS F

Table 10 illustrates LOS and delay measures on the impacted system that is associated with the Five Mile Road Alignment alternative. It can be seen that there are some measurable differences between LOS and delay at a number of system intersections associated with this alternative and those indicated in Tables 8 and 9. The only substantial difference would be at the Main Street/1st Avenue N/US 87 intersection, where relatively acceptable levels of service would exist for the Mary Street alignments. The LOS would drop to "D" and "E" for traffic demand associated with the Five Mile Road Alignment alternative.

Table 10. Five Mile Road Alignment - Existing Street System Capacity

			Inte	ersection	n Appro	ach		
	N	В	S	В	E	В	W	В
		Delay		Delay		Delay		Delay
Intersection	LOS	(s/v)	LOS	(s/v)	LOS	(s/v)	LOS	(s/v)
Highway 312 & Dover*	F	194					В	13
Dover & Bitterroot*	В	12					Α	8
Main & Wicks Lane	F	95	D	42	Е	57	F	102
Main & Airport Road	F	111	С	33	F	93	F	178
Main/1st Ave N/US 87			D	35	D	37	Е	57
Lockwood US87/WB I-90 Ramps			С	30	С	30	В	17
Lockwood US87/EB I-90 Ramps	F	80			D	44	Е	64

^{*} Minimal Difference from No-Build Alt.





= LOS F

Crash Projections

Table 11 represents a projection of future crash statistics that would be associated with each of the Build alternative alignments if current crash and severity rates were applicable in the design year 2035. Crash and severity rates on the new alignments were estimated based upon historic crash data on similar facilities that were constructed using current design standards, including Old HWY 312 from US 87 to Five Mile Road and Airport Road. In order to provide a sense of the associated impacts, the No-Build crash projections are included in Table 11. Crash projections for the alternative alignment systems indicated in Table 11 are also subject to the same limitations associated with the no-build alternative. Thus, relative differences in the number and type of crashes are more significant than the total numbers.

The No-Build alternative is projected to have an annual total of 551 crashes on the impacted system, while the Mary Option 1 Alignment alternative would experience approximately 503 crashed. A reduction of 48 crashes would be projected on the alternative system even though there would be an additional 4.5 miles of roadway. The number of injuries and injury crash would have a similar proportion while the number of fatalities would remain at about the same level. Mary Street Option 2 Alignment alternative would be at about the same level as the Option 1 alternative and the Five Mile Alignment alternative would have higher crash rates, yet still substantially lower than the No-Build alternative. All of the alternative alignments would have safety benefits over the No-Build alternative by reducing exposure (traffic) on the existing streets and diverting traffic to newer, safer facilities.



Table 11. Alternative Alignments Annual Crash Projections on Existing Road & Street System Year 2035

	,			1	No Buil	No Build Projections	tions	r	-	Mary Alignment Opt.	ment Or	t. 1	-	Ma	ry Alignn	Mary Alignment Opt	2	Ĺ	ive Mile	Five Mile Road Alignment	nment	Γ
EXIS	EXISTING STREET LINK SEGMENTS		Length	2035	No.	Injury	Н	No.	\vdash	No. In	Injury N	Н		⊢	o. Injury	ry No.	No.	000	No.	Injury	No.	No.
ROUTE NAME	from	to	(miles)	_	Crash	Crash	Inuny	atals	ADT	Crash Cr	Crash	lnury Fat	Fatals ADT	T Crash	sh Crash	sh Inury	_	ADT	Crash	Crash	Inuny	Fatals
Interstate 94	Pinehill Interchange	Pinehill Interchange Huntley Interchange	6.21	10600	23.6	5.4	6.9	0.0	9200	20.5	4.7 6	6.0 0.9	0.0 8900	19.8	8 4.5	5.8	0.0	8900	19.8	4.5	5.8	0.0
Interstate 90	Johnson Lane	Lockwood	1.27	32700	22.2	6.0	9.6	0.0	27550	18.7	5.1 8	8.1 0	0.0 27950	50 19.0	.0 5.1	8.2	0.0	27100	18.4	5.0	8.0	0.0
Interstate 90	Pinehill Interchange	Johnson Lane	2.45	21200	2.1	0.3	0.3	0.0	19800	2.0	0.3	0.3	0.0 19500	00	9 0.3	0.3	0.0	19600	1.9	0.3	0.3	0.0
Johnson Lane	L90 Interchange	Coulson Road	0.29	0069	0.9	6.0	1.5	0.0	18000	15.7	2.3	3.9 0.	0.0 17700	15.4	4 2.3	3.8	0.0	15100	13.1	2.0	3.3	0.0
Johnson Lane	Old Hardin Road	I-90 Interchange	0.17	18000	3.0	9.0	1.5	0.0	18800	3.1	0.6	1.6 0.	0.0 18800	3.1	1 0.6	1.6	0.0	18800	3.1	9.0	1.6	0.0
(OIQ US 87)	Lockwood Interchan	Lockwood Interchang Jct Old Hardin Road	0.58	16400	5.1	2.4	4.5	0.0	16400	5.1	2.4 4	4.5 0	0.0 16400	00 5.1	1 2.4	4.5	0.0	16400	5.1	2.4	4.5	0.0
Highway 87	L90 Lockwood Inter	1st Avenue N	1.25	42000	53.8	15.3	22.3	0.0	29350	37.6	10.7	15.6 0.	0.0 29850	50 38.	2 10.9	9 15.8	0.0	32350	41.4	11.8	17.2	0.0
Main Street	1st Avenue N	6th Avenue N	0.35	54000	40.1	12.4	17.9	0.0	41350	30.7	9.5	13.7 0	0.0 41850	50 31.1	1 9.6	13.8	0.0	44350	33.0	10.2	14.7	0.0
Main Street	6th Avenue N	Airport Road	0.37	00	27.5	8.7	14.4	0.0	52150	23.0 7			0.0 52400	00 23.1		12.1	0.0	54900	24.2	7.7	12.7	0.0
Main Street	Airport Road	Hilltop Road	0.64	001	83.0	28.5	16.1	0.0	49750	66.1 2	22.7 36	36.7 0	0.0 50000	00 66.	.5 22.8	8 36.9	0.0	52500	8.69	24.0	38.8	0.0
Main Street	Hilltop Road	Wicks Lane	1.02	49100	81.4	30.9	47.7	9.0	39500	65.5	24.8 38	38.4 0	0.5 39700	00 65.8	.8 25.0	0 38.6	0.5	42250	70.0	26.6	41.0	0.5
Main Street	Wicks Lane	HWY 312/Bench	1.00	30700	46.4	9.9	0.0	0.0	28350	42.9	9.1 0	0.0	0.0 28650	50 43.3	.3 9.2	0.0	0.0	27750	42.0	6.8	0.0	0.0
Highway 87	HWY 312/Bench	Independence Road	0.96	13000	15.7	3.6	5.8	0.0	13000	15.7	3.6 5	5.8 0.	0.0 13000		3.6	5.8	0.0	13000	15.7	3.6	5.8	0.0
Wicks Lane	Lake Elmo	Main Street	0.24	21000	5.3	1.1	1.1	0.0	20250	5.1	1.1	1.1 0	0.0 20250	50 5.1	1.1	1.1	0.0	20250	5.1	1.1	1.1	0.0
Wicks Lane	Main Street	Bench Boulevard	0.24	21900	13.1	4.7	5.5	0.0	21600	13.0	4.6 5	5.5 0	0.0 21550	50 12.9	9 4.6	5.5	0.0	21550	12.9	4.6	5.5	0.0
Wicks Lane	Bench Boulevard	Bitterroot Drive	1.00	6400	15.1	2.7	4.1	0.0	6050	14.3	2.6 3	3.9 0.	0.0 6050	14.3	.3 2.6	3.9	0.0	6050	14.3	2.6	3.9	0.0
Mary Street	Bench Boulevard	Five Mile Road	1.67	4500	5.4	0.0	0.0	0.0	2050	2.5	0.0	0.0	0.0 2050	50 2.5	5 0.0	0.0	0.0	9250	11.1	0.0	0.0	0.0
Highway 312	US 87 (N16)	Dover Road	1.32	16600	6.2	6.0	6.0	0.3	13550	5.1	0.8 0	0.8	0.3 13550	50 5.1	1 0.8	8.0.8	0.3	13500	5.0	8.0	8.0	0.3
Highway 312	Dover Road	Pioneer Road	2.20	13600	19.5	8.0	11.9	9.0	10950	15.7	6.5	9.6	0.3 10550	50 15.2	.2 6.2	9.2	0.3	10900	15.7	6.4	9.5	0.3
Highway 312	Pioneer Road	S-522 Huntley	5.43	9000	28.8	11.4	18.9	0.3	10500	33.6	13.3 22	22.1 0	0.4 10800	34.6	.6 13.7	7 22.7	0.4	10800	34.6	13.7	22.7	0.4
Bench Bld	Wicks Lane U-1012 US 87 (N16)	US 87 (N16)	1.03	5800	24.0	8.4	10.8	0.0	5350	22.1	7.7 10	10.0	0.0 4900	20.3	.3 7.1	9.1	0.0	5200	21.5	7.5	9.7	0.0
Dover Road	HWY 312 CO56788 Pioneer Road	Pioneer Road	1.56	2300	2.3	9.0	0.4	0.0	3100	3.1	0.5 0	0.5 0.	0.0 3100	3.1	1 0.5	9.0	0.0	3100	3.1	0.5	9.0	0.0
Bitterroot Drive	Wicks (U-1012)	Mary Street	1.00	4000	10.5	1.8	3.1	0.0	4250	11.1	2.0 3	3.3 0.	0.0 4100	10.7	7. 1.9	3.2	0.0	4100	10.7	1.9	3.2	0.0
Bitterroot Drive	Mary Street	Dover Road	0.96	2500	0.0	0.0	0.0	0.0	2650	0.0	0.0	0.0	0.0 2650	0.0	0.0	0.0	0.0	2650	0.0	0.0	0.0	0.0
5 Mile Road	Mary Street	Dover Road	0.65	200	0.7	0.7	0.7	0.0	4850	3.2	3.2 3	3.2 0.	0.0 5150	3.4	4 3.4	3.4	0.0	0	0.0	0.0	0.0	0.0
Pioneer Road	Dover Road	HWY 312 CO56788	1.50	400	2.0	1.2	1.2	0.0	400	2.0	1.2	1.2 0.	0.0 400	0 2.0	0 1.2	1.2	0.0	400	2.0	1.2	1.2	0.0
Huntley Main St	L94 Huntley Inter	CO56788 (HWY 312	2.37	5500	8.6	4.2	4.8	0.0	4800	7.5	3.6	4.2 0.	0.0 4200	9.9 0.0	6 3.2	3.6	0.0	4200	9.9	3.2	3.6	0.0
	Highway 312	Bitterroot Drive	0.97						9400	2.6	0.4 0	0.5 0.	0.1									
Mary St Opt 1	Bitterroot Drive	Five Mile Road	0.65						11550	2.1	0.3 0	0.4 0	0.0		_							
	Five Mile Road	Johnson Lane	3.08						15900	13.9	2.1 2	2.8 0.	0.3									
	Highway 312	Bitterroot Drive	0.97		Ī								8	9000 2.5	5 0.4	0.5	0.0					
Mary St Opt 2	Bitterroot Drive	Five Mile Road	1.18										ě	10900 3.6	6 0.5	0.7	0.1					
	Five Mile Road	Johnson Lane	2.75										15(15600 12.1	1.8	2.4	0.2					
	Highway 312	Dover Road	0.93											4	-			4400	1.2	0.2	0.2	0.0
5 Mile Rd Align	Dover Road	Five Mile/Mary	0.45															5200	2.0	1.0	0.1	0.0
	Five Mile/Mary	Johnson Lane	2.82											-				13000	10.4	1.6	2.1	0.2
	Totals =		51.53	19756	551.3	170.3	241.8	1.6	Τ	503.3 15	152.9 21	215.4 1	1.7 17556		501.9 152.6	.6 215.0	1.7	17961	512.3	152.7	217.5	1.6
				Avg				ľ	Avg				Avg	6				Avg				



ALTERNATIVE ALIGNMENT INTERSECTIONS

This section of the report deals with intersections located along each of the three alternative alignments. The intersection design concepts presented herein were evaluated by the project team and it was determined that the intersection geometry and operational characteristics would be appropriate for the anticipated traffic demand. While various design options may be considered in final design, the basic geometry and controls proposed herein will be carried through into the final EIS. All capacity calculations for the intersections presented in this section of the report can be found in Appendix G.

Johnson Lane/Coulson Road Intersections

All of the alternative alignments would intersect Coulson Road and Johnson Lane at the same location. Figure 17 Illustrates the proposed geometry associated with the intersection of Coulson Road and Johnson Lane with the alternatives' alignment. The Johnson Lane intersection with the new alignment would be a "T"-intersection on the outside of a curve. Sufficient intersection sight distance would be available for the Johnson Lane approach to the new alignment. Sufficient storage would be available for the Johnson Lane approach and an existing railroad crossing north of the new intersection.

Coulson Road would curve into the intersection with the new arterial road alignment at a location opposite an existing commercial access road on the south side of Coulson Road. The Coulson Road approach would have a left-turn lane and a right/thru lane at the intersection. The existing section of Coulson Road would be obliterated between that intersection and the current intersection with Johnson Lane.

Capacity calculations (Appendix G) indicate that all approaches at these intersections would operate at LOS "B" or better in the year 2035. Adequate intersection sight distance and left-turn bays for movements on the new arterial would provide the safety potential of these intersections to meet current design standards.





Mary Street Alignment Intersections

There are three intersections on the Mary Street Alignments that are detailed within this section of the report. Mary Street Options 1 & 2 Alignments intersect with Five Mile Road at two different locations, but both Mary Street Alignments intersect Hawthorne Lane at the same location, and thus, both alignments are covered by the same concept design.

Option 1 & Five Mile Road

Figure 18 illustrates the proposed design geometry and operational controls for the intersection of Mary Street Option 1 Alignment and the existing Mary Street/Five Mile Road corridor. A signalized intersection alternative was investigated at this location, however it was determined that a roundabout intersection would be more adaptable to the numerous driveway and roadway approaches that exist within the operational area of influence of this intersection.

The year 2035 typical section of the Mary Street Option 1 Alignment would have two through lanes in each direction and the roundabout would perpetuate the thru-lanes through the intersection. The Mary Street (Frontage Road) approach would serve a minor volume of traffic only requiring a single lane approach. The Five Mile Road approach would have a higher volume of traffic, but a single lane approach would be sufficient for operations at this intersection. The two-lane facility to the north would be associated with secondary improvements to Five Mile Road, for which the typical sections indicate that a median section would apply. A simple two-lane approach is illustrated in Figure 18 to indicate that the existing bridge over Five Mile Creek could be utilized in the future.

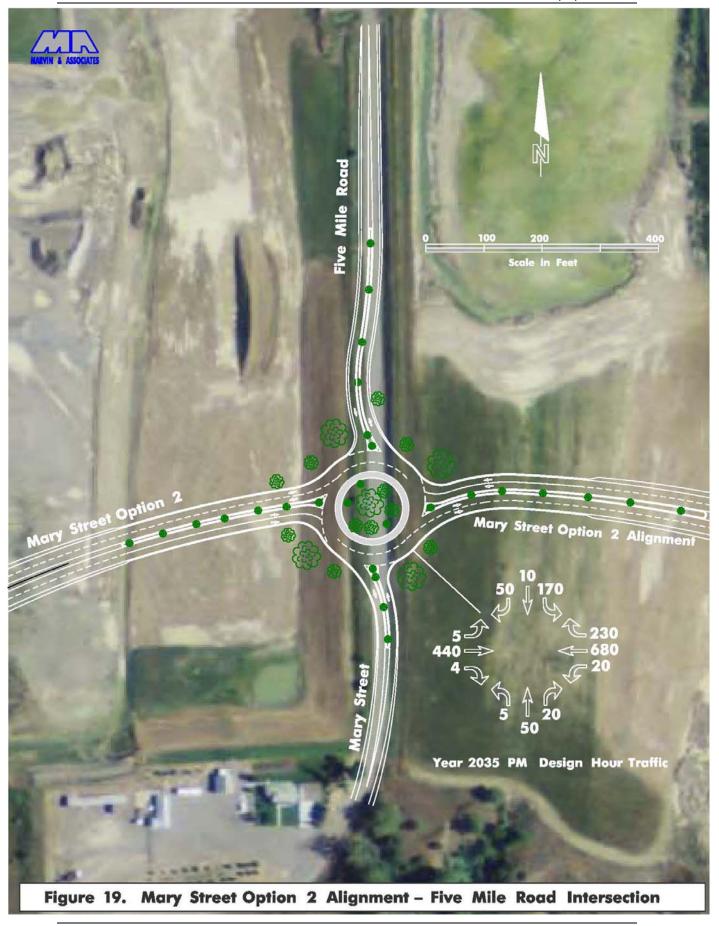
Capacity calculations (Appendix G) indicated that all approaches to this intersection would operate at a LOS "A" in the year 2035. The immediately adjacent approaches and intersections would be limited to right-in and right-out movements. However, the roundabout intersection would allow departures and arrivals from and to all approaches from all directions.

Option 2 & Five Mile Road

Figure 19 presents the intersection geometry and associated traffic control related to the Mary Street Option 2 Alignment intersection with Five Mile Road. This intersection would be located north of the existing Mary Street corridor and in the middle of a long sweeping curve along the Mary Street Option 2 Alignment. A traffic signal was evaluated at this location, and it was determined that even though sight distance would be adequate, the approach angles from the Mary Street northbound approach could create a situation where the drivers' judgment may be compromised. Even though this would not be an overwhelming consideration, there are no structures within the intersection area that would make it difficult to construct a roundabout, and the roundabout would have the benefit of slowing approach speeds enough to counter issues related to the curved approach on the Mary Street Option 2 Alignment.







Approach lane configurations would be similar to the assignments associated with Mary Street Option 1 Alignment design. Lane capacity calculations (Appendix G) indicate that all approaches would operate at LOS "A" in the design year 2035.

Options 1 & 2 & Hawthorne Lane

Both Mary Street Options 1 & 2 Alignments would be coincident at the Hawthorne Lane intersection. Thus, Figure 20 applies to both alternative alignments. Hawthorne Lane is currently a low volume, collector street approach at Mary Street. Hawthorne Lane is the only other north-south street, other than minor subdivision streets, that intersects the existing Mary Street corridor. A gated approach to an old gravel pit operation also intersects Mary Street from the north at this location. Figure 20 shows that a minor connection street between Mary Street and the Mary Street Alignment is proposed at this intersection. A raised median within the short connector street is proposed to ensure that vehicle approach angles are sharp enough to discourage higher speed short-cuts across opposing lanes.

Capacity Calculations (Appendix G) indicate that stop controls on the north-south approaches to both streets would be sufficient to ensure that all movements operate at LOS "B" or better in the year 2035.

Five Mile Road Alignment Intersections

There are four intersections related to the Five Mile Road Alignment. Only one of those intersections is related to the Five Mile Road Alignment geometry and the remaining three intersections involve secondary improvements on the existing Mary Street corridor necessary to accommodate the projected year 2035 traffic demands.

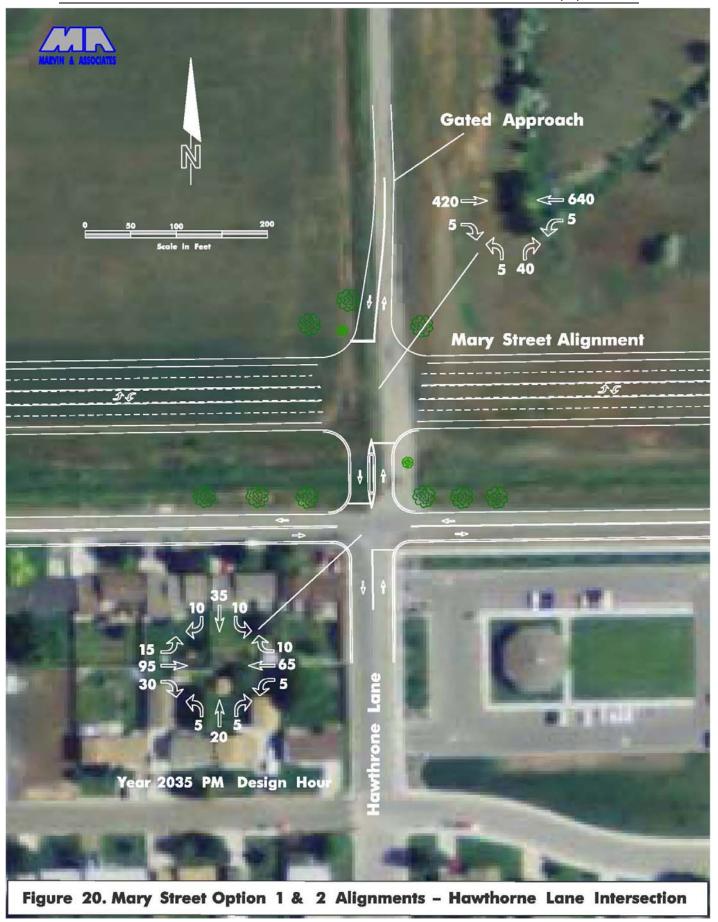
Five Mile Road and Mary Street

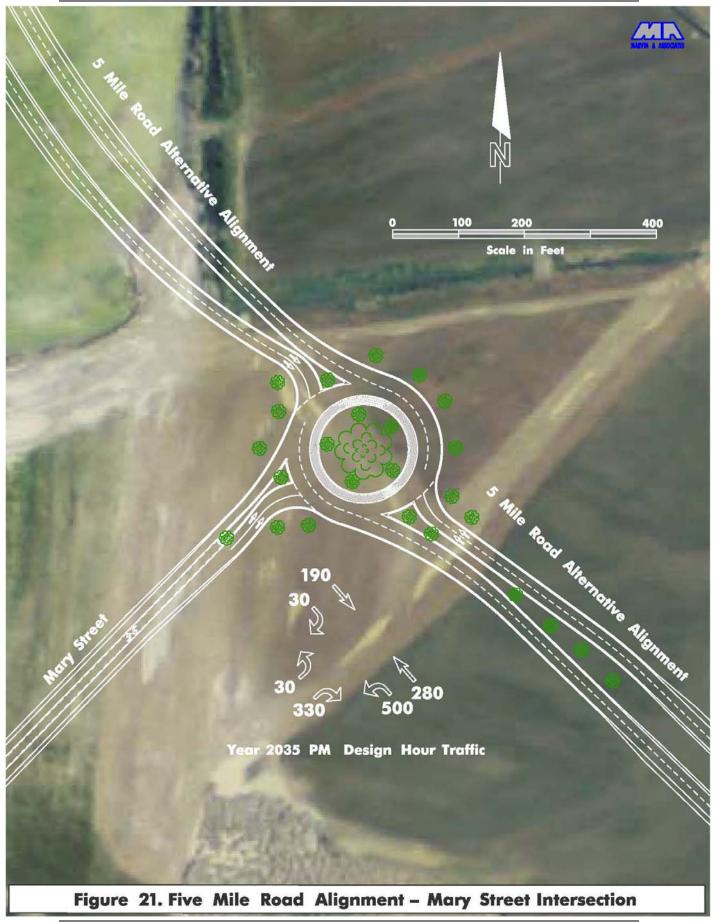
Figure 21 shows the proposed design geometry and operational controls for the intersection of Five Mile Road Alignment and existing Mary Street. A signalized intersection alternative was investigated, and it was determined that a roundabout intersection would be more appropriate at this location.

The year 2035 Five Mile Road Alignment typical section would have two thrulanes in each direction and the thru-lanes would be perpetuated through the roundabout intersection. The Mary Street approach would only require a single lane approach. However, a short right-turn lane was added to that approach to provide sufficient capacity would be available well beyond the 2035 design year.

Capacity calculations (Appendix G) indicate that all approaches to this intersection would operate at a LOS "B" or better in the year 2035.







Mary Street & Bitterroot Drive Secondary Improvements

The typical section for Mary Street, as a secondary improvement associated with the Five Mile Road Alignment alternative, incorporates one vehicle and bike lane in each direction of travel plus a two-way left-turn lane (TWLTL) in the center. It was determined that a stop sign on Bitterroot Road would operate at LOS "F" and that a traffic signal would probably be justified. Figure 22 illustrates the traffic signal design concept that incorporates the secondary improvements' typical section on Mary Street, and a single lane for each Bitterroot Drive approach.

Capacity calculations (Appendix G) indicate that all approaches would operate at LOS "B" or better in the design year 2035.

Mary Street & Hawthorne Lane Secondary Improvements

Secondary Five Mile Road Alignment alternative improvements for the Mary Street and Hawthorne Lane intersection would involve a northbound stop sign on Hawthorne Lane. Capacity calculations (Appendix G) indicate that the northbound approach to the improved Mary Street section would operate at LOS "B" in the design year 2035. Traffic pavement markings on Mary Street would include left-turn lanes at the intersection.

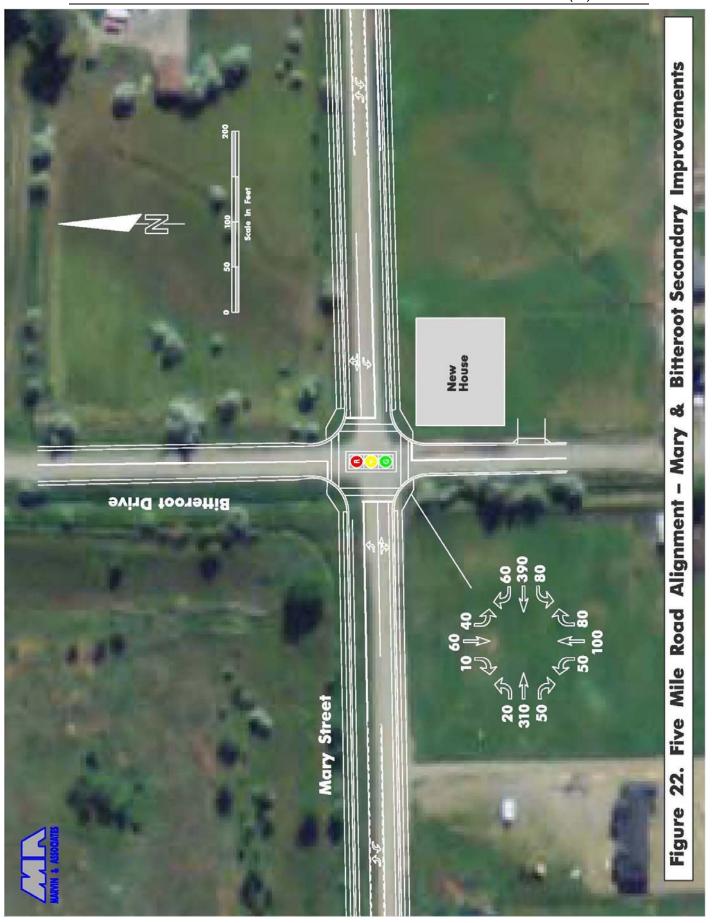
US87/HWY 312 Secondary Improvements

Figure 23 illustrates the design concept proposed for the intersection of Mary Street with US 87/Old Hwy 312/Bench Boulevard as a secondary improvement to the Five Mile Road Alignment alternative. The proposed concept includes a large diameter (220 feet), five legged roundabout. The Main Street – Hwy 312 corridor would be the major traffic movement, and two traffic lanes would be perpetuated in each direction through the roundabout. Two right-turn slip ramps for northbound Bench Boulevard and southbound US 87 would be used to enhance operations within the roundabout.

A short section of Mary Street, serving approximately five residences, would be accessed by a stop controlled intersection east of the roundabout. Bikes lanes along Mary Street would converge at that intersection and proceed west to connect with new bike lanes along Bench Boulevard.

A new traffic signal currently in design as a part of the Bench Boulevard reconstruction project was evaluated with the Five Mile Road Alignment and it was determined that the signal would not be able to accommodate the addition traffic demands. In addition, the acute angle of the intersection (37 degrees) and number of approaches at this intersection made it impractical to use traffic signals at this location. Capacity calculations (Appendix G) indicated that the roundabout would operate at a LOS "C" or better on all legs.







Five Mile Road and Dover Road

Operations at the intersection of Five Mile Road and Dover Road for all alternative alignments were investigated and capacity calculations (Appendix G) indicated that stop control on the Dover Road approaches would result in LOS "C" in all cases. As traffic on Dover Road increases beyond design year 2035 projections, alternative traffic control may be necessary.

ALTERNATIVE INTERCHANGE/INTERSECTION DESIGN OPTIONS

Johnson Lane Interchange

The existing Johnson Lane Interchange is a conventional diamond type interchange that was constructed to serve residential areas in the community of Lockwood. Johnson Lane is a north-south arterial roadway that connects Old US 87 1.6 miles south of I-90 and Coulson Road, south of the railroad tracks. Interstate-90 crosses above Johnson lane at a skew angle of approximately 53 degrees. Johnson Lane intersects the North I-90 Frontage Road, north of I-90, and Old Hardin Road, south of I-90. The separation distance between these two intersections is approximately 1,450 feet. Located between I-90 and the adjacent roadway intersections are the eastbound (EB) and westbound (WB) I-90 interchange ramps. The ramp separation distance is approximately 750 feet and the WB Ramps are located only 250 feet away from the North Frontage intersection. The EB Ramps are located 450 feet north of Old Hardin Road.

Intensive development exists around both the Old Hardin Road/Johnson Lane intersection and the North Frontage Road/Johnson Lane intersection. large trucks plazas exist on the west side of Johnson Lane north and south of the interchange. The east side of Johnson Lane, at the North Frontage Road intersection, has relatively sparse development. However, there are numerous commercial developments that exist on the east side of Johnson Lane at the Old Hardin Road intersection. Since the degree of development on either side of the interchange makes it impractical to expand the existing interchange footprint to any substantial degree, interchange design options at this location must necessarily embrace relatively recent and non-conventional intersection design configurations. Because many of these options are not commonly used in Montana, it was decided that all five design options developed during the EIS screening process would be carried forward. It is anticipated that some of the alternatives will be screened-out prior to final design and the remaining design options will allow enough flexibility to allow for unforeseen situations that may be encountered during final design.

Design concept drawings for all of the Johnson Lane Interchange design options can be found in Appendix H of this report. Capacity calculations for individual intersections associated with each of the design options can also be found in Appendix H of this report. All capacity calculations were based upon the Mary Option 1 Alignment year 2035 volumes, as the worst case scenario. Note that all design options have the same turning movements at the North Frontage Road, Old Hardin Road, and Becraft intersections, where capacity calculations for either



the roundabouts or the signals at those intersections apply to all of the design options.

It should also be noted that that there are a number of roundabout intersection concepts where one of more of the approach legs has a v/c ratio of 0.81 or greater. Normally this would indicate that operations on that approach leg are unstable and large queues could result when sort duration traffic peaks occurred. In this case, the most recent software was used for capacity calculations, and the newer software analysis makes this less of an issue. In addition, the higher v/c ratios analyzed within this study were on approach legs with minor traffic volumes. Reassessment of these approaches should be made during design to insure that short-term queue formations would not impede overall operations.

Design Option Descriptions

Option 1 – Modified Diamond with Roundabouts

This option would modify the existing standard diamond interchange by reconstructing the signalized intersections at North Frontage Road, north access ramps, south access ramps, and Old Hardin Road with roundabouts. I-90 would be realigned slightly to the south, enabling equal spacing of the roundabout intersections, and Johnson Lane would pass underneath the interstate via new I-90 structures. A schematic of this interchange design is shown in Appendix H, Figure H1.

This option would also require modifications to the Becraft Lane/Old Hardin Road intersection immediately east of the Johnson lane/Old Hardin Road intersection. The Becraft/Old Hardin Road intersection currently operates at unacceptable levels of service and a future traffic signal constructed so close to the Old Hardin Road/Johnson Lane roundabout would negatively impact operations along Johnson Lane. Thus, the Becraft Lane intersection would be reconstructed, at its current location, to include a second roundabout as a part of Option 1. Modifications to adjacent business approaches would be required to enable safe and efficient operations at the two new roundabouts on Old Hardin Road. Some accesses would have limited movements.

The alternative alignments' typical section incorporates two through lanes in each direction and that section would be carried through the interchange roundabouts on the Johnson Lane corridor. Slip ramps at the Old Hardin Road/Johnson Lane roundabout and at the WB ramps roundabout would be provided to remove high traffic volumes from circulating flows. Other lane configurations were determined by demand, capacity constraints, and weaving requirements at the intersections. All of the intersections associated with this design option would operate at LOS "B" or better. The worst movements would be the WB Off-ramp left-turn movement and the NB Johnson Lane through movement at Old Hardin Road. Both of these movements would operate at LOS "C".



Option 2 – Single-Point Urban Interchange

This option would implement a single-point urban interchange (SPUI) to replace the standard diamond interchange. The signalized intersections at North Frontage Road and Old Hardin Road would be reconstructed. This option could be modified to use either signalized intersections or roundabouts at these locations. The north and south access ramps would be controlled by one signalized intersection located below new I-90 structures. A schematic of this interchange design is shown in Appendix H, Figure H2.

The Old Hardin Road/Johnson Lane intersection would require four approach lanes on the SB and WB intersection approaches. Operational controls at the signal would create vehicle gueues during the peak design hours that would limit access to existing driveway within its operational area of influence. Driveway closures and relocations would be necessary for the traffic signal to operate safely and efficiently. The intersection of Becraft and Old Hardin Road would need to be modified to allow only right-turn-in and right-turn-out movements, and a new connector road would need to be constructed east of Becraft Lane's current location, between two existing commercial properties. This would allow eastbound traffic on Becraft Lane to access Old Hardin Road/Johnson Lane. The new connector road would require modifications to existing driveways accessing the two adjacent commercial properties. The eastern most commercial property could benefit from the new connector street since it is a retail building that would gain a substantial volume of passerby traffic adjacent to its site.

Access to the truck plaza on the west side of the Old Hardin Road/Johnson Lane intersection would also need to be modified to avoid conflicts within the intersection's operational area-of-influence. Some on-site circulation modifications may be required to accommodate the access changes shown in Figure H-2.

All of the intersections associated with this design option would operate at LOS "B" or better except for the Old Hardin Road intersection, which would operate at LOS "C". A 80 second cycle length was used in the capacity calculations which assumed minimal pedestrian activity. Additional pedestrian clearance time may actually be required for future operations and the cycle length could increase to 90 seconds. Thus, the operation of some movements at this intersection could be less than those calculated herein. The worst movements would be the EB Offramp approach and the SB Johnson Lane approach at Old Hardin Road. Both of these movements would operate at LOS "C".

The eastbound off-ramp free-right-turn movement weaving section between its intersection with Johnson Lane and the Old Hardin Road intersection has an overall weave distance of 500 feet. The capacity calculation for the weave movements (appendix) indicate that a LOS "B" could be achieved. However, there is a potential for trapping eastbound right-turn vehicles in the wrong lane or for timid drivers to block the free-right movement by stopping in the traffic lane before weaving.



Option 3 – Single-Point Urban Interchange with Roundabouts

Similar to Option 2, Option 3 would implement a single-point urban interchange to replace the standard diamond interchange. However, the signalized intersections at the North Frontage Road and Old Hardin Road intersections would be roundabouts instead of traffic signals, and the eastbound and westbound I-90 ramps would be controlled by one large diameter (300 foot) roundabout located below new double-span I-90 structures. A schematic of this interchange design is shown in Appendix H, Figure H3.

The roundabouts at the North Frontage Road and Old Hardin Road intersections would be identical in appearance and operations to the Option 1 design concept. The large diameter roundabout located beneath the new I-90 structures would accommodate entering traffic at four locations and departing traffic at four locations, similar to typical four-legged roundabouts. However, a wide separation between entering and departing traffic would exist for the minor street legs (EB and WB Ramps). Slip ramps would be used in each quadrant of the SPUI roundabout to avoid high circulation flows, except for the WB Off-ramp right-turn movements. A slip ramp would not be workable at that location since the majority of approach traffic on the ramp would turn left at the North frontage Road intersection and there is insufficient separation between intersections to accommodate the weaving movement. Circulation speeds within the SPUI roundabout would be higher than with a conventional multi-lane roundabout. Thus, crash severity potential could be relatively higher. There are only a few modern roundabouts of this nature that currently exist and thus, it is not known with any certainty whether there are operational problems that could accompany this concept.

The North Frontage Road and Old Hardin Road intersections that are also associated with Option 1 would operate at LOS "B" or better. The SPUI roundabout would operate at LOS "C" and the worst movement would be the EB Ramp left-turn movement, which would also operate at LOS "C" with a maximum vehicular storage distance of 225 feet.

Option 4 – Double Crossover Diamond with Traffic Signals

This option would implement a diverging diamond interchange to replace the standard diamond interchange. The signalized intersections at North Frontage Road and Old Hardin Road would be reconstructed. The north and south access ramps would be controlled by cross-over signalized intersections. I-90 would be realigned slightly to the south in order to provide equal spacing of the four Johnson Lane corridor intersections. Johnson Lane would pass below the new I-90 structures. A schematic of this interchange design is shown in Appendix H, Figure H4.

The Double Crossover Diamond interchange is a relatively new concept in the United States, although it has been used extensively in Europe for a number of years. The basic operational concept of the interchange involves two signalized intersections that allow traffic on the crossroad to cross each other's paths to allow traffic entering the freeway free right or left turns onto the freeway on-



ramps. Traffic on the off-ramps would be controlled by two phased traffic signals. This would result in four approaches at each intersection and a total of six conflict movements, or approximately one fourth the number of conflicts associated with a normal four-legged approach. From the schematic layout, it would appear that vehicles on Johnson Lane would be driving on the wrong side of the road between the intersections, but they can actually be considered one-way streets with only a small separation between them. The median section between intersections would have barriers and would provide a refuge for pedestrian traffic. The ramp intersections would operate with simple two phase signals that can be demand responsive and coordinated. Phasing diagrams for these signals are illustrated in Figure H4. Since Design Option 4 would utilize four interconnected signals, the cycle lengths for the ramp signals would necessarily need to be on the same cycle as the adjacent intersections, which may reduce the level of efficiency that the ramp signals would be able to achieve independently.

The access conditions and other operational characteristics of the North Frontage Road and Old Hardin Road intersections would be the same as was detailed for Option 2. Capacity calculations for Option 4 indicate that the two ramp intersections would operate at LOS "B". The worst movement would be associated with the Old Hardin Road intersection signal, similar to Option 2.

Option 5 – Double Crossover Diamond with Roundabouts

This option would be similar to Option 4 except that the signalized intersections at North Frontage Road and Old Hardin Road would be reconstructed with roundabouts. A schematic of this interchange design is shown in Appendix H, Figure H5.

The roundabout intersection at Old Hardin Road and North Frontage would be identical to those detailed in Options 1 and 3, above. With the adjacent roundabouts on either side of the ramp signals, the two ramp intersections could be fully coordinated and cycle lengths adjusted to coincide with traffic demand during different times of the day. Capacity calculations indicate that the maximum vehicle queues at the signals and roundabouts would not impede operations at any of the intersections. All of the intersections associated with this design option would operate at LOS "B" or better. The worst movement would be the NB Johnson Lane through movement at Old Hardin Road, which would operate at LOS "C".

Capacity Comparisons

Table 12 presents the LOS, volume to capacity (v/c) ratios, and hours of delay for each of the five design options. For more detailed information on individual movements, Appendix H provides individual intersection capacity analysis summaries.



Table 12. Johnson Lane Interchange Design Options Capacity Summary

Option 1 Modified Diamond		PM Hou	ır		
with Roundabouts	LOS	V/C	Hrs Delay	Max Queue	Comments
North Frontage Road	Α	0.81	4.92	181' WB	Worst Move SB Left LOS E
WB Ramps	Α	0.76	3.64	143' EB	Worst Move WB Left LOS (
SPUI Intersection					
EB Ramps	В	0.78	8.36	307' NB	Worst Move NB Thru LOS
Old Hardin Road	В	0.72	9.70	224 SB	Worst Move NB LOS C
Average All Intersections	Α	0.77	6.66		
	Total I	Delay =	26.62		
Option 2 - Single-Point		PM Hou	ır		
Urban Interchange	LOS	V/C	Hrs Delay	Max Queue	Comments
North Frontage Road	В	0.56	10.07	175' NB Thru	Worst Move EB Thru LOS
WB Ramps			. 5.01		, 13.31313 ED 11114 E00 (
SPUI Intersection	В	0.89	12.10	270' WB Off	Worst Move EB Ramp LOS
EB Ramps		<u> </u>	24.55	050165:-	
Old Hardin Road	С	0.77	21.90	250' SB LT	Worst Move SB LT LOS C
Average All Intersections	A	0.74	14.69		
	I otal L	Delay =	44.07		
Option 3- Single-Point		PM Hou	ır		
Urban with Roundabouts	LOS	V/C	Hrs Delay	Max Queue	Comments
North Frontage Road	А	0.81	4.92	181' WB	Worst Move SB Left LOS B
WB Ramps	, (0.01	1.02	101 112	World Wove OD Earl 200 E
SPUI Intersection	С	0.73	18.49	200' NB Thru	Worst Move EB LT LOS C
EB Ramps					
Old Hardin Road	В	0.72	9.70	224 SB	Worst Move NB LOS C
Average All Intersections	С	0.75	11.04		
	Total I	Delay =	33.11		
Option 4 - Double Crossover		PM Hou	ır		
Diamond with Signals	LOS	V/C	Hrs Delay	Max Queue	Comments
	_	0.50	40.07	475! ND Th	W .M .ED.T. 100
North Frontage Road WB Ramps	B B	0.56 0.58	10.07 8.72	175' NB Thru 175' NB Thru	Worst Move EB Thru LOS (Worst Move NB Thru LOS
SPUI Intersection	ט	0.50	0.12	וווו טאו כזו	ANOIST INIONG IND THIR FOST
EB Ramps	В	0.43	8.39	125' WB RT	Worst Move NB Thru LOS
Old Hardin Road	С	0.77	21.90	250' SB LT	Worst Move SB LT LOS C
Average All Intersections	В	0.59	12.27		
*	Total [Delay =	49.08		
Option 5 - Double Crossover		PM Hou			
Diamond with Roundabouts	LOS	V/C	Hrs Delay	Max Queue	Comments
Diamona with Noundabouts	LUS				Comments
North Frontage Road	Α	0.81	4.92	181' WB	Worst Move SB Left LOS E
NB Ramps	В	0.64	6.83	150' NB Thru	Worst Move NB Thru LOS
		0.40	6.34	175' NB Thru	West Mars ND Thank CO
SPUI Intersection	P			LAD INC. LDDI	Worst Move NB Thru LOS
SPUI Intersection EB Ramps	B R	0.46			
SPUI Intersection	В В	0.46 0.72 0.66	9.70 6.95	224' SB	Worst Move NB LOS C



Corridor Travel Speeds

Travel times are the average travel times along a 1,650 foot segment of Johnson Lane. They were calculated based upon average speeds between intersections, stopped delay, and circulation speeds within roundabouts. The speeds were calculated in an effort to compare relative travel efficiencies along the Johnson Lane corridor. However, travel speeds on the Johnson Lane corridor would actually be a minor consideration with regard to interchange efficiency, since the majority of traffic on Johnson Lane involves turning movements at ramps and local intersecting roads, yet it does provide one additional measure of efficiency that may be considered in the final design screening process.

Table 13 summarizes the calculations for each design option and provides the relative travel time and travel speed associated with each option. The highest travel speeds are associated with Option 1 and Option 3 roundabouts and the slowest travel speeds are associated with Option 2 and Option 4 traffic signals. It should be noted that differences between the maximum and minimum times are less than one minute and the differences in travel speeds are less than six mph.



Table 13. Johnson Lane Corridor Travel Speeds Through Interchange

Option 1 Mod	dified Diamor	nd Round	SB PM	Distance	Speed	Distance	Speed	Southbound
Intersection	From	То	Int. Delay	Between	Between	In Circle	In Circle	Time (sec)
Old Hardin Rd			10.2			248	20	18.6
	Old Hardin	EB Ramps		320	35			6.2
EB Ramps			3.1			200	20	9.9
	EB Ramps	WB Ramps		380	35			7.4
WB Ramps			3.5			155	20	8.7
	WB Ramps	N Frontage		300	35			5.8
N Frontage			3.9			185	20	10.2
						Travel Tim	ne (sec) =	66.8
						Travel Spe	eed (mph) =	16.7

Option 2 - Sin	ngle-Point U	rban Signals To	SB PM Int. Delay	Distance Between	Speed Between	Distance In Circle		Southbound Time (sec)
	-	-						. (,
Old Hardin Rd			22.4					22.4
	Old Hardin	SPUI		1110	35			21.6
SPUI			30					30.0
	SPUI	N Frontage		540	35			10.5
N Frontage		•	17.4					17.4
			8	=		Travel Tim	ne (sec) =	102.0
						Travel Spe	= (mnh) =	10.9

Option 3- Sin	gle-Point Ur	abn Round	SB PM	Distance	Speed	Distance	Speed	Southbound
Intersection	From	То	Int. Delay	Between	Between	In Circle	In Circle	Time (sec)
Old Hardin Rd			10.2			250	20	18.6
	Old Hardin	SPUI		690	35			13.5
SPUI			7.3			380	25	17.6
	SPUI	N Frontage		350	35			6.8
N Frontage			3.9			185	20	10.2
			-	-		Travel Tim	ne (sec) =	66.6
						Travel Spe	eed (mph) =	16.7

Option 4 - Do	uble Crosso	ver Signals	SB PM	Distance	Speed	Distance	Speed	Southbound
Intersection	From	То	Int. Delay	Between	Between	In Circle	In Circle	Time (sec)
Old Hardin Rd			22.4					22.4
	Old Hardin	EB Ramps		530	35			10.3
EB Ramps			13.4					13.4
	EB Ramps	WB Ramps		560	35			10.9
WB Ramps			16.7					16.7
	WB Ramps	N Frontage		550	35			10.7
N Frontage			17.4					17.4
						Travel Tim	ne (sec) =	101.9
						Travel Spe	ed (mph) =	10.9

Option 5 - Do			SB PM	Distance	Speed	Distance	•	Southbound
Intersection	From	То	Int. Delay	Between	Between	In Circle	In Circle	Time (sec)
Old Hardin Rd			10.2			248	20	18.6
	Old Hardin	EB Ramps		315	35			6.1
EB Ramps			11.1					11.1
	EB Ramps	WB Ramps		560	35			10.9
WB Ramps			13.5					13.5
	WB Ramps	N Frontage		380	35			7.4
N Frontage			3.9			185	20	10.2
<u>-</u>				-		Travel Tim	ne (sec) =	77.8
						Travel Spe	eed (mph) =	14.3



Mary Street Alignments - US 87/ Old Hwy 312 Intersection

The existing intersection of US 87/Old Hwy 312 incorporates approaches to only Main Street and Bench Boulevard. Mary Street intersects Bench Boulevard immediately south of the Main Street Intersection with access from northeast bound Main Street to Bench and Mary, but does not allow access from Mary Street directly onto Main Street. Westbound traffic on Mary Street can access Main Street by either executing a left-turn at the stop controlled US 87/Old Hwy 312 intersection or can turn left onto Bench and turn right onto Pemberton Lane, which intersects Main Street at an existing signalized intersection. The latter movement is more common since the Main Street/Old Hwy 312 roadway alignment is sharply skewed (37 degree angle) to the north-south alignment of Bench Boulevard/US 87 and it is difficult to judge gaps on the higher speed facility. In addition, that movement involves out of direction travel and more potential for delay than the Pemberton Lane/Main Street intersection.

The Bench Boulevard reconstruction project, currently in final design stages, would modify access to Mary Street by further limiting access to Mary Street from Main Street, US 87, and Old Hwy 312. A raised median on Bench Boulevard at Mary Street is planned to better accommodate major traffic movements at the planned signalized intersection. Implementation of a new alignment associated with this project would substantially change traffic patterns at this intersection and the following design options were conceived for potential implementation in the final design of either the Mary Street Option 1 or Option 2 Alignment alternatives. Improvements to this intersection would also be required for the Five Mile Road Alignment alternative and the proposed design concept was presented in the previous section of this report.

Design concept drawings for the three US 87/Old Hwy 312 design options can be found in Appendix I of this report. Capacity calculations for individual intersections associated with each of the design options can also be found in Appendix I. All capacity calculations were based upon the Mary Option 1 Alignment year 2035 volumes, which has the highest traffic volumes and was used as the worst case scenario.

Design Option Descriptions

Option 1 - Main Street Roundabout with Access to Mary Street/Bench T-intersection

Option 1 involves a 200 foot diameter roundabout on the Main Street/Highway 312 corridor. The roundabout would include Main Street, Old Hwy 312, US 87, and the Mary Street Options 1 or 2 Alignments. Bench Boulevard and Existing Mary Street would intersect at a channelized T-intersection southeast of the roundabout, and Bench Boulevard would access the Mary Street Alignment as shown on Figure I-1 (Appendix I). Option 1 would utilize a roundabout to serve the major street facilities while separating the lower volume, localized traffic at a stop controlled intersection. Main Street/Old Hwy 312 is the primary corridor at this intersection, and two thru-lanes of traffic would be carried through the



roundabout. The roundabout would have a right-turn slip ramp to remove southbound traffic on US 87 from the circulating roundabout traffic.

Option 1 does not provide for direct access from Main Street, US 87, or Old Hwy 312 to the existing Mary Street corridor. Traffic from those routes, that need to access Mary Street, would do so by using the Hawthorne Street connection to the Mary Street Option 1 & 2 Alignments. Hawthorne Street is located approximately 0.46 miles east of the Option 1 roundabout. There are approximately 25 residential properties that this access restriction would affect, and it is estimated that total volume of traffic that would experience out of direction travel would be less than 50 ADT.

Capacity calculations (see Appendix I) indicate that the Option 1 Roundabout would operate at an overall LOS "B" in the year 2035. The worst LOS would be LOS "C" for the Mary Street Alignment approach. The Bench Boulevard approach to the Mary Street Alignment would operate at LOS "E". However, a 30 foot wide raised median in the Mary Street Alignment design would allow for two-stage left-turns from Bench Boulevard, and the resultant capacity would then be LOS "D". The Existing Mary Street approach to Bench Boulevard would operate at LOS "B". However, there is a possibility that vehicle queues on Bench Boulevard could impede westbound traffic on Existing Mary Street.

Option 2 – Primary & Secondary Roundabouts

Option 2 involves two roundabouts. One is a 280 foot diameter roundabout at the Main Street/US87/312 intersection and the other is a single lane roundabout that would be located south of the larger roundabout at an intersection with Bench and Mary Street. The single lane roundabout would connect to the major roundabout as a fifth approach leg. Access from US 87 to Bench would be a more direct path than that associated with Option 1. A southbound US 87 slip ramp would also be provided with this alternative.

The major feature of this design option is its ability to isolate localized traffic on Bench and Mary Street, which would have little if any truck traffic. The US 87/Old Hwy 312/Mary Street Alignment traffic would have approximately 4% heavy trucks, and longer trips lengths. Unlike Option 1, Option 2 would serve all traffic movements to and from the six roadways intersecting at this junction. While not unique, the five legged roundabout configuration is not common in the United States, and signing for proper lane usage and directional exits would be critical during final design.

Capacity calculations (see Appendix I) indicate that the primary roundabout would operate at an overall LOS "B", and the worst movement would be the Mary Street Alignment through and left-turn lane which would operate at LOS "C". The secondary roundabout would operate at an overall LOS "A", and the worst movement would be the Existing Mary Street approach which would operate at LOS "B".



Option 3 - Dual Roundabouts

Option 3 would use two roundabouts on the US 87/Mary Street Alignment corridor. The first roundabout would include Main Street, Old Hwy 312, US 87 and the Mary Street Alignment, and would be a multilane roundabout with an approximate diameter of 200 feet. The second roundabout would be a smaller single lane roundabout serving the Mary Street Option 1 or 2 Alignment, Existing Mary Street, Bench Boulevard, and the connector link to the larger northern roundabout. There would be a US 87 southbound slip ramp that is common to all of the options and a westbound Mary Street Alignment slip ramp. This option would partially segregate localized traffic between Existing Mary Street and Bench, but US 87/Mary Street Alignment traffic, which has heavy trucks and longer trip lengths, would interact with local traffic within the smaller roundabout. Circulation traffic within the roundabout would only include half of the US 87/Mary Street Alignment traffic volumes, since the other half would use the Mary Street Alignment slip ramp.

Option 3 would involve realignment of the Main Street/Old Hwy 312 corridor to the north in order to achieve acceptable roundabout entry angles, and to provide sufficient separation between the two roundabouts. Each roundabout would have four approach legs and would serve all traffic movements to and from the six intersecting roadway approaches. Some out-of-direction travel between Main Street and the Mary Street Alignment would be perceived, but the actual travel time would be similar to Option 2 and only slightly longer than Option 1.

Capacity calculations (see Appendix I) indicate that the roundabout at US 87/Old Hwy 312/Main Street would operate at an overall LOS "B", and the worst movement would be the Mary Street Alignment (connector road) left-turn and through lane at LOS "C". The smaller roundabout at Existing Mary Street and Bench Boulevard would operate at an overall LOS "A", and the worst movement would be the Bench Boulevard approach at LOS "B". The Bench Boulevard approach would also have the longest maximum vehicle queue of approximately seven vehicles. That length of queue would not impede vehicle movements at any adjacent intersections or approaches.

Capacity Comparisons

Table 14 presents the LOS, delay (seconds/vehicle), volume to capacity (v/c) ratios, and maximum queue lengths (feet) for each of the three design options. For more detailed information on individual movements, Appendix I provides individual intersection capacity analysis summaries.



Table 14. Mary Street Alignments US 87/Old Hwy 312 Capacity

		Measures of Efficiency			
Intersection	Approach	LOS	Delay(sec)	V/C	Qmax(ft)
Design Option 1 - Main Street Roundabout with Access to Mary Street/Bench T-					
intersection					
US87/312/Main/ Bench Intersection	Main Street NEB	В	13.5	0.66	190
	HWY 3 SWB	С	23.1	0.73	155
	Mary Align NWB	С	21.8	0.85	210
	US 87 SEB	В	13.0	0.46	65
	Intersection	В	17.9	0.85	210
Bench & Mary Intersection	Bench NB	D	27.5	0.76	150
	Mary St WB	В	12.3	0.21	25
	Intersection	D	27.5	0.76	150
Design Option 2 - Primary & Secondary Roundabouts					
US87/312/Main/ Bench Intersection	Main Street NEB	В	11.0	0.60	150
	HWY 3 SWB	В	16.8	0.58	120
	Mary Align NWB	В	18.4	0.66	125
	US 87 SEB	Α	9.4	0.39	55
	Bench NB	В	11.3	0.58	100
	Intersection	В	13.5	0.66	150
Bench & Mary Intersection	Mary Align WB	В	10.6	0.19	25
	Bench EB	Α	6.2	0.54	125
	Bench SB	Α	3.2	0.34	60
	Intersection	Α	6.0	0.54	125
Design Option 3 - Dual Roundabouts					
	Main Street NEB	В	11.1	0.62	155
US87/312/Main/	HWY 3 SWB	В	17.0	0.59	115
Bench	Mary Align NWB	В	17.4	0.82	195
Intersection	US 87 SEB	В	10.7	0.41	55
	Intersection	В	14.2	0.82	195
Bench & Mary Intersection	Mary Align WB	Α	5.7	0.34	25
	Bench EB	В	10.8	0.64	165
	Bench SB	Α	6.2	0.30	50
	Mary St NB	В	12.0	0.23	40
	Intersection	Α	7.7	0.65	165

Five Mile Road/Old Hwy 312

There are two proposed locations for a connection of Five Mile Road to Old Hwy 312 that have been carried forward in this project. The western most location, Option A, involves a sweeping curve to the northwest from the north-south alignment of Five Mile Road. The eastern most location, Option B, would be located approximately 900 feet farther northeast on Old Hwy 312, involves a shorter curve to intersect Old Hwy 312. Because there may be yet unidentified impacts at either location, both a signal and a roundabout have been identified as potential design configurations for both locations, resulting in four optional designs. The figures contained in Appendix J of this report represent the Five Mile Road Alignment alternative connections, yet the final design of this intersection would also apply to secondary Five Mile Road improvements



associated with the Mary Street Option 1 or 2 Alignment alternatives. The only difference would be the number of lanes on the Five Mile Road approach. The typical section for the Five Mile Road secondary improvements alignment would involve a two-lane facility. Thus, at its approach to Old Hwy 312, Five Mile Road as a secondary improvement facility would either have a single approach lane for the roundabout option or one through/left-lane and one right-turn lane for the signal alternative. Capacity calculations for the secondary improvement signal option is included in Appendix J.

For all alternative design options, it was assumed that the newly constructed section of Old Highway 312 between US 87 and a point 900 feet west of the Option A intersection would be extended east beyond the Option B intersection location. A five lane section on Old Hwy 312 is shown for all of the Five Mile Road connection figures.

Design Option Descriptions

Option A

Figures J1 and J2, in Appendix J, illustrate the traffic signal and roundabout design options, respectively, at this location. The Option A traffic signal configuration would incorporate three approach lanes on Five Mile Road. Modifications to an existing private roadway approach on the north side of the intersection would align that approach with the Five Mile Road approach. The middle lane on Five Mile Road would accommodate a through movement to the private approach road on the north side of the intersection. This configuration allows the potential for a future continuation of Five Mile that would connect to US 87, at some future time. For Five Mile Road secondary improvements associated with the Mary Street Option 1 or 2 Alignments, there would be one approach lane accommodating left and through traffic movements, and an auxiliary right-turn lane, which would accommodate the majority of traffic on the Five Mile Road approach. In addition, there would only be one departure lane on Five Mile Road for the secondary improvements alternative.

The Option A roundabout design is shown in Figure J2. It shows the two approach and departure lanes associated with the Five Mile Road Alignment typical section. The two approach and departure lanes would allow for a future extension north to US 87. Five Mile Road as a secondary improvement would have single approach and departure lanes.

Capacity calculations (see Appendix J) indicate that the Option A traffic signal intersection would operate at LOS "A" in the design year 2035. The v/c ratio would be 0.37, and the intersection delay would be 8.7 seconds per vehicle. The worst movement would be the Five Mile Road approach at LOS "B". The maximum queue in any lane would be three vehicles in the Five Mile Road right-turn lane. For the Option A roundabout intersection, the overall LOS would be "A" and the worst movement would be the Five Mile Road left-turn lane which would operate at LOS "B". The intersection's v/c ratio would be 0.28 and none of the approaches would have more than two vehicles in the maximum queue.



If the Five Mile Road connection is made as a secondary improvement associated with the Mary Street Option 1 or 2 Alignment, the capacity calculations indicated that for a signal with a single through/left lane and an auxiliary right-turn lane on the Five Mile Road approach the intersection LOS would be "A". All other measures of efficiency would be almost identical to the Five Mile Road alignment Intersection.

Option B

Figures J3 and J4 in Appendix J illustrate the traffic signal and roundabout design options, respectively, at this location. These two design options are almost identical to the Option A geometric layout for the signal and roundabout, including the private approach road relocation on the north side of Old Hwy 312. In addition, the close proximity of Option B to Option A would result in identical traffic demands. Therefore, the analysis results for Option A would be identical to those detailed in the preceding section.

Final design of the Five Mile Road connection to Old Hwy 312 would ultimately be determined by factors other than traffic operations.

Mary Street/Bitterroot Drive

The original concept design for the intersection of Bitterroot Drive and Mary Street Option 1 and 2 Alignments occurred early in the development of screening alternatives for the EIS. Since that time, a new residential dwelling was constructed in the southeast corner of the intersection of Mary Street and Bitterroot Lane. Because the original concept involved a realignment of Mary Street that would be in direct conflict with the new house, it was determined that additional design concepts would be required in an attempt to minimize impacts at this intersection location.

The design options presented within this section of the report include the original concept and six additional options. Three of the new options are based upon adjustments that move the Mary Street Option 1 and 2 Alignment to the north while maintaining the existing Mary Street alignment as it currently exists. The remaining three options are based on maintaining the Mary Street Alignment location and modify the existing Mary Street intersection with Bitterroot Drive.

Design Option Descriptions

Option A – Signal

Option A was the original concept that was prepared prior to knowledge of the new house. This concept involves realigning the existing Mary Street to the south of the signalized intersection to maintain adequate spacing between intersections. In this concept, the realignment of Mary Street would require removal of the new house. Left-turn lanes would be constructed on Bitterroot Drive, both north and south of the Mary Street Alignment intersection. The intersection of Bitterroot and existing Mary Street would operate with stop control



on Mary Street which would allow through traffic movements on the higher volume street (Bitterroot Drive).

Capacity calculations (see Appendix K) indicate that the intersection of Mary Street Option 1 Alignment and Bitterroot Drive would operate at LOS "B" with the worst movement being LOS "B" on the northbound Bitterroot Drive approach. At the stopped controlled intersection of Bitterroot Drive and Mary Street, Bitterroot Drive would operate at LOS "A" and Mary Street would operate at LOS "B".

Option B – Roundabout

Options B and C involve shifting the proposed Mary Street Alternative alignment to the north at Bitterroot Drive to achieve the necessary spacing from the intersection of Mary Street and Bitterroot Drive. Option B uses a roundabout and Option C uses a traffic signal. These alternatives would avoid removing a house on the southeast corner but would in-turn impact landowners on the north side of the Mary Street Option 1 and 2 Alignment.

The roundabout shown in Figure K2 (Appendix K) would perpetuate the Mary Street Alignments' typical section of two lanes in each direction through the roundabout. Bitterroot Drive would have single entrance and exit lanes on both sides of the intersection. The intersection of Mary Street and Bitterroot would be stop controlled on Mary Street, similar to Option A, except both Bitterroot Drive approaches would have a single lane of travel in each direction without a left-turn lane. Traffic volumes for Option B are the same as all of the intersections' design options.

Appendix K capacity calculations indicate that the Mary Street Option 1 Alignment roundabout would operate at LOS "A" and all of the approaches and movement would operate at the same LOS.

Option C – Signal

Option C is the same as Option B except the roundabout on the Mary Street Option 1 Alignment would be replaced with a traffic signal. This Option would require more gradual entry curves on the Mary Street Alignment approaches which would impact a garage structure in the private parcel northeast of the intersection. All of the traffic volumes would be the same as the other design options, and the same geometry and control features at the existing Mary Street/ Bitterroot Drive intersection would be the same as that used for Option B.

Capacity calculations for the Mary Street Alignment signalized intersection would be the same as the Option A design, the existing Mary Street/Bitterroot Drive intersection LOS would be the same as design Option B.

Option D – Raised Median Bitterroot Drive

Option D would involve a signalized intersection at the Mary Street Alignment and Bitterroot Drive, as shown in Figure K4. The southern approach to the intersection would have a raised median between the northbound left-turn lane and the southbound lane. The adjacent intersection of Mary Street and Bitterroot Drive would only allow right-turn entry and exit movements. This would eliminate



6 of the 12 movements that are currently served by this intersection. East-west through and left-turn movements on Mary Street would then be served by the Mary Street Alignment roadway. Northbound and southbound left-turn movements on Bitterroot Drive at Mary Street would be detoured onto the new Mary Street alignment and would access Mary Street at either Hawthorne Lane or at Five Mile Road. The total volume of traffic that would be redistributed due to prohibited movements would be approximately 130 vehicles during the peak pm design hour period in the year 2035. This amounts to about 24% of the total projected traffic that would be entering the Mary Street-Bitterroot Drive intersection.

Most of the additional right-of-way necessary for construction of this option would be on the west side of Bitterroot Drive. This option requires the least amount of total new R/W area of any of the options. This option also has the least potential impact on adjacent property in terms of structure relocation and access.

This option allows full operational signal control of the Mary Street Alignment intersection with Bitterroot Drive with little if any conflicts created by the adjacent intersection. The only issue would involve westbound right-turn movements from Mary Street that could have a minor volume of traffic associated with a weave across the northbound through traffic lane. Conflicts points at the Mary Street and Bitterroot Drive intersection would be reduced from 32 to 2, thus increasing the safety potentially dramatically. Capacity calculations for both of the intersections involved with this option are attached.

Design Option E – Grade Separation

Option E represents a grade separation option that would have the least impact to adjacent properties while providing full access to the Mary Street Alignment from Bitterroot Drive. The grade separation Option E, shown in Figure K5, would have Bitterroot Drive overpass a slightly horizontally shifted Mary Street allowing a fully operation signal for the Bitterroot Drive intersection with the Mary Street Alignment. The vertical profile of the Mary Street Alignment would be raised, along with the north and south approaches on Bitterroot Drive. The option would eliminate all but the east-west through movements on Mary Street, at its intersection with Bitterroot Drive, and would only serve 55 east-west vehicles in the peak pm design hour. Other grade separation options would involve a Bitterroot Drive overpass of the Mary Street Alignment, which without connecting ramps would either create a circuitous route for traffic accessing the Mary Street Alignment or actually reduce traffic demand on the Mary Street Alternative by approximately 3,000 ADT.

The R/W required for this option would be measurably greater than Option D, but somewhat less than some of the other options. The large fill sections and retaining walls that would be required could possibly impact access to adjacent properties and would create a circuitous route for adjacent residents living along Mary Street. Nearby residents, especially those in the new house located in the southeast corner of the intersection would have their views substantially altered by the raised profile of Bitterroot drive and the Mary Street Alignment.



Design Option F – Signal Northwest

Option F is similar to design Option C except that the intersection of Bitterroot Drive and Mary Street Alignment would be shifted west of the current Bitterroot Drive Alignment, thus minimizing the impacts to developed property in the northeast corner of the intersection that would be associated with Option C. All movements would be served at both intersections. Figure K6 illustrates the reverse curves and approach angles that would be needed to achieve the shifted intersection alignment associated with Design Option F. Some degree of crash potential would be associated with this option due to operational conditions typically inherent within curvilinear alignments. Thus, it is noted in Figure K6 that a roundabout could also be considered as a control option at the Mary Street Alignment intersection with Bitterroot Drive.

This design option would entail the most R/W acquisition of all alternatives, but would minimize impacts to structures and access to adjacent developed properties. There would also be a larger tract of land between Mary Street and the Mary Street Alignment that could not be developed, but would still need to be maintained.

Design Option G – Mary Street Termination

Option G would involve termination of Mary Street at Bitterroot Drive. Figure K7 illustrates the realignment of the Mary Street west approach to the south, which would create a "T" intersection at the intersection Mary Street and Bitterroot Drive. Since existing and future traffic demand on Mary Street, east of Bitterroot Drive, would be substantially less than on Mary Street west of Bitterroot Drive, Mary Street would be terminated at a cul de sac and a minor connection road between Mary Street and the Mary Street Alignment roadway would be constructed. Capacity calculations indicate that all three intersections would operate at acceptable levels of service (LOS) and the separation distances between intersections would be conducive to safe operations.

The large tract of land between Mary Street and the Mary Street Alignment could be accessed from Mary Street. This would allow for potential development of that property.

Capacity

A summary of the additional design options capacity calculations is shown in Table 15. It can be seen that all of the alternatives would provide a desirable LOS. There are no substantial differences in the LOS and other measures of effectiveness between all of the alternatives. Thus, deciding factors would be: safety, impacts to adjacent properties, and responsiveness to overall travel demands. Final design of the intersection geometry and control will involve coordination with the City of Billings and a complete evaluation of traffic operations and land use impacts.



Table 15. Mary Street Alignment - Bitteroot Drive Design Options - Capacity Summary

		L	Measures of Efficiency	Efficie	ncv				Measures of Efficiency	Efficie	JCV				Measures of Efficiency	Efficie	νoc
Intersection	Approach	LOS		N/C	Qmax(ft)	Intersection	Approach	SOT	Delay(sec)	N/C	Qmax(ft)	Intersection	n Approach	ros	Delay(sec)	N/C	Qmax(ft)
DESIGN AL	DESIGN ALTERNATIVE A					DESIGN ALT	DESIGN ALTERNATIVE D					DESIGN AL	DESIGN ALTERNATIVE G			-	
	Mary Align EB	۷	7.7	0.22	75		Mary Align EB	A	7.9	0.25	100		Mary Align EB	٧	7.7	0.22	75
Money Alicement	Mary Align WB	A	8.5	0.34	100	Mary	Mary Align WB	A	9.8	0.35	150	Mary	Mary Align WB	٧	8.7	0.35	100
P Different	Bitteroot NB	В	16.6	86.0	75	Alignment &	Bitteroot NB	В	16.2	0.31	75	Alignment &	Bitteroot NB	В	16.9	0.43	100
o Dillei 001	Bitteroot SB	В	15.4	0.16	50	Bitteroot	Bitteroot SB	В	15.4	0.16	50	Bitteroot	Bitteroot SB	В	15.4	0.15	50
	Intersection	В	10.0	0.35	100		Intersection	٨	6.6	0.34	150		Intersection	В	10.2	0.38	100
	Mary Street EB	၁	15.9	0.32	35		Mary Street EB	٧	9.3	0.05	25		Mary Street EB	В	11.0	0.15	25
Dittoroot 8	Mary Street WB	၁	15.2	0.12	15	Different 9	Mary Street WB	A	9.4	0.05	25	Bitteroof &	Mary Street WB	na	na	na	na
Many Street	Bitteroot NB	Α	7.8	0.03	5	Man Street	Bitteroot NB	٧	0.0	na	na	Man Street	Bitteroot NB	Α	7.7	0.02	25
Mary Street	Bitteroot SB	А	7.8	0.01	5	ividi y sileet	Bitteroot SB	٧	0.0	na	na	maly sueer	Bitteroot SB	na	na	na	na
	Intersection	na	na	na	na		Intersection	na	na	na	na		Intersection	na	na	na	na
DESIGN AL	DESIGN ALTERNATIVE B			(harry		DESIGN ALT	DESIGN ALTERNATIVE E			2							
	Mary Align EB	۷	5.7	0.17	25		Mary Align EB	∢	7.9	0.26	75						
Money A linemont	Mary Align WB	A	9.9	0.29	20	Mary	Mary Align WB	A	9.8	0.37	100						
Wally Angillien	Bitteroot NB	А	4.7	0.31	35	Alignment &	Bitteroot NB	В	16.1	0.32	75						
on lelling &	Bitteroot SB	٧	6.9	0.20	20	Bitteroot	Bitteroot SB	В	15.4	0.14	50						
	Intersection	A	6.0	0.31	50		Intersection	A	6.6	0.35	100						
	Mary Street EB	၁	15.9	0.32	35		Mary Street EB	A	0.0	na	0						
Bitteroot &	Mary Street WB	၁	15.2	0.12	15	Bitteroot &	Mary Street WB	A	0.0	na	0						
Mary Street	Bitteroot NB	А	7.8	0.03	5	Mary Street	Bitteroot NB	A	0.0	na	0						
Hally Stice	Bitteroot SB	Α	7.8	0.01	2	Illial y Street	Bitteroot SB	A	0.0	na	0						
	Intersection	na	na	na	na		Intersection	na	na	na	na						
DESIGN AL	DESIGN ALTERNATIVE C					DESIGN ALT	DESIGN ALTERNATIVE F										
	Mary Align EB	А	7.7	0.22	75		Mary Align EB	٧	7.7	0.22	75						
Many & lignmont	Mary Align WB	A	8.5	0.34	100	Mary	Mary Align WB	A	8.7	0.38	125						
& Ritteroot	Bitteroot NB	В	17.0	0.42	75	Alignment &	Bitteroot NB	В	16.4	0.36	100						
מ פוונפו ממנ	Bitteroot SB	В	16.1	0.28	50	Bitteroot	Bitteroot SB	В	15.4	0.14	50						
	Intersection	8	10.0	0.35	100		Intersection	٧	10.0	0.37	125						
	Mary Street EB	င	15.9	0.32	35		Mary Street EB	ပ	15.9	0.32	35						
Ritteroof &	Mary Street WB	ပ	15.2	0.12	15	Bitternot &	Mary Street WB	ပ	15.2	0.12	15						
Mary Street	Bitteroot NB	∢	7.8	0.03	2	Mary Street	Bitteroot NB	4	7.8	0.03	2						
	Bitteroot SB	٧	7.8	0.01	2		Bitteroot SB	∢	7.8	0.01	2						
	Intersection	na	na	na	na		Intersection	na	na	na	na						



City of Billings Coordination

Consultant team members met with the City Engineer and members of the Traffic Engineering Department to obtain feedback regarding design options being considered for the Mary Street alignments and Bitterroot Drive intersection. They reviewed the genesis of the intersection design and subsequent analysis of all seven design options. Through the process of elimination, the City felt that they could provide strong support for Option G which involves a cul de sac on Mary Street east of Bitterroot and a realignment of Mary Street on the west side of the intersection. The reasons behind their selection of Option G were:

- 1 When the Mary Street Alignment is constructed, it will replace Mary Street as the east-west Principal Arterial and Mary Street's functional classification will revert to a local street or a collector street, at best. Thus, the continuity of Mary Street must be broken to ensure that it does not function as a parallel arterial.
- 2 The cul de sac located in the southeast corner of the intersection would serve as a buffer between the signalized intersection and the residence located in that corner.
- 3 The three lane street section on Bitterroot between Mary Street Alignment and the Mary Street intersection would fit with improvements that would eventually be made on Bitterroot Drive at some future date.
- 4- They also indicated that if an alternative to Option G were to be considered they could support Option D, the raised median separator on Bitterroot that would limit movements to right-in and right-out on Mary Street at Bitterroot.

SUMMARY & CONCLUSIONS

The proposed alternative alignments between Old Highway 312 and I-90 being carried forward into the EIS would provide an alternate Yellowstone River crossing to the existing US 87 river crossing between the I-90 Lockwood Interchange and the intersection of Main Street and 1st Avenue North. With respect to impacts on the existing street system, the alternative alignments would substantially reduce future traffic demand on the existing river crossing and on Main Street. No-Build traffic projections in the year 2035 indicate that both corridors would suffer from poor levels-of-service and congestion. At some corridor intersections, the reduction in traffic demand associated with the new alignment alternative is substantial enough to delay major improvements that may be required before the year 2035. This study has also determined that the design year (2035) street system, with the new alignments, would have safety benefits by reducing exposure (traffic) on the existing streets and diverting traffic to a newer, safer facility.



All of the new alignment alternatives would require substantial improvements at the alignment connections to Old Hwy 312 and Johnson Lane. At Old Hwy 312, two connections are required: one at an extension of Five Mile Road, and the other at the intersection of US 87/Old Hwy 312/Main Street/Bench. Various conditions exist at both of these connection points that create complex traffic control issues. A number of design options have been proposed at these intersections. Since all of the design options are viable, MDT and the project team have decided to carry the design options further into the EIS and potentially, final design.

The Johnson Lane Interchange is currently in the early stages of congestion and projected growth in the area will create capacity problems which will eventually require major reconstruction. The directional flow of traffic would change dramatically with the alignment alternatives. Current geometric and surrounding land use conditions at the interchange will require a higher level of traffic control using contemporary design solutions. Five design options at the Johnson Lane Interchange have been proposed and evaluated. All of the options will provide acceptable operations with varying degrees of impacts. Because of the complexities involve, a decision was made to advance all five options, similar to the Old Hwy 312 connection.

Other intersections along the project alignment have been proposed and evaluated within this study. All of the intersections would provide good LOS well beyond the design year. The intersection of Bitterroot Drive and the project alignments would be a critical intersection, and as with Johnson Lane and Old Hwy 312 connections, design options are being carried forward.



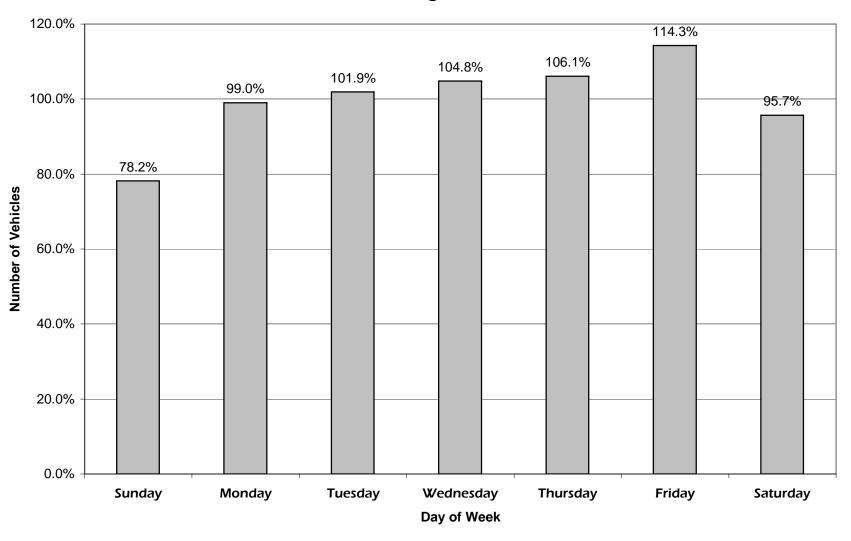
APPENDIX A

Traffic Volume Variations

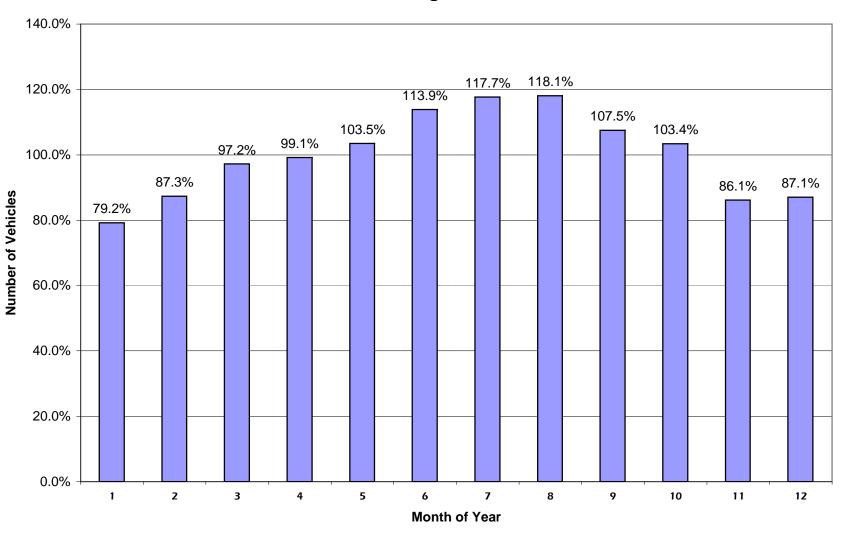


er.			

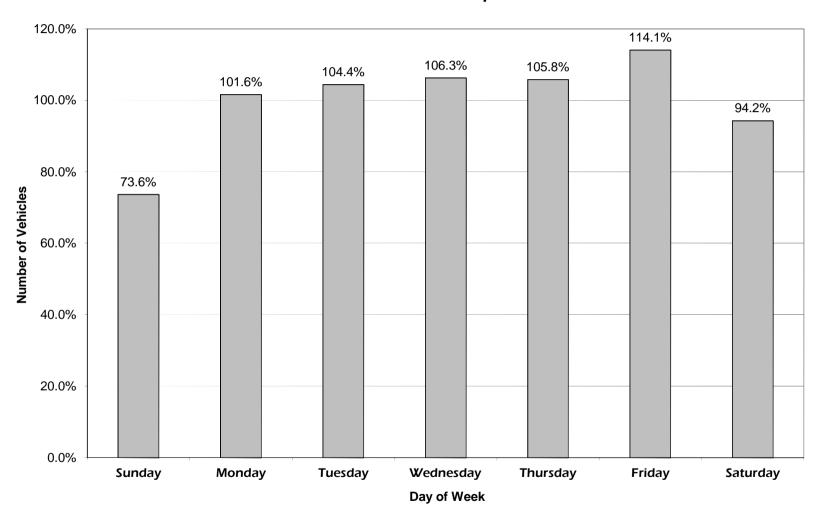
Average Daily Variation I-90 East of S. Billings Blvd. Station A-059



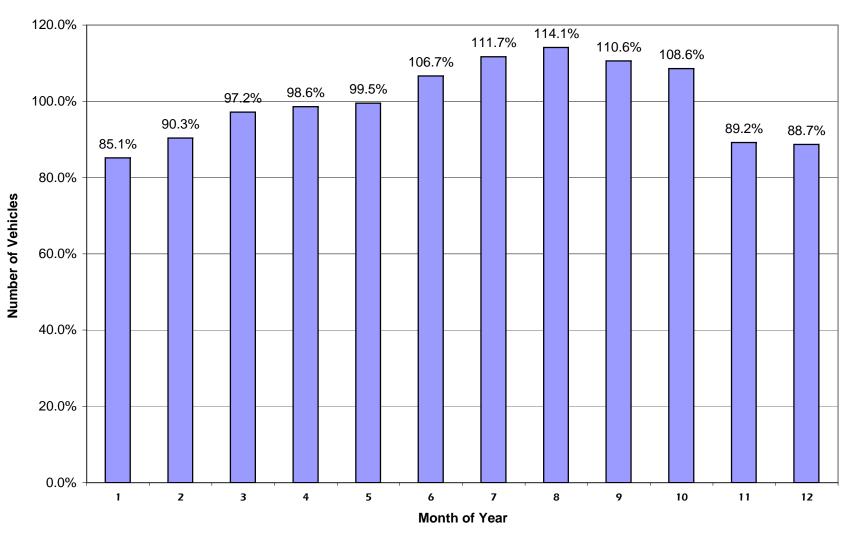
Average Monthly Variation I-90 East of S. Billings Blv. Station A-059



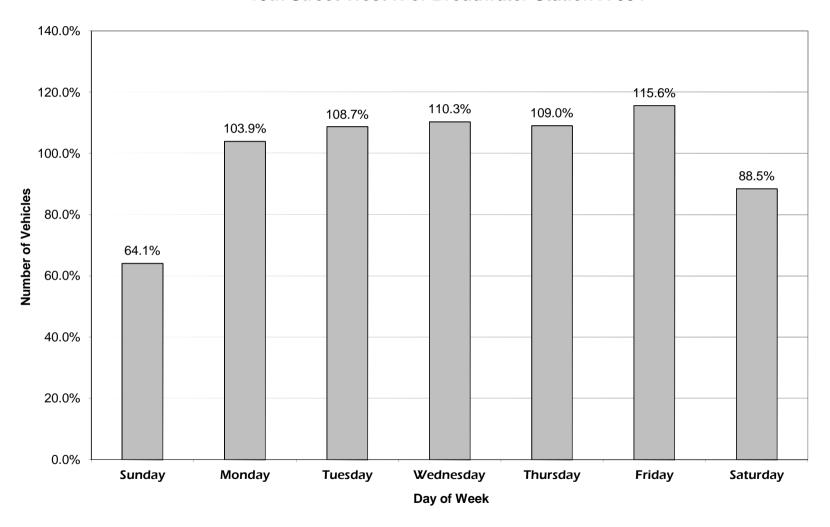
Average Daily Variation US 87 Main Street N of Hilltop Road Station A-050



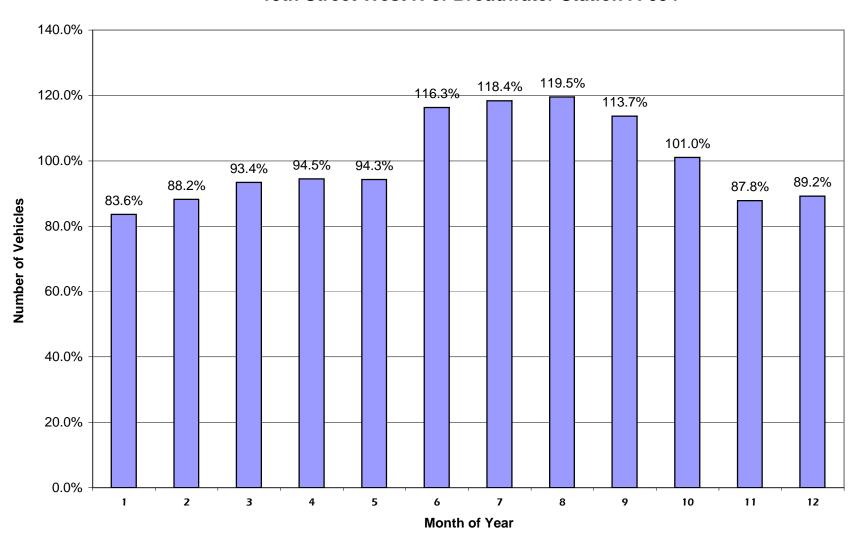
Average Monthly Variation US 87 Main Street N of Hilltop Road Station A-050



Average Daily Variation 19th Street West N of Broadwater Station A-054



Average Monthly Variation 19th Street West N of Broadwater Station A-054



APPENDIX B

Existing Roads & Streets

Capacity Calculations

er.			

	TW	O-WAY STOP	CONTR	OL SU	MMARY			
General Information	n		Site I	nforma	ition			
Analyst	R Marvin		Interse	ection		Dover & I	Five Mile	ļ
Agency/Co.		Associates	Jurisdi			MDT		
Date Performed	10/27/20		Analys	is Year		2010 Exis	sting	
Analysis Time Period	Peak PM							
	llings Bypass							
East/West Street: Dove					eet: Five M	lile Road		
Intersection Orientation:	East-West		Study F	Period (h	rs): 0.25			
Vehicle Volumes ar	<u>nd Adjustme</u>							
Major Street	<u> </u>	Eastbound				Westbou	ınd	
Movement	1 1	2	3		4	5		6
\/ala /ab-/b\	<u> </u>	40	R 1		L 	T 37		R
Volume (veh/h) Peak-Hour Factor, PHF	1.00	0.50	0.50		0.50	0.50	-+	1.00
Hourly Flow Rate, HFR				-		1		
(veh/h)	0	80	2		8	74		0
Percent Heavy Vehicles	0				5			
Median Type				Undivid	ded			
RT Channelized			0					0
Lanes	0	1	0		0	1		0
Configuration			TR		LT			
Upstream Signal		0				0		
Minor Street		Northbound				Southboo	und	
Movement	7	8	9		10	11		12
	L	Т	R		L	Т		R
Volume (veh/h)	1		4					
Peak-Hour Factor, PHF	0.50	1.00	0.50		1.00	1.00		1.00
Hourly Flow Rate, HFR (veh/h)	2	0	8		0	0		0
Percent Heavy Vehicles	5	0	5		0	0		0
Percent Grade (%)		0				0		
Flared Approach		N				N		
Storage		0				0		
RT Channelized			0					0
Lanes	0	0	0		0	0		0
Configuration		LR						
Delay, Queue Length, a	and Level of Se	ervice						
Approach	Eastbound	Westbound	١	Northbou	ınd	S	Southbou	nd
Movement	1	4	7	8	9	10	11	12
Lane Configuration		LT		LR				
v (veh/h)		8		10		1		
C (m) (veh/h)		1497		933		1	i	1
v/c		0.01		0.01		†		_
95% queue length		0.02		0.03	+	1		+
Control Delay (s/veh)		7.4		8.9		+		_
LOS		7.4 A		6.9 A	_	+	 	+
						+	<u> </u>	
Approach Delay (s/veh)				8.9		+		
Approach LOS	orida. All Rights Res			A	ersion 5.6			7/2011 8:46 PI

HCS+TM Version 5.6

	TW	O-WAY STOP	CONTR	OL SI	JMM	IARY				
General Information	n		Site I	nform	atio	n				
Analyst	R Marvin		Interse	ection			Dover & I	Bitteroc	ot .	
Agency/Co.	Marvin A	ssociates	Jurisdi	ction			MDT			
Date Performed	12/8/201		Analys	is Year	r		Existing 2	2010		
Analysis Time Period	PM Desig	gn Hour								
Project Description Bi	llings Bypass									
East/West Street: Dove						: Bittero	ot			
Intersection Orientation:	East-West		Study F	Period ((hrs):	0.25				
Vehicle Volumes a	<u>nd Adjustme</u>									
Major Street	<u> </u>	Eastbound					Westbou	nd _		
Movement	1	2	3			4	5 T			6
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	L	T	R			L				R
Volume (veh/h) Peak-Hour Factor, PHF	1.00	51 0.80	38 0.80			10 0.70	29 0.70	-	1	00
Hourly Flow Rate, HFR				1				-		
(veh/h)	0	63	47			14	41			0
Percent Heavy Vehicles	0					1				
Median Type				Undiv	rided					
RT Channelized			0							0
Lanes	0	1	0			0	1			0
Configuration			TR			LT				
Upstream Signal		0					0			
Minor Street		Northbound	_				Southbou	ınd		
Movement	7	8	9			10	11			12
	L	Т	R			L	Т			R
Volume (veh/h)	22		6							
Peak-Hour Factor, PHF	0.60	1.00	0.60	<u> </u>		1.00	1.00		1.	00
Hourly Flow Rate, HFR (veh/h)	36	0	9			0	0			0
Percent Heavy Vehicles	1	0	1			0	0			0
Percent Grade (%)	ĺ	3					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0							0
Lanes	0	0	0			0	0			0
Configuration		LR								
Delay, Queue Length, a	and Level of Se	ervice								
Approach	Eastbound	Westbound	1	Northbo	ound		S	outhbo	und	
Movement	1	4	7	8		9	10	11		12
Lane Configuration		LT		LR			ĺ			
v (veh/h)		14		45					\dashv	
C (m) (veh/h)		1486		837	,		1		\dashv	
v/c		0.01		0.05	5					_
95% queue length		0.03		0.17	7		ĺ		\dashv	
Control Delay (s/veh)		7.4		9.5			İ	ĺ	寸	
LOS		Α		Α			1	Ì	寸	
Approach Delay (s/veh)				9.5			1			
Approach LOS				Α						
Copyright © 2010 University of F	orido All Diabto Dos	onyod	·	tC:S+ TM			Cons	rotod: 10	0/0/201	1 3:42 F

HCS+TM Version 5.6 Generated: 12/8/2011 3:42 PM

		TW	O-WA	Y STOP	CONT	RC	DL S	UMN	JARY					
General Information	n				Site	In	form	natio	on					
Analyst		R Marvin			Inter	se	ction			Mai	ry & B	itter	oot	
Agency/Co.		Marvin As	ssociate	S	Juris	dic	ction			MD	T			
Date Performed		10/8/201			Anal	ysi	s Yea	r		Exis	sting 2	2010)	
Analysis Time Period		Peak PM	Hour											
Project Description Bi														
East/West Street: Mary						_			t: <i>Bittero</i> c	ot				
Intersection Orientation:	Eas	t-West			Study	/ P	eriod	(hrs)	: 0.25					
Vehicle Volumes ar	nd Ad	djustme												
Major Street			Eas	stbound						We	stbou	nd		
Movement		1		2		3			4		5		_	6
		<u>L</u>		Т		λ_			_ <u>L</u>		T			R
Volume (veh/h)	_	8	_	16	1.				9		17			4
Peak-Hour Factor, PHF	+	0.50		0.50	0.5	υ			0.50	├	0.50		 	0.50
Hourly Flow Rate, HFR (veh/h)		16		32	2	6			18		34			8
Percent Heavy Vehicles		0							0					
Median Type							Undi	/idea	1					
RT Channelized						0								0
Lanes		0		1	()			0		1			0
Configuration		LTR							LTR					
Upstream Signal				0							0			
Minor Street			Nor	thbound						Sou	ıthbou	ınd		
Movement		7		8	(9			10		11			12
		L		Т	F	₹			L		Т			R
Volume (veh/h)		14		27	5	5			1		26			20
Peak-Hour Factor, PHF		0.50		0.50	0.5	50			0.50		0.50		(0.50
Hourly Flow Rate, HFR (veh/h)		28		54	10	0			2		52			40
Percent Heavy Vehicles		0		0	C)			0		0			0
Percent Grade (%)				0							0			
Flared Approach				N	ĺ						Ν			
Storage				0							0			
RT Channelized						0								0
Lanes		0		1	C)			0		1			0
Configuration				LTR							LTR			
Delay, Queue Length, a	and Le	evel of Se	rvice											
Approach	East	tbound	Westl	bound		N	lorthb	ound			S	outh	bound	
Movement		1		4	7		8		9	1	0		11	12
Lane Configuration	L	.TR	Lī	ΓR			LTF	?				L	.TR	
v (veh/h)		16	1	8		\prod	92						94	
C (m) (veh/h)	1.	580	15	59			735	5				8	326	
v/c	0	0.01	0.	01		T	0.13	3				0).11	
95% queue length	0	.03	0.	04		寸	0.4	3				0	.38	
Control Delay (s/veh)	-	7.3	7.	.3		寸	10.0	6					9.9	
LOS		A		4		寸	В					_	A	
Approach Delay (s/veh)						_	10.0	 6	<u> </u>).9	!
Approach LOS							B	-		 			<u>A</u>	
Convigant © 2010 University of F					L		cs.TM			L				11 8:48

HCS+TM Version 5.6

Generated: 12/7/2011 8:48 PM

Canaral Information			C:45 I	of o vine of	tion			
General Information				nformat	tion			
Analyst	R Marvin		Interse				lawthorne	
Agency/Co.		Associates	Jurisdi			MDT		
Date Performed	10/27/20		Analys	is Year		2010 Exi	sting	
Analysis Time Period	Peak PM							
Project Description Bil			b) (I O)		,		
ast/West Street: Mary					eet: Hawtl	norne		
ntersection Orientation:			Study F	eriod (hr	rs): 0.25			
/ehicle Volumes ar	<u>nd Adjustme</u>							
Major Street		Eastbound	_			Westbou	ınd	
Movement	1	2	3		4	5		6
	L	Т	R		L	Т		R
/olume (veh/h)		38	35		1	29		
Peak-Hour Factor, PHF	1.00	0.50	0.50		0.50	0.50		1.00
lourly Flow Rate, HFR veh/h)	0	76	70		2	58		0
Percent Heavy Vehicles	0				0			
/ledian Type				Undivid	ed			
RT Channelized			0					0
anes	0	1	0		0	1		0
Configuration	1	Ī	TR		LT			
Jpstream Signal	1	0				0		
Minor Street	i	Northbound	•	i		Southboo	ınd	
Movement	7	8	9		10	11	1	12
	L	T	R		L	T	\neg	R
/olume (veh/h)	19	<u>'</u>	1	-+		+	_	
Peak-Hour Factor, PHF	0.50	1.00	0.50		1.00	1.00		1.00
Hourly Flow Rate, HFR			1				\neg	
veh/h)	38	0	2		0	0		0
Percent Heavy Vehicles	0	0	5		0	0		0
Percent Grade (%)		0				0		
Flared Approach		N				N		
Storage		0				0		
RT Channelized			0	Ī		1		0
_anes	0	0	0		0	0	$\overline{}$	0
Configuration	1	LR	1		-	 		
Delay, Queue Length, a	nd Level of S							
pproach	Eastbound	Westbound	N	Northbou	nd		Southboun	d
Novement	1	4	7	8	9	10	11	12
	I				+ 3	10	''	12
ane Configuration		LT		LR			<u> </u>	
(veh/h)		2		40				
C (m) (veh/h)		1448		826				
/c		0.00		0.05				\perp
5% queue length		0.00		0.15	1		1	
Control Delay (s/veh)		7.5		9.6	1	1	1	\dagger
OS		A A		A	+	+	1	
						+	<u> </u>	
Approach Delay (s/veh)				9.6				
Approach LOS				Α		1		

	TW	O-WAY STOP	CONTR	OL SI	JMI	MARY				
General Informatio	n		Site I	nform	natio	on				
Analyst	R Marvin		Interse				Mary & B	Bench		
Agency/Co.		Associates	Jurisdi				MDT			
Date Performed	10/27/20	11	Analys	sis Yea	r		Existing 2	2010		
Analysis Time Period	Peak PM	Hour								
	llings Bypass		•							
East/West Street: Mary						t: Bench	Blvd			
Intersection Orientation:			Study I	Period	(hrs)	: 0.25				
Vehicle Volumes a	<u>nd</u> Adjustme									
Major Street	<u> </u>	Northbound					Southbou	ınd r		
Movement	1	2	3			4	5 T			6
Volume (veh/h)	L	106	R 32			6	57			R
Peak-Hour Factor, PHF	1.00	0.75	0.75			0.70	0.70	\dashv		1.00
Hourly Flow Rate, HFR			1	' 				-		
(veh/h)	0	141	42			8	81			0
Percent Heavy Vehicles	0					0				
Median Type				Undiv	/idec	1				
RT Channelized			0							0
Lanes	0	1	0			0	1			0
Configuration			TR			LT				
Upstream Signal		0					0			
Minor Street		Eastbound					Westbou	ınd		
Movement	7	8	9			10	11			12
	L	Т	R			L	Т			R
Volume (veh/h)		66	6			59				6
Peak-Hour Factor, PHF	1.00	0.75	0.75	5		0.70	1.00		(0.70
Hourly Flow Rate, HFR (veh/h)	0	88	8			84	0			8
Percent Heavy Vehicles	0	0	0			0	0			0
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0				ĺ	Ĩ		0
Lanes	0	1	0		0		0			0
Configuration	Ī		TR				LR	ĺ		
Delay, Queue Length, a	and Level of Se	ervice						,,		
Approach	Northbound	Southbound	,	Westbo	ound		[Eastbo	ound	
Movement	1	4	7	8		9	10	1	1	12
Lane Configuration		LT		LR						TR
v (veh/h)		8		92						96
C (m) (veh/h)		1404		590			1			648
v/c		0.01		0.16			<u> </u>			0.15
95% queue length		0.02		0.5						0.52
Control Delay (s/veh)		7.6		12.2						11.5
LOS		7.0 A		12.2 B	=		 	\vdash		11.5 B
					,			11	E	B
Approach Delay (s/veh)				12.2				11.		
Approach LOS	orida. All Rights Res			В		ion 5.6		В)11 8:48 PM

HCS+TM Version 5.6

	1 44	O-WAY STOP	CONTR	OL 30	IMIMALI			
General Information	n		Site I	nforma	ation			
Analyst	R Marvin		Interse	ection		Dover &	Highway	312
Agency/Co.	Marvin A		Jurisdi			MDT		
Date Performed	12/8/201		Analys	is Year		Existing 2	2010	
Analysis Time Period	PM Desig	gn Hour						
Project Description Bil			,					
East/West Street: High					reet: Dover	Road		
ntersection Orientation:	East-West		Study I	Period (ł	nrs): 0.25			
Vehicle Volumes ar	nd Adjustme	ents						
Major Street		Eastbound				Westbou	nd	
Movement	1	2	3		4	5		6
	L	Т	R		L	Т		R
/olume (veh/h)	1.00	574	69		20	272		1.00
Peak-Hour Factor, PHF	1.00	0.92	0.92	-	0.90	0.90		1.00
Hourly Flow Rate, HFR veh/h)	0	623	74		22	302		0
Percent Heavy Vehicles	0				4			
Median Type			Two V	Vay Left	Turn Lane	•		
RT Channelized			0					0
_anes	0	2	0		1	2		0
Configuration		T	TR		L	Т		
Jpstream Signal		0				0		
Minor Street		Northbound				Southboo	ınd	
Movement	7	8	9		10	11		12
	L	Т	R		L	Т		R
/olume (veh/h)	36		16					
Peak-Hour Factor, PHF	0.60	1.00	0.60	'	1.00	1.00		1.00
Hourly Flow Rate, HFR veh/h)	59	0	26		0	0		0
Percent Heavy Vehicles	4	0	4		0	0		0
Percent Grade (%)		2				0		
-lared Approach		N				N		
Storage		0				0		
RT Channelized			0					0
_anes	1	0	1		0	0		0
Configuration	L		R					
Delay, Queue Length, a	nd Level of Se	ervice	•	-		"		
Approach	Eastbound	Westbound	١	Vorthboo	und	S	outhbour	nd
Movement	1	4	7	8	9	10	11	12
_ane Configuration		L	L		R	†	ì	
/ (veh/h)		22	59		26			1
C (m) (veh/h)		882	358		674		†	1
//c		0.02	0.16		0.04	+	 	+
95% queue length		0.02	0.78		0.12	+	 	+
		9.2	17.0		10.6	+		+-
Control Delay (s/veh)						+		+
_OS		Α	С		В	+	<u> </u>	
Approach Delay (s/veh)				15.0				
Approach LOS				С		1		

HCS+TM Version 5.6

Generated: 12/8/2011 3:36 PM

	TW	O-WAY STOP	CONTR	OL SI	JMN	MARY				
General Information	n		Site I	nform	atio	on .				
Analyst	R Marvin		Interse	ection			Main & B	ench	US87	
Agency/Co.		Associates	Jurisdi				MDT			
Date Performed	10/27/20	11	Analys	is Yea	r		2010 Exs	iting		
Analysis Time Period	Peak PM									
	llings Bypass		-							
East/West Street: Main						t: Bench l	US87			
Intersection Orientation:	East-West		Study I	Period ((hrs)	: 0.25				
Vehicle Volumes ar	<u>nd Adjustme</u>									
Major Street		Eastbound	1 0				Westbou	nd r		
Movement	1	2 	3			4	5 T			6
Volume (veh/h)	302	541	R			49	330			R 3
Peak-Hour Factor, PHF	0.90	0.90	1.00)		0.88	0.88		().88
Hourly Flow Rate, HFR								_		
(veh/h)	335	601	0			55	375			3
Percent Heavy Vehicles	5					0				
Median Type				Raised	d cur	b .				
RT Channelized			0							0
Lanes	1	2	0			1	2			0
Configuration	L	T				L	Т			TR
Upstream Signal		1					0			
Minor Street		Northbound	1				Southbou	ınd		
Movement	7	8	9			10	11			12
	L	T	R			L	Т			R
Volume (veh/h)	2	25	85			8	13			194
Peak-Hour Factor, PHF Hourly Flow Rate, HFR	0.75	0.75	0.75	'		0.80	0.80	_	ι	0.80
(veh/h)	2	33	113			9	16		2	242
Percent Heavy Vehicles	0	0	0			1	0			5
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0							0
Lanes	0	1	1		0		1		1	
Configuration	LT		R			LT		Ì		R
Delay, Queue Length, a	and Level of Se	ervice	,							
Approach	Eastbound	Westbound	ľ	Northbo	ound		S	outhb	ound	
Movement	1	4	7	8		9	10	1	1	12
Lane Configuration	L	L	LT			R	LT			R
v (veh/h)	335	55	35			113	25			242
C (m) (veh/h)	1156	1071	59			902	51			842
v/c	0.29	0.05	0.59			0.13	0.49			0.29
95% queue length	1.21	0.16	2.42			0.43	1.84			1.19
Control Delay (s/veh)	9.4	8.5	131.5			9.6	130.4			11.0
LOS	A	A	F			A	F			В
Approach Delay (s/veh)			'	38.4	1	- ' '	'	22.	2	
Approach LOS				E	•			C		
Copyright © 2010 University of FI		!	L	HCS+TM	14	F C	Gono			11 8:45 PM

HCS+TM Version 5.6

Generated: 12/7/2011 8:45 PM

HCM Analysis Summary

Existing 2010 Wicks Lane/Main Street Area Type: Non CBD
R Marvin 10/12/2011 Analysis Duration: 15 mins.
Peak PM Hour Case: WICKSM~1

Pea	ak PM Ho	ur						Case	e: WIC	ĊKS	M~1				Daraci	011. 15	
	Lanes						Geom	etry: Mo	ovemen	ts Sei	rviced b	y Lane ar	d Lane W	idths (f	eet)		
	Approach (Outbour	nd	Lane	1		Lane	e 2]	Lane	3	Laı	ne 4	La	ane 5	La	ne 6
EB	3	2		L	12.0	7	Γ	12.0	TR		12.0						
WB	3	2		L	12.0	L	т	12.0	TR		12.0						
NB	5	3		L	12.0	I		12.0	Т		12.0	Т	12.0	TR	12.0		
SB	4	3		L	12.0	7	Γ	12.0	Т		12.0	TR	12.0				
					East				Wes	t			North			South	
	Data			L	Т	I	۲	L	Т		R	L	Т	R	L	Т	R
Move	ement Volun	ne (vph)) 1	158	306	2:	35	386	274		26	468	1098	228	38	553	93
PHF			0	.90	0.90	0.9	90	0.90	0.90)	0.90	0.90	0.90	0.90	0.90	0.90	0.90
% He	avy Vehicle	es		0	0		0	0	0		0	0	2	1	0	2	0
Lane	Groups			L	TR			L	LTR	2		L	TR		L	TR	
Arriv	al Type			5	5			3	3			5	5		4	4	
RTO	R Vol (vph)				80				5				80			30	
Peds/	Hour				0				5				5			5	
% Gr	ade				0				0				0			0	
Buses	s/Hour				0				0				0			0	
Parke	ers/Hour (Le	ft Right)							-							
Signa	al Settings: A	Actuated			Operat	ional A	analys	is	Су	cle L	ength:	120.0 Sec	:	Lost Tin	ne Per Cy	Cycle: 18.0 Sec	
Phase	e:	1		2	2	3	3	4			5	6		7	8	Pe	ed Only
EB								LT	'n								
WB						L'	ГР										
NB		L		Т	P												
SB		L			P												
Greei		21.			5.0		5.0	20			Т						0
Yello	w All Red	3.0	0.0	3.5	1.5	3.5	1.5	3.5	1.5								

			Conor	city Analysis R	aculta				Annua	oh.
	T							I	Approa	CII.
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay	
App	Group	(vph)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB										
	L	301	0.098	0.167	L	0.585	48.1	D	58.3	E
	* TR	571	0.149	0.167	TR	0.897	61.8	Е		
WB										
	* L	376	0.166	0.208	L	0.798	55.7	Е	48.9	D
	LTR	736	0.129	0.208	LTR	0.620	44.4	D		
NB										
	* L	613	0.148	0.175	L	0.848	54.8	D	44.1	D
	* TR	1498	0.277	0.300	TR	0.924	40.1	D		
SB										
	L	316	0.023	0.175	L	0.133	42.7	D	35.0	D
	TR	1502	0.137	0.300	TR	0.455	34.6	С		

Intersection: Delay = 45.8 sec/veh SIG/Cinema v3.08

Int. LOS=D $X_c = 0.87$

* Critical Lane Group

 \sum (v/s)Crit= 0.74

Page 1

NETSIM Summary Results

Existing 2010 R Marvin Peak PM Hour Wicks Lane/Main Street 10/12/2011 Case: WICKSM~1

App EB	Lane Group L TR	Queues Per Lane Avg/Max (veh) 3 / 7 3 / 6	Average Speed (mph) 7.6 13.5	Spillback in Worst Lane (% of Peak Period) 0.0 0.0	553 93 38
	All		11.8	0.0	<u></u>
WB	L	7/9	4.1	0.0	
	LTR	7 / 8	8.6	0.0	
					158 —
	All		7.2	0.0	306 →
NB	L	9/9	4.0	0.0	
	TR	7 / 10	8.9	0.0	
					468 228
	All		6.8	0.0	
SB	L	3 / 5	3.2	0.0	1 2 1 3 4
	TR	2 / 5	14.9	0.0	
					21 3 0 35 4 2 24 4 2 19 4
	All		11.8	0.0	
	Inte	rsect.	8.1		

SIG/Cinema v3.08 Page 2

HCM Analysis Summary

Existing 2010 Airport Road/Main Street Area Type: Non CBD R Marvin 10/12/2011 Analysis Duration: 15 mins. Peak PM Hour Case: AIRPOR~1 Geometry: Movements Serviced by Lane and Lane Widths (feet) Lanes Approach Outbound Lane 1 Lane 2 Lane 3 Lane 4 Lane 5 Lane 6 EB 3 L 12.0 LT 12.0 R 12.0 2 LT WB 2 12.0 R 12.0 NB 4 3 L 12.0 T 12.0 T 12.0 TR 12.0 SB4 3 L 12.0 Т 12.0 T 12.0 TR 12.0 East West North South Т T T R T Data L R L R L L R Movement Volume (vph) 576 12 26 24 89 142 2757 9 69 1743 265 0.93 0.93 0.93 0.93 0.93 0.93 0.93 0.93 0.93 0.93 0.93 PHF 0.93 % Heavy Vehicles 2 0 4 2 0 LT R LT TR TR Lane Groups L R L L Arrival Type 3 3 3 3 5 5 RTOR Vol (vph) 20 30 0 100 5 0 5 5 Peds/Hour % Grade 0 0 0 0 Buses/Hour 0 0 0 0 Parkers/Hour (Left|Right) Cycle Length: 150.0 Sec Signal Settings: Actuated Operational Analysis Lost Time Per Cycle: 20.0 Sec Phase: 2 4 5 7 8 Ped Only 6 EB LTP R

			Capac	city Analysis R	esults				Approa	ch:
App EB	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
LD	L	378	0.175	0.213	L	0.817	68.5	Е	70.4	Е
	* LT	379	0.182	0.213	LT	0.852	72.8	Е		
	R	515	0.004	0.333	R	0.012	33.5	С		
WB										
	LT	86	0.037	0.047	LT	0.791	106.1	F	114.1	F
	* R	75	0.039	0.047	R	0.840	122.7	F		
NB										
	L	177	0.086	0.100	L	0.864	101.0	F	38.4	D
	* TR	2846	0.585	0.560	TR	1.045	35.2	D		
SB										
	* L	84	0.041	0.047	L	0.881	138.0	F	15.0	В
	TR	2609	0.409	0.520	TR	0.786	10.6	В		

 $X_c = 0.98$

Intersection: Delay = 35.2 sec/veh SIG/Cinema v3.08

WB

NB SB

Green

Yellow All Red

Int. LOS=D

LTP

7.0

1.5

3.5

32.0

1.5

3.5

LTP

15.0

0.0

3.0

ΤP

TP

66.0

1.5

3.5

LTR

3.5

7.0

1.5

* Critical Lane Group

 \sum (v/s)Crit= 0.85

Page 1

0

NETSIM Summary Results

Existing 2010 R Marvin Peak PM Hour Airport Road/Main Street 10/12/2011 Case: AIRPOR~1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	1743 265 69
EB	L	11 / 12	5.0	0.0	
	LT	11 / 11	6.5	0.0	→ 89 → 39 → 24
	R	1 / 1	17.4	0.0	\downarrow
	All		5.9	0.0	
					<u> </u>
WB	LT	3 / 4	5.3	0.0	
	R	3 / 4	9.8	0.0	576 -
	All		7.8	0.0	576 — 12 — 14 14 17 17 17 17 17 17
NB	L	5 / 8	4.6	0.0	26 —
	TR	17 / 21	9.4	1.4	
					142 9 2757
	All		9.1	1.4	
SB	L	4 / 7	3.4	0.0	1 2 3 4 1
	TR	6 / 10	15.2	0.0	
					31 4 2 6 4 2 15 3 0 65
	All		13.7	0.0	
	Inte	rsect.	9.7		6 4 2

SIG/Cinema v3.08 Page 2

HCM Analysis Summary

Existing 2010 1st Ave N/ Area Type: Non CBD R Marvin 10/12/2011 Analysis Duration: 15 mins. Peak PM Hour Case: US87MA~1

Pea	ak PM Ho	our					Case	e: US87	MA~1						
	Lanes					Geom	etry: Mo	vements	Serviced b	y Lane ar	nd Lane W	idths (f	eet)		
	Approach	Outbound	L	ane 1		Lane	e 2	La	ne 3	La	ne 4	La	ne 5	La	ne 6
EB	4	2	L	12.0		L	12.0	L	12.0	Т	12.0				
WB	3	2	T	12.0		Т	12.0	R	12.0						
NB	0	3													
SB	4	0	L	12.0		L	12.0	R	12.0	R	12.0				
				East				West	•		North			South	
	Data		L	Т		R	L	Т	R	L	Т	R	L	Т	R
Move	ement Volui	ne (vph)	1207	318		0	0	345	899	0	0	0	889	0	429
PHF			0.93	0.93	0	.90	0.90	0.93	0.93	0.90	0.90	0.90	0.93	0.90	0.93
% He	avy Vehicle	es	2	2		2	2	2	4	2	2	2	4	2	2
Lane	Groups		L	T				Т	R				L		R
Arriv	al Type		5	5				3	3				5		5
RTO	R Vol (vph)			0				200			0			0	
Peds/	Hour			5				0			0			0	
% Gr	ade			0				0			0			0	
Buses	s/Hour			0				0			0			0	
Parke	ers/Hour (Le	eft Right)		-											
Signa	l Settings: A	Actuated		Opera	tional	Analys	is	Cycle	e Length:	140.0 Sec	с	Lost Tim	e Per Cyc	le: 10.0 S	ec
Phase	e:	1		2		3	4		5	6		7	8	Pe	d Only
EB		LT													
WB				TP		R									
NB															
SB		R				_ P									
Greei		45.0		25.0	_	55.0	1								0
Yello	w All Red	3.5 1	1.5 3	.5 1.5	3.5	1.5									

		Como	iter Amaleraia D	14a				A	ala.
		Capac	ity Analysis R	esuits	1	1	1	Approa	CII:
Lane	Cap	v/s	g/C	Lane	v/c	Delay		Delay	
Group	(vpĥ)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
				_					
k L	1655	0.252	0.321	L	0.784	33.3	C	32.8	C
T	599	0.184	0.321	T	0.571	30.9	С		
Т	632	0.105	0.179	Т	0.587	53.7	D	34.8	С
k R	943	0.484	0.607	R	0.797	25.4	С		
L	1323	0.284	0.393	L	0.723	23.9	С	16.2	В
R	2090	0.165	0.750	R	0.221	0.2	A		
		_						_	
	T R	T 632 R 943	T 632 0.105 R 943 0.484 L 1323 0.284	Group (vph) Ratio Ratio L 1655 0.252 0.321 T 599 0.184 0.321 T 632 0.105 0.179 R 943 0.484 0.607 L 1323 0.284 0.393	L 1655 0.252 0.321 L T 599 0.184 0.321 T T 632 0.105 0.179 T R 943 0.484 0.607 R L 1323 0.284 0.393 L	L 1655 0.252 0.321 L 0.784 T 599 0.184 0.321 T 0.571 T 632 0.105 0.179 T 0.587 R 943 0.484 0.607 R 0.797 L 1323 0.284 0.393 L 0.723	L 1655 0.252 0.321 L 0.784 33.3 T 599 0.184 0.321 T 0.571 30.9 T 632 0.105 0.179 T 0.587 53.7 R 943 0.484 0.607 R 0.797 25.4 L 1323 0.284 0.393 L 0.723 23.9	L 1655 0.252 0.321 L 0.784 33.3 C T 599 0.184 0.321 T 0.571 30.9 C T 632 0.105 0.179 T 0.587 53.7 D R 943 0.484 0.607 R 0.797 25.4 C L 1323 0.284 0.393 L 0.723 23.9 C	L 1655 0.252 0.321 L 0.784 33.3 C 32.8 T 599 0.184 0.321 T 0.571 30.9 C T 632 0.105 0.179 T 0.587 53.7 D 34.8 R 943 0.484 0.607 R 0.797 25.4 C L 1323 0.284 0.393 L 0.723 23.9 C 16.2

Intersection: Delay = 27.7 sec/veh SIG/Cinema v3.08

Int. LOS=C

 $X_{c} = 0.79$

* Critical Lane Group

 \sum (v/s)Crit= 0.74

Page 1

NETSIM Summary Results

Existing 2010 R Marvin Peak PM Hour 1st Ave N/ 10/12/2011 Case: US87MA~1

App EB	Lane Group L T	Queues Per Lane Avg/Max (veh) 10 / 19 3 / 3	Average Speed (mph) 5.3 13.6	Spillback in Worst Lane (% of Peak Period) 0.0	429 889
	All		6.0	0.0	
WB	T	6/9	6.1	0.0	 -
	R	7 / 8	15.7	0.0	
	All		11.0	0.0	1207 —
					318
	All		6.1	0.0	
SB	L	18 / 24	4.5	0.0	
	R	1 / 2	22.5	0.0	44 4 2 24 4 2 54 4 2
	Inte	rsect.	7.0		

SIG/Cinema v3.08 Page 2

HCM Analysis Summary

Existing 2010

R Marvin
PM Design Hour

Case: WBRAMP~1

Lanes

Geometry: Movements Serviced by Lane and Lane Widths (feet)

Approach Outbound

Lane 1

Lane 2

Lane 3

Lane 4

Lane 5

Lane 6

	Lanes				Ge	eometry:	Move	ments	Serviced b	y Lane ar	nd Lane W	idths (f	eet)		
	Approach	Outbound	La	ine 1	I	Lane 2		La	ne 3	Laı	ne 4	La	ine 5	La	ne 6
ЕВ	2	2	Т	12.0) TR	12.0	0								
WB	3	2	L	12.0) T	12.0	0	T	12.0						
NB	0	0													
SB	1	1	LTR	12.0)										
				Eas	t			West			North			South	
	Data		L	Т	R	L		T	R	L	Т	R	L	Т	R
Move	ment Volui	me (vph)	0	776	323	14:	5	696	0	0	0	0	9	2	289
PHF			0.90	0.90	0.90	0.90	0	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
% He	avy Vehicle	es	2	5	5	1		5	2	2	2	2	1	0	5
Lane	Groups			TR		L		T						LTR	
Arriva	al Type			2		2		2						3	
RTOI	R Vol (vph))		120)			0			0			80	
Peds/	Hour			0				5			0			0	
% Gra	ade			0				0			0			0	
Buses	/Hour			0				0			0			0	
Parke	rs/Hour (Le	eft Right)													
Signa	l Settings: A	Actuated		Opera	ational Ana	alysis		Cycle	Length:	90.0 Sec	;	Lost Tin	ne Per Cyc	le: 14.0 S	Sec
Phase	:	1		2	3		4		5	6		7	8	Pe	ed Only
EB				TR											
WB		LT		LT											
NB															
SB					LTR										
Green	1	10.0		44.0	22.0)									0
Yello	w All Red	4.0	0.0 3.:	5 1.5	3.5	1.5									

			Capac	city Analysis R	esults				Approa	ch:
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
EB	Огоцр	(121)	111110	744470	Огоцр	7111170	(800/ 1011)	200	(800, 1011)	200
	* TR	1628	0.327	0.489	TR	0.668	23.6	С	23.6	C
WB	Lper	134	0.000	0.544					12.1	В
	* Lpro	199	0.090	0.111	L	0.483	15.8	В		
	T	2216	0.225	0.644	T	0.349	11.4	В		
SB										
	* LTR	385	0.155	0.244	LTR	0.634	33.0	C	33.0	C

Intersection: Delay = 19.9 sec/veh SIG/Cinema v3.08

Int. LOS=B

 $X_{c} = 0.68$

* Critical Lane Group

 \geq (v/s)Crit= 0.57

Page 1

NETSIM Summary Results

Existing 2010 R Marvin PM Design Hour Old US 87/I90 WB On Ramp 10/13/2011 Case: WBRAMP~1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	2 289 9 ,
EB	TR	10 / 14	12.0	0.0	← 696
	All		12.0	0.0	
WB	L	1/3	7.7	0.0	
	Т	0 / 1	25.5	0.0	
	All		21.2	0.0	776 → 323 →
	All		16.6	0.0	
					$oxed{1}$
SB	LTR	3 / 5	16.6	0.0	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
					10 4 0 43 4 2 21 4 2
	Inte	rsect.	14.9		

SIG/Cinema v3.08 Page 2

HCM Analysis Summary

Old US 87/I90 EB Off Ramp Area Type: Non CBD Existing 2010 R Marvin 10/13/2011 Analysis Duration: 15 mins. Peak PM Hour Case: EBRAMP~2 Lanes Geometry: Movements Serviced by Lane and Lane Widths (feet) Approach Outbound Lane 2 Lane 4 Lane 1 Lane 3 Lane 5 Lane 6

	Арргоасп	Outboulla	Lai	IIC I	Lai	IC 2	1	zanc 5	La	IC 4		anc 3	La	iic o
EB	3	2	L	12.0	Т	12.0	Т	12.0						
WB	2	2	Т	12.0	TR	12.0								
NB	2	1	L	12.0	TR	12.0								
SB	0	0												
				East			West			North			South	
	Data		L	Т	R	L	Т	R	L	Т	R	L	Т	R
Move	ment Volu	me (vph)	360	426	0	0	375	10	466	1	222	0	0	0
PHF			0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
% He	avy Vehicle	es	4	1	2	2	2	2	5	0	2	2	2	2
Lane	Groups		L	Т			TR		L	TR				
Arriva	al Type		3	3			3		3	3				
RTOF	R Vol (vph))		0			5			100			0	
Peds/l	Hour			5			0			0			5	
% Gra	ade			0			0			0			0	
Buses	/Hour			0			0			0			0	
Parke	rs/Hour (Le	eft Right)												
Signa	l Settings:	Actuated		Operation	onal Analy	sis	Сус	cle Length:	100.0 Sec	;	Lost Tir	ne Per Cyc	le: 9.0 S	Sec
Phase	:	1		2	3	4	-	5	6		7	8	Pe	ed Only
EB		LT	1	LT										
WB				TR										
NB					LTP									
SB											·			
Green	1	18.0	3	30.0	38.0				ļ ,					0

		T	Capac	city Analysis R	lesults	1	1		Approa	ch:
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
EB	* Lper	232	0.133	0.350					18.3	В
	* Lpro	312	0.180	0.180	L	0.735	23.8	C		
	T	1858	0.132	0.520	T	0.255	13.6	В		
WB										
	TR	1060	0.120	0.300	TR	0.399	29.0	С	29.0	С
NB										
	* L	651	0.303	0.380	L	0.796	33.8	C	31.2	C
	TR	602	0.086	0.380	TR	0.228	21.1	С		

Intersection: Delay = 24.9 sec/veh SIG/Cinema v3.08

Yellow All Red

0.0

3.5

1.5

3.5

1.5

Int. LOS=C

 $X_{c} = 0.68$

* Critical Lane Group

 \sum (v/s)Crit= 0.62

Page 1

NETSIM Summary Results

Existing 2010 R Marvin Peak PM Hour Old US 87/I90 EB Off Ramp 10/13/2011 Case: EBRAMP~2

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)
EB	L	9 / 14	6.8	0.0
	Т	4 / 5	18.8	0.0
	All		12.9	0.0
WB	TR	4 / 6	10.2	0.0
	All		10.2	0.0
NB	L	10 / 12	9.4	0.0
	TR	2/2	20.6	0.0
	All		11.2	0.0
	Inte	rsect.	11.6	

SIG/Cinema v3.08 Page 2

HCM Analysis Summary

Old US 87/I90 EB Off Ramp Area Type: Non CBD Existing 2010 R Marvin 10/13/2011 Analysis Duration: 15 mins. Peak PM Hour Case: EBRAMP~2 Lanes Geometry: Movements Serviced by Lane and Lane Widths (feet) Approach Outbound Lane 2 Lane 4 Lane 1 Lane 3 Lane 5 Lane 6

Approach Outbound			Lanc 1		Lanc 2		Lanc 3		Lanc 4			anc 3	La	Lanc 0	
EB	3	2	L	12.0	Т	12.0	Т	12.0							
WB	2	2	Т	12.0	TR	12.0									
NB	2	1	L	12.0	TR	12.0									
SB	0	0													
			East			West			North			South			
Data			L	Т	R	L	Т	R	L	Т	R	L	Т	R	
Movement Volume (vph)			360	426	0	0	375	10	466	1	222	0	0	0	
PHF	PHF			0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
% He	% Heavy Vehicles			1	2	2	2	2	5	0	2	2	2	2	
Lane	Lane Groups			Т			TR		L	TR					
Arriva	Arrival Type			3			3		3	3					
RTOR Vol (vph)			0			5			100			0			
Peds/Hour			5			0			0			5			
% Grade			0			0			0			0			
Buses/Hour			0			0			0			0			
Parke	Parkers/Hour (Left Right)														
Signal Settings: Actuated				Operation	onal Analy	rsis Cycle Length:			100.0 Sec Lost Tir			me Per Cycle: 9.0 Sec			
Phase	Phase: 1		2		3	4	-	5	6		7	8 P		ed Only	
EB		LT	1	LT											
WB				TR											
NB		LTP		LTP											
SB															
Green	1	18.0	3	30.0	38.0				ļ ,					0	

Capacity Analysis Results Approach:											
	Approach:										
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS	
EB	* Lper	232	0.133	0.350					18.3	В	
	* Lpro	312	0.180	0.180	L	0.735	23.8	C			
	T	1858	0.132	0.520	T	0.255	13.6	В			
WB											
	TR	1060	0.120	0.300	TR	0.399	29.0	С	29.0	С	
NB											
	* L	651	0.303	0.380	L	0.796	33.8	C	31.2	C	
	TR	602	0.086	0.380	TR	0.228	21.1	С			

Intersection: Delay = 24.9 sec/veh SIG/Cinema v3.08

Yellow All Red

0.0

3.5

1.5

3.5

1.5

Int. LOS=C

 $X_{c} = 0.68$

* Critical Lane Group

 \sum (v/s)Crit= 0.62

Page 1

Existing 2010 R Marvin Peak PM Hour Old US 87/I90 EB Off Ramp 10/13/2011 Case: EBRAMP~2

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)
EB	L	9 / 14	6.8	0.0
	T	4 / 5	18.8	0.0
	All		12.9	0.0
WB	TR	4 / 6	10.2	0.0
	All		10.2	0.0
NB	L	10 / 12	9.4	0.0
	TR	2/2	20.6	0.0
	All		11.2	0.0
	Inte	rsect.	11.6	

General Information			Site Ir	form	ation				
					ation		14/0.5		
Analyst	R Marvin		Interse			Johnson WB Ramps			
Agency/Co.	Marvin As		Jurisdio			MDT Fixiation			
Date Performed Analysis Time Period	10/10/20 ⁻ Peak PM		Anaiys	is Year		Existing I	-IVI		
	<u> </u>	Hour							
Project Description Bil			North/South Street: Johnson Lane						
ast/West Street: WB F						on Lane			
ntersection Orientation:			Study P	rerioa (hrs): <i>0.25</i>				
Vehicle Volumes ar	<u>ıd Adjustme</u>								
Major Street		Northbound				Southbou	ınd		
Movement	1 1	2	3		4	5		6	
	L	T	R		L	T		R	
/olume (veh/h)	253	157	1.00	\longrightarrow	1.00	186		63	
Peak-Hour Factor, PHF Hourly Flow Rate, HFR	0.80	0.80	1.00	\dashv	1.00	0.80		0.80	
veh/h)	316	196	0		0	232		78	
Percent Heavy Vehicles	8				0				
Median Type				Undivi	ided		,		
RT Channelized			0					0	
_anes	1	1	0		0	1		1	
Configuration	L	T				Т		R	
Jpstream Signal		0				0			
Minor Street		Eastbound				Westbou	nd		
Movement	7	8	9		10	11		12	
	L	Т	R		L	Т		R	
/olume (veh/h)			1		82	1		38	
Peak-Hour Factor, PHF	1.00	1.00	1.00		0.75	1.00		0.75	
Hourly Flow Rate, HFR	0	0	0		109	0		50	
veh/h)								40	
Percent Heavy Vehicles	0	0	0		8	0		10	
Percent Grade (%)		0	1			0	ı		
Flared Approach	1	N				N			
Storage		0				0			
RT Channelized			0					0	
_anes	0	0	0		0	0		0	
Configuration						LR			
Delay, Queue Length, a	nd Level of Se	ervice							
Approach	Northbound	Southbound	V	Vestbo	und		Eastbound		
Movement	1	4	7	8	9	10	11	12	
_ane Configuration	L	·	 	LR	- 	 	· · ·	†	
	316		 		+	+		+	
/ (veh/h)				159		+		-	
C (m) (veh/h)	1217			227				4	
//c	0.26		<u> </u>	0.70					
95% queue length	1.04			4.56					
Control Delay (s/veh)	9.0			51.1					
_OS	Α			F		1			
Approach Delay (s/veh)			<u>'</u>	51.1		1			
1 1 22.2 = 3.07 (3, 1011)			}	F		+			

Existing 2010 Old Hardin Road/Johnson lane Area Type: Non CBD R Marvin 10/13/2011 Analysis Duration: 15 mins. Peak PM Hour Case: OLDHAR~1

Lanes Geometry: Movements Serviced by Lane and Lane Widths (feet)

геа	IK FIVI FIC	oui					Case	e. OL	חת	AK^{-1}						
	Lanes					Geor	netry: Mo	ovemer	nts Se	erviced b	y Lane an	d Lane V	Vidths (1	feet)		
	Approach	Outbound	L	ane 1		Lar	ne 2		Lane	3	Lar	ne 4	La	ane 5	La	ne 6
EB	2	1	L	12	.0	TR	12.0									
WB	2	1	LT	12	.0	R	12.0									
NB	2	1	L	12	.0	TR	12.0									
SB	3	1	L	12	.0	Т	12.0	R		12.0						
				Ea	st			We	st			North			South	
	Data	-	L	Т		R	L	Т		R	L	Т	R	L	Т	R
Move	ment Volur	ne (vph)	116	31	14	18	28	82	2	288	18	64	28	480	70	128
PHF			0.88	0.8	38	0.88	0.80	0.8	0	0.80	0.75	0.75	0.75	0.90	0.90	0.90
% He	avy Vehicle	es	10		0	0	0	0)	0	1	1	0	0	1	10
Lane	Groups		L	TI	R			LT		R	L	TR		L	T	R
Arriv	al Type		3	3	;			3		3	3	3		3	3	3
RTO	R Vol (vph)			:	5			60	0			5			15	
Peds/	Hour			:	5			C)			5			5	
% Gr	ade			(0			0)			0			0	
Buses	s/Hour			C)			0				0			0	
Parke	rs/Hour (Le	eft Right)		-												
Signa	l Settings: A	Actuated		Ope	ration	al Analy	sis	Cy	ycle I	Length: 1	00.0 Sec	;	Lost Tin	ne Per Cyc	le: 14.0 S	Sec
Phase	»:	1		2		3	4	ļ		5	6		7	8	Pe	ed Only
EB		LTP		LTP												
WB				LTR		R										
NB							Lī	ГР								
SB						LTP	Lī									
Greer		12.0		20.0		30.0		0.0								0
Yello	w All Red	4.0	0.0 3.	5 1.	5 4	4.0 0.0	3.5	1.5								

	1		Capac	city Analysis R	lesults				Approa	ch:
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay	
App	Group	(vph)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB	Lper	213	0.000	0.250					25.0	C
	Lpro	197	0.080	0.120	L	0.322	22.0	C		
	* TR	680	0.197	0.360	TR	0.547	26.0	C		
WB										
	LT	314	0.087	0.200	LT	0.436	35.4	D	19.9	В
	R	888	0.176	0.550	R	0.321	12.4	В		
NB										
	L	265	0.018	0.200	L	0.091	32.6	С	34.1	С
	* TR	360	0.064	0.200	TR	0.322	34.4	С		
SB	Lper	252	0.000	0.250					15.0	В
	* Lpro	542	0.295	0.300	L	0.671	16.4	В		
	T	1016	0.041	0.540	T	0.077	11.0	В		
	R	789	0.086	0.540	R	0.160	11.6	В		

 $X_{c} = 0.65$

Intersection: Delay = 20.4 sec/veh

Int. LOS=C

* Critical Lane Group

 $\sum (v/s)$ Crit= 0.56

Existing 2010 R Marvin Peak PM Hour Old Hardin Road/Johnson lane 10/13/2011 Case: OLDHAR~1

App EB	Lane Group L	Queues Per Lane Avg/Max (veh) 3 / 4 7 / 9	Average Speed (mph) 7.7 11.9	Spillback in Worst Lane (% of Peak Period) 0.0	70 128 480 ,
	110	117	11.7	0.0	
	All		10.9	0.0	
					—
WB	LT	3 / 4	17.7	0.0	→
	R	2 / 4	18.7	0.0	$\begin{array}{c c} 116 & \longrightarrow \\ 314 & \longrightarrow \end{array} \qquad \begin{array}{c c} & & & & & & & & & & & & & & & & & & &$
	All		18.0	0.0	
NB	L	1 / 2	4.7	0.0	
	TR	2/3	11.6	0.0	
					18 28 64
	All		10.5	0.0	
SB	L	7 / 10	12.8	0.0	1 2 3 11 4 11
	Т	1 / 4	19.2	0.0	$\begin{bmatrix} 1 \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ \vdots \end{bmatrix}$
	R	1 / 2	21.5	0.0	12 4 0 19 4 2 30 4 0 19
	All		14.7	0.0	
	Inte	rsect.	13.7		

0	_		lo:		•			
General Information			_	nformat	ion			
Analyst	R Marvin		Interse			Becraft &	Old Hardi	n Road
Agency/Co.		ssociates	Jurisdio			MDT		
Date Performed	10/28/20		Analys	is Year		Existing F	PM	
Analysis Time Period	Peak PM							
Project Description Bio			h u) (I O()		Cr. 1		
East/West Street: Old F					et: Becrai	t Lane		
ntersection Orientation:			Study P	Period (hrs	s): <i>0.2</i> 5			
/ehicle Volumes ar	nd Adjustme							
Major Street		Eastbound	1 0			Westbou	nd I	
Movement	1	2 	3 R		4	5 T		6 R
/olume (veh/h)	L L	400	410		30	300		K
Peak-Hour Factor, PHF	1.00	0.92	0.92		0.88	0.88	_	1.00
Hourly Flow Rate, HFR						1		
veh/h)	0	434	445		34	340		0
Percent Heavy Vehicles	0				0		Ĺ	
Median Type				Undivide	ed			
RT Channelized			0					0
_anes	0	1	0		0	1		0
Configuration	1		TR		LT		ĺ	
Jpstream Signal	1	1				0		
Minor Street	i	Northbound	•			Southbou	nd	
Movement	7	8	9		10	11	1	12
	Ī L	T	R		L	T		R
/olume (veh/h)	95	-	25			 		
Peak-Hour Factor, PHF	0.80	1.00	0.80		1.00	1.00		1.00
Hourly Flow Rate, HFR					0			0
veh/h)	118	0	31		Ü	0		U
Percent Heavy Vehicles	0	0	0		0	0		0
Percent Grade (%)		0				0		
-lared Approach		N				N		
Storage		0	1			0		
RT Channelized	1	1	0			1		0
_anes	0	0	0	- 	0	0		0
Configuration	 	LR	† 			 		
Delay, Queue Length, a	and Level of Sa		Ţ.			1		
Approach	Eastbound	Westbound	N	Vorthboun	d	S	outhbound	1
Movement	1	4	7	8	9	10	11	12
	ı	LT	'		+ =	1 10	11	+ '
_ane Configuration				LR	+			+-
/ (veh/h)		34		149	 	1		╄
C (m) (veh/h)		670		243	 			<u> </u>
//c		0.05		0.61				
95% queue length		0.16		3.63				
Control Delay (s/veh)		10.7		40.8				
OS		В		E	1			1
Approach Delay (s/veh)				40.8		+		
Approach LOS				E		+		
τρρισαστί ΕΟΟ								

	TW	O-WAY STOP	CONTR	OL SI	JMI	MARY				
General Information	n		Site I	nform	natio	on .				
Analyst	R Marvin		Interse	ection			N Frntg &	Johr	nson	
Agency/Co.	Marvin As	ssociates	Jurisdi				MDT			
Date Performed	10/8/201	1	Analys	is Yea	r		Existing 2	2010		
Analysis Time Period	Peak MP	M Hour								
	llings Bypass		-							
East/West Street: N Fro						t: Johnso	n Lane			
Intersection Orientation:	North-South		Study I	Period	(hrs)	: 0.25				
Vehicle Volumes ar	<u>nd Adjustme</u>									
Major Street	<u> </u>	Northbound	1 -				Southbou	ınd		
Movement	1	2	3			4	5 T			6
Volume (veh/h)	155	30	R 10			<u>L</u>	32			R 20
Peak-Hour Factor, PHF	0.75	0.75	0.75	:		0.50	0.50	-		2.0 0.50
Hourly Flow Rate, HFR			1	' 						
(veh/h)	206	40	13			2	64			40
Percent Heavy Vehicles	10					4				
Median Type				Undi	/idec	1				
RT Channelized			0							0
Lanes	1	1	0			1	1			0
Configuration	L		TR			L				TR
Upstream Signal		0					0			
Minor Street		Eastbound					Westbou	nd		
Movement	7	8	9			10	11			12
	L	Т	R			L	Т			R
Volume (veh/h)	23	4	192			25	7			1
Peak-Hour Factor, PHF	0.75	0.75	0.75			0.50	0.50		(0.50
Hourly Flow Rate, HFR (veh/h)	30	5	256			50	14			2
Percent Heavy Vehicles	4	4	10			4	4			4
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0							0
Lanes	1	1	0			1	1			0
Configuration	L		TR			L				TR
Delay, Queue Length, a	and Level of Se	ervice								
Approach	Northbound	Southbound	,	Westbo	ound		E	Eastbound		
Movement	1	4	7	8		9	10	1	1	12
Lane Configuration	L	L	L			TR	L			TR
v (veh/h)	206	2	50			16	30			261
C (m) (veh/h)	1439	1540	235			401	379			927
v/c	0.14	0.00	0.21			0.04	0.08			0.28
95% queue length	0.50	0.00	0.78			0.12	0.26			1.16
Control Delay (s/veh)	7.9	7.3	24.4			14.4	15.3			10.4
LOS	A	A	C			В	С	<u> </u>		В
Approach Delay (s/veh)				22.0)			10.	9	
Approach LOS				С				В		
Copyright © 2010 University of F				HCS+TM	Vorei	ion F.C	Gene			 11 8:49 PM

HCS+TM Version 5.6

Generated: 12/7/2011 8:49 PM

General Information	<u> </u>		Site Ir	nformat	ion			
					.1011	0	0 1-1	
Analyst Agency/Co.	R Marvin Marvin A	esociatos	Interse Jurisdi			MDT	& Johnsor	l
Date Performed	10/8/201			is Year		Existing 2	2010	
Analysis Time Period	Peak PM		Allalys	is rear		Existing 2	2010	
		Tioui						
Project Description Bit East/West Street: Couls	nngs Bypass		North/S	outh Stro	eet: Johns	on Long		
ntersection Orientation:					s): <i>0.25</i>	on Lane		
			Study F	enou (ni	5). 0.23			
/ehicle Volumes ar	nd Adjustme							
Major Street	 	Northbound	1 0			Southbou	und	
Movement	1	2	3		4	5 -		6
/ a l / / /	L L	T	R		L 	T 45	_	R
olume (veh/h) Peak-Hour Factor, PHF	1.00	2 0.50	28 0.50		0.50	15 0.50		1.00
Hourly Flow Rate, HFR			1	- 				
veh/h)	0	4	56		2	30		0
Percent Heavy Vehicles	0				5			
Median Type	 			Undivide		<u> 1</u>	<u>I</u>	
RT Channelized	1		0				0	
anes	0	1	0	-+	0	1	_	0
Configuration	 	'	TR	-+	LT	 		
Jpstream Signal		0	111			0	_	
/linor Street	 							
Movement	7	Eastbound 8	9		10	Westbou	ina I	12
Movement		T	+			 ''	_	
/ a l / / /	L	<u>'</u>	R		L	 '	_	2 2
/olume (veh/h) Peak-Hour Factor, PHF	1.00	1.00	1.00		38	1.00		
Hourly Flow Rate, HFR	1.00	1.00	1.00		0.50	1.00	_	0.50
veh/h)	0	0	0		76	0		4
Percent Heavy Vehicles	0	0	0		5	0		5
Percent Grade (%)	-	0				0		
Flared Approach		T N	1			1 N	1	
		_	+				_	
Storage	+	0	1 -			0		
RT Channelized	1		0		_			0
anes	0	0	0		0	0		0
Configuration			<u></u>			LR		
elay, Queue Length, a	nd Level of Se	ervice						
pproach	Northbound	Southbound	V	Vestbour	nd		Eastbound	
Novement	1	4	7	8	9	10	11	12
ane Configuration		LT		LR		1		
(veh/h)		2		80	1	1	†	†
(ven/n) C(m) (veh/h)		1525		936	+	+	 	+-
 					+	+	 	+
/c		0.00		0.09	+		 	
5% queue length		0.00		0.28			<u> </u>	
Control Delay (s/veh)		7.4		9.2				<u> </u>
OS		Α		Α				
Approach Delay (s/veh)				9.2	.,			
pproach LOS				Α		1		

	BASIC FR	EEWAY SE	GMENTS WORKSHEE	Т		
General Information			Site Information			
Analyst Agency or Company Date Performed Analysis Time Period	R Marvin Marvin Asso 12/5/2011 PM Design F		Highway/Direction of Trave From/To Jurisdiction Analysis Year	el EB N 27th to Lockwood MDT 2010 Existing		
	gs Bypass		N (A1)	□ DI-		
✓ Oper.(LOS)		I L	Des.(N)	II Plai	nning Data	
Flow Inputs Volume, V AADT	1500	veh/h veh/day	Peak-Hour Factor, PHF %Trucks and Buses, P _T	0.92 15		
Peak-Hr Prop. of AADT, K Peak-Hr Direction Prop, D DDHV = AADT x K x D		veh/h	%RVs, P _R General Terrain: Grade % Length Up/Down %	2 Level mi		
Calculate Flow Adjus	tments					
f _p E _T	0.95 1.5		E_R $f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	1.2)] 0.927		
Speed Inputs			Calc Speed Adj and	FFS		
Lane Width		ft				
Rt-Side Lat. Clearance	2	ft	f _{LW}		mph	
Number of Lanes, N	2		f _{LC}		mph	
Total Ramp Density, TRD	05.0	ramps/mi	TRD Adjustment		mph	
FFS (measured) Base free-flow Speed, BFFS	65.0	mph mph	FFS	65.0	mph	
LOS and Performanc	e Measures	3	Design (N)			
Operational (LOS) v _p = (V or DDHV) / (PHF x I x f _p) S D = v _p / S	N x f _{HV} 926 65.0 14.2	pc/h/ln mph pc/mi/ln	$\frac{\text{Design (N)}}{\text{Design LOS}}$ $v_p = (V \text{ or DDHV}) / (PHF \text{ x} \text{ x f}_p)$ S	N x f _{HV}	pc/h/ln mph	
LOS	В	рс/пп/п	$D = v_p / S$ Required Number of Lanes	s, N	pc/mi/ln	
Glossary			Factor Location			
N - Number of lanes V - Hourly volume v _p - Flow rate LOS - Level of service speed DDHV - Directional design	Number of lanes S - Speed Hourly volume D - Density Flow rate FFS - Free-flow speed - Level of service BFFS - Base free-flow d		E_R - Exhibits 11-10, 11-12 E_T - Exhibits 11-10, 11-11, f_p - Page 11-18 LOS, S, FFS, v_p - Exhibits 11-3	11-13	f _{LW} - Exhibit 11-8 f _{LC} - Exhibit 11-9 TRD - Page 11-1	

HCS 2010TM Version 6.1

Generated: 12/16/2011 5:08 PM

	BASIC FR	EEWAY SE	GMENTS WORKSHEE	Т		
General Information			Site Information			
Analyst Agency or Company Date Performed Analysis Time Period	R Marvin Marvin Asso 12/5/2011 PM Design F		Highway/Direction of Trave From/To Jurisdiction Analysis Year	l EB Lockwood to Johnson MDT 2010 Existing		
· · · · · ·	gs Bypass				. 5.	
Oper.(LOS)			Des.(N)	□ Pla	nning Data	
Flow Inputs						
Volume, V AADT	1300	veh/h veh/day	Peak-Hour Factor, PHF %Trucks and Buses, P _T	0.90 15		
Peak-Hr Prop. of AADT, K Peak-Hr Direction Prop, D DDHV = AADT x K x D		veh/h	%RVs, P _R General Terrain: Grade % Length Up/Down %	2 Level mi		
Calculate Flow Adjus	tments					
f _p E _⊤	0.95 1.5		E_R $f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	1.2 0 927		
Speed Inputs	1.0		Calc Speed Adj and			
Lane Width		ft	Caro opoca / taj ana l			
Rt-Side Lat. Clearance		ft	,		mah	
Number of Lanes, N	2	It	f _{LW}		mph	
Total Ramp Density, TRD	_	ramps/mi	f _{LC}		mph	
FFS (measured)	65.0	mph	TRD Adjustment		mph	
Base free-flow Speed, BFFS	00.0	mph	FFS	65.0	mph	
LOS and Performanc	e Measures	3	Design (N)			
Operational (LOS) v _p = (V or DDHV) / (PHF x l	N x f _{HV} 820	pc/h/ln	Design (N) Design LOS v _p = (V or DDHV) / (PHF x	N x f _{HV}	4.4	
x f _p)			x f _p)		pc/h/ln	
S D / C	65.0	mph	s		mph	
$D = v_p / S$	12.6	pc/mi/ln	$D = v_p / S$		pc/mi/ln	
LOS	В		Required Number of Lanes	s, N		
Glossary			Factor Location			
N - Number of lanes S - Speed V - Hourly volume D - Density v _p - Flow rate FFS - Free-flow speed LOS - Level of service BFFS - Base free-flow speed DDHV - Directional design hour volume		E_R - Exhibits 11-10, 11-12 E_T - Exhibits 11-10, 11-11, f_p - Page 11-18 LOS, S, FFS, v_p - Exhibits 11-3	11-13	f _{LW} - Exhibit 11-8 f _{LC} - Exhibit 11-9 TRD - Page 11-1		

HCS 2010TM Version 6.1

Generated: 12/16/2011 5:06 PM

	BASIC FR	EEWAY SE	GMENTS WORKSHEE	Т	
General Information			Site Information		
Analyst Agency or Company Date Performed Analysis Time Period	R Marvin Marvin Asso 12/5/2011 PM Design F		Highway/Direction of Trave From/To Jurisdiction Analysis Year		n to Pinehills xisting
Project Description Billing Oper.(LOS)	gs Bypass) o (N)	□ Die	oning Data
- ' '		L	Des.(N)	II Plai	nning Data
Flow Inputs Volume, V AADT Peak-Hr Prop. of AADT, K Peak-Hr Direction Prop, D DDHV = AADT x K x D	850	veh/h veh/day veh/h	Peak-Hour Factor, PHF %Trucks and Buses, P _T %RVs, P _R General Terrain: Grade % Length	0.90 22 2 Level mi	
			Up/Down %		
Calculate Flow Adjus	tments				
f _p E _T	0.95 1.5		E_R $f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	1.2)] 0.898	
Speed Inputs			Calc Speed Adj and		
Lane Width Rt-Side Lat. Clearance Number of Lanes, N Total Ramp Density, TRD FFS (measured) Base free-flow Speed, BFFS	2 65.0	ft ft ramps/mi mph mph	f _{LW} f _{LC} TRD Adjustment FFS	65.0	mph mph mph mph
LOS and Performanc	e Measures	<u> </u>	Design (N)		
Operational (LOS) v _p = (V or DDHV) / (PHF x I x f _p) S D = v _p / S LOS	N x f _{HV} 554 65.0 8.5 A	pc/h/ln mph pc/mi/ln	Design (N) Design LOS $v_p = (V \text{ or DDHV}) / (PHF \text{ x} \text{ x } f_p)$ S $D = v_p / S$ Required Number of Lanes		pc/h/ln mph pc/mi/ln
Glossary			Factor Location		
N - Number of lanes V - Hourly volume v _p - Flow rate LOS - Level of service speed DDHV - Directional design	BFFS - Ba		E_R - Exhibits 11-10, 11-12 E_T - Exhibits 11-10, 11-11, f_p - Page 11-18 LOS, S, FFS, v_p - Exhibits 11-3	11-13	f _{LW} - Exhibit 11-8 f _{LC} - Exhibit 11-9 TRD - Page 11-1

HCS 2010TM Version 6.1

Generated: 12/16/2011 5:11 PM

		RAMPS	S AND RAM	P JUNCTI	ONS WO	RKSH	EET			
General Inf	formation			Site Infor						
Analyst		larvin	Fr	reeway/Dir of Tr		EB Off-Ra	gmn			
Agency or Compa	oany Mar	vin Associates		unction		I-90 Lock	•			
Date Performed	•	16/2011	Ju	ırisdiction		MDT				
Analysis Time Pe	eriod PM	Design Hour	Aı	nalysis Year		2010 Exis	ting			
Project Description	on Billings Bypas	SS								
Inputs										
Upstream A	dj Ramp	Number of Lar Acceleration L	nes, N ane Length, L _∆	2					Downstrea Ramp	am Adj
☐ Yes	☐ On	Deceleration L	- ^	500					☐ Yes	☐ On
✓ No	☐ Off	Freeway Volur	ne, V _F	1300					✓ No	☐ Off
L _{up} =	ft	Ramp Volume	••	690					L _{down} =	ft
.,			Flow Speed, S_{FF}	65.0					\	ما/ مامیر
$V_u =$	veh/h	Ramp Free-Flo	ow Speed, S _{FR}	35.0					$V_D =$	veh/h
Conversion	n to pc/h Un	der Base (Conditions							
(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f _H	V	f _p	v = V/PHF	x f _{HV} x f _p
Freeway	1300	0.92	Level	15	0	0.93	0	0.95	15	99
Ramp	690	0.92	Level	10	0	0.95	2	0.95	82	29
UpStream										
DownStream		<u> </u>			ļ					
Catimatian		Merge Areas			Catingat	ion of		Diverge Areas		
Estimation	1 01 V ₁₂				Estimat	ion or	v ₁₂			
	$V_{12} = V_{12}$	_F (P _{FM})					V ₁₂ =	$= V_R + (V_F - V_F)$	R)P _{FD}	
L _{EQ} =	(Equ	ation 13-6 or	13-7)		L _{EQ} =		(Equation 13-1	2 or 13-13)
P _{FM} =	using		P _{FD} =		1.	000 using Equ	uation (Exhi	bit 13-7)		
V ₁₂ =	pc/h		,		V ₁₂ =			599 pc/h	,	,
V ₃ or V _{av34}	•	(Equation 13-	14 or 13-17)		V ₃ or V _{av34}			pc/h (Equatio	n 12 14 or	12 17)
	2,700 pc/h? <u></u> Y€		14 01 13-17)			> 2.700		Yes Vo	JII 13-14 UI	13-17)
						• •				
	1.5 * V ₁₂ /2		10 10 10 0		IS V ₃ or V _{av}	34 > 1.5		Yes ✓ No	10 10 10	10 0 10
If Yes,V _{12a} =	13-19	(Equation 13-	16, 13-18, 01		If Yes,V _{12a} =	=		oc/h (Equation 9)	13-16, 13-	18, 01 13-
Capacity C		• /			Capacit	y Chec		<u> </u>		
	Actual	C	apacity	LOS F?	1		Actual	Ca	pacity	LOS F?
					V _F		1599	Exhibit 13-8		No
V_{FO}		Exhibit 13-8			$V_{FO} = V_{F}$		770	Exhibit 13-8	3 4700	No
FO					V _R		829	Exhibit 13-1		No
Elow Entor	ring Merge I	nfluoneo A	ro2					rge Influen		110
Flow Linter	Actual		Desirable	Violation?	FIOW EI	Act		Max Desirab		Violation?
V _{R12}	Actual	Exhibit 13-8	ocsii ubic	Violation.	V ₁₂	159		Exhibit 13-8	4400:All	No
	ervice Deter		f not F)					terminatio		
	+ 0.00734 v _R +				* 			.0086 V ₁₂ - 0.	_	' /
	• • • • • • • • • • • • • • • • • • • •	0.0070 V ₁₂	0.00027 L _A					.0000 v ₁₂ - 0.	003 LD	
) _ /~~/	•				1 "	3.5 (pc/m	-			
**						(Exhibit				
LOS = (Exhil	bit 13-2))otorm	ınatır	า <i>ท</i>		
LOS = (Exhil					Speed L					
LOS = (Exhil					$D_s = 0.$.503 (Exh	ibit 13	-12)		
LOS = (Exhilt Exhibit Exhibi	ermination				$D_s = 0.$		ibit 13	-12)		
LOS = (Exhilt Exhibits Exhib	ermination it 13-11)				$D_{S} = 0.$ $S_{R} = 5.$.503 (Exh	ibit 13- Exhibit	-12) 13-12)		
LOS = (Exhild Exhild Exhibits Exhibit	ermination it 13-11) Exhibit 13-11)				$D_{s} = 0.$ $S_{R} = 5.$ $S_{0} = N$.503 (Exh 3.4 mph (E	ibit 13- Exhibit xhibit	-12) 13-12) 13-12)		

		MPS AND	INAMIE 3014			<u> </u>			
Inform	ation			Site Infor					
	R Ma	arvin	Fr	eeway/Dir of Tr	avel	EB On-Ramp			
ompany	Mary	vin Associates	Ju	ınction		Lockwood			
ned	12/5	/2011	Ju	risdiction		MDT			
e Period	PM [Design Hour	Ar	nalysis Year		2010 Existing			
ription Bi	llings Bypas	S							
j Ramp		Number of Lan	es, N	2				Downstre	am Adj
		Acceleration La	ne Length, L	1000				Ramp	•
☐ On			- /					□ Vaa	On
_			- 0					res	i On
Off		Freeway Volun	ne, V _F	930				✓ No	Off
		Ramp Volume,	V_p	370				_	ft
π			• •	65 O				Ldown _	11
- / -		1						V_ =	veh/h
ven/n		Ramp Free-Flo	w Speed, S _{FR}	35.0				VD -	VCII/II
ion to	pc/h Un	der Base C	Conditions						
)	V	PHF	Terrain	%Truck	%Rv	funz	f.	v = V/PHI	F x f _{init} x f
<u> </u>		 					· ·		•
	930	0.92	Level	15	4	0.923	0.95		1152
	370	0.92	Level	4	4	0.973	0.95	ļ	435
		oxdot							
1					ļ		<u> </u>		
		Merge Areas					Diverge Areas		
on of v	12				Estimat	ion of v ₁₂			
	V ₁₂ = V _F	(P _{EM})				V ₁₂ =	V _R + (V _F - V _F)P _{ED}	
	12 1	1 141	13-7)		L ₅₀ =	.=			13)
			•		1		-		-
			on (Exhibit 13-6)		1			on (Exhibit i	3-7)
		•					•		
	0 pc/	h (Equation 1	3-14 or 13-17)		V_3 or V_{av34}		pc/h (Equation	13-14 or 13-1	17)
₄ > 2,700 J	oc/h? 🥅 Ye	s 🗹 No			Is V ₃ or V _{av}	34 > 2,700 pc/h?	Tyes □ No		
, > 1.5 * V	₁₂/2 T Ye	s 🔽 No			Is V ₂ or V ₂	₂₄ > 1.5 * V ₁₂ /2	Yes No		
•			-16, 13-18, or						3-18, or
					II Yes, v _{12a} =				,
/ Chec	ks				Capacit	y Checks			
	Actual	Ca	pacity	LOS F?		Actual	Ca	pacity	LOS F?
		1 1			V _F		Exhibit 13-	.8	
	1507	F.,,b,;b,;t, 12, 0		NI-	$V_{FO} = V_{F}$	- V _D	Exhibit 13-	.8	
	1587	EXNIBIL 13-8		INO		· R			
		1			V_R			<u>'</u>	
terina	Merae Ir	fluence A	rea	•	Flow Fr	terina Dive		ice Area	<u> </u>
	Actual	i		Violation?	†	Actual			Violation
				î e	V	7.0.001	1	1	3.0.000
				110		f Sorvice D	<u> </u>	n (if not	! \
					+				. r-)
		u.uu/& V ₁₂ - 0.0	UOZ/LA		1	• •).UU86 V ₁₂ - C	.009 L _D	
.4 (pc/mi/lr	1)				$D_R = (p)$	oc/mi/ln)			
	-2)				LOS = (E	Exhibit 13-2)			
Exhibit 13					Speed L	Determinati	on		
	nation								
etermi					<u> </u>	xhibit 13-12)			
Petermi 270 (Exibit	13-11)				$D_s = (E_s)$	Exhibit 13-12)			
Petermi 270 (Exibit					$D_s = (E_s)$	ph (Exhibit 13-12)			
Petermi 270 (Exibit .8 mph (Ex	13-11)				$D_S = (E_S)$	•			
	mpany ed Period iption Bi Ramp On Off ft veh/h ion to on of v cering tering Service	R Manmany Manwed 12/5 Period PM I iption Billings Bypas Ramp	R Marvin Marvin Associates ed 12/5/2011 PM Design Hour iption Billings Bypass Ramp	R Marvin Associates Jumpany Marvin Associate	R Marvin Freeway/Dir of Tr Junction Period PM Design Hour Analysis Year iption Billings Bypass Ramp	R Marvin Freeway/Dir of Travel Junction ed 12/5/2011 Jurisdiction PM Design Hour Analysis Year ipition Billings Bypass Ramp	R Marvin	R Marvin	R Marvin

		RAMP	S AND RAM			JKNOI	1661			
General In	formation			Site Infor						
Analyst Agency or Comp Date Performed	any Ma	Marvin Arvin Associates V16/2011	Ji Ji	reeway/Dir of Tr unction urisdiction	avel	WB Off- I-90 Loc MDT	kwood			
Analysis Time Pe		1 Design Hour	A	nalysis Year		2010 Ex	isting			
	on Billings Bypa	ass								
Inputs		I		_						
Upstream A		Number of Lan Acceleration La		2					Downstrea Ramp	am Adj
Yes	□ On	Deceleration L	* D	1000					☐ Yes	☐ On
✓ No	☐ Off	Freeway Volur	'	950					✓ No	☐ Off
L _{up} =	ft	Ramp Volume	V_R Flow Speed, S_{FF}	300 65.0					L _{down} =	ft
$V_u =$	veh/h	Ramp Free-Flo		35.0					V _D =	veh/h
Conversio	n to pc/h U	nder Base (Conditions							
(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f	: HV	f _p	v = V/PHF	x f _{HV} x f _p
Freeway	950	0.90	Level	15	0	0.9	30	0.95	11	94
Ramp	300	0.90	Level	10	0	0.9	952	0.95	3	68
UpStream										
DownStream		Marga Arasa			<u> </u>			Niverge Areas		
stimation	of v	Merge Areas			Estima	tion o		Diverge Areas		
_Stimation					LStilla	uon o				
		/ _F (P _{FM})						$V_R + (V_F - V_F)$		
EQ =	(Eq	uation 13-6 or	13-7)		L _{EQ} =		(Equation 13-1	2 or 13-13	5)
FM =	usin	ng Equation (E	xhibit 13-6)		$P_{FD} =$		1.	000 using Equ	uation (Exh	ibit 13-7)
/ ₁₂ =	pc/h	ı			V ₁₂ =		11	94 pc/h		
V_3 or V_{av34}	pc/h	ı (Equation 13-	14 or 13-17)		V_3 or V_{av34}		0	pc/h (Equation	n 13-14 o	r 13-17)
Is V_3 or $V_{av34} >$	2,700 pc/h? 🥅 Y	′es 🗏 No			Is V ₃ or V _a	_{v34} > 2,70	00 pc/h? [Yes ✓ No		
Is V_3 or $V_{av34} >$	1.5 * V ₁₂ /2 🔲 Y				Is V ₃ or V _a	_{v34} > 1.5		Yes Vo		
Yes,V _{12a} =	pc/h 13-1	n (Equation 13-	16, 13-18, or		If Yes,V _{12a}	=		c/h (Equation	13-16, 13	-18, or 13
Capacity C		9)			Capaci	tv Che		9)		
oupuonty c	Actual	Ca	apacity	LOS F?		1	Actual	Ca	pacity	LOS F
		Î			V _F		1194	Exhibit 13-8		No
V_{FO}		Exhibit 13-8			V _{FO} = V		826	Exhibit 13-8		No
- FO		Exiliate 10 0			V _R		368	Exhibit 13-1		No
Flow Entor	ing Marga	Influence A	***							INU
TOW EIITE	Actual	Influence A	rea Desirable	Violation?	ILIOM EI		g <i>Dive</i> .ctual	rge Influen Max Desirab		Violation
V _{R12}	nctual	Exhibit 13-8	,collable	v iolation:	V ₁₂		194	Exhibit 13-8	4400:All	No
	rvice Dete	rmination (i	f not F	1				terminatio		
		+ 0.0078 V ₁₂ -			Level O			.0086 V ₁₂ - 0.		• /
		· 0.0070 V ₁₂ -	0.00021 LA		n			.0000 v ₁₂ - 0.	ooo LD	
$O_R = (pc/m)$					l "	.5 (pc/m	•			
•	bit 13-2)					(Exhib				
•	ermination				Speed					
$M_{\rm S} = $ (Exib	it 13-11)				_ ~	•	chibit 13	,		
$S_R = mph ($	Exhibit 13-11)				I	-	(Exhibit	*		
1 1					IC .					
	Exhibit 13-11)				$S_0 = N$	I/A mph (Exhibit	13-12)		

			MPS AND	RAMP JUN						
Genera	I Inform	nation			Site Infor	mation				
Analyst Agency or (Date Perfor	rmed	12/5/	in Associates 2011	Jı Jı	reeway/Dir of Tr unction urisdiction	avel	WB On-Ramp Lockwood MDT			
	me Period		Design Hour	A	nalysis Year		2010 Existing			
	scription I	Billings Bypass	5							
nputs			Number of Lor	una M	<u> </u>				<u>.</u>	A 1'
Jpstream <i>F</i>	Adj Ramp On		Number of Lar Acceleration L	ane Length, L _A	2 1000				Downstrea Ramp	am Adj
✓ No	□ Off		Deceleration L	о р	/ 55				Yes	□ On
INO	I OII		Freeway Volur	'	655				™ No	Off
-up =	ft		Ramp Volume Freeway Free-	V_R Flow Speed, S_{FF}	470 65.0				L _{down} =	ft
/ _u =	veh/h		Ramp Free-Flo		35.0				V _D =	veh/h
Conver	sion to	pc/h Und	der Base (Conditions						
(pc/		V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f _{HV}	fp	v = V/PHF	x f _{HV} x f _p
Freeway		655	0.92	Level	15	4	0.923	0.95	}	312
Ramp		470	0.92	Level	4	4	0.973	0.95	Ę	553
UpStream			\vdash							
DownStrea	am		Morgo Arono			-		Divorgo Arono		
Estima	Merge Areas stimation of v ₁₂						ion of v ₁₂	Diverge Areas		
-suma			15 .			LSumat		.,	`-	
		$V_{12} = V_F$	1 141				.=	$V_R + (V_F - V_R)$		
EQ =		(Equa	ation 13-6 or	13-7)		L _{EQ} =		(Equation 13-	·12 or 13-1	3)
FM =		1.000	using Equati	on (Exhibit 13-6))	P _{FD} =		using Equation	n (Exhibit 13	3-7)
′ ₁₂ =		812 p	c/h			V ₁₂ =		pc/h		
V_3 or V_{av34}				3-14 or 13-17)	V ₃ or V _{av34}		pc/h (Equation 1	13-14 or 13-1	7)
Is V ₃ or V _a	_{v34} > 2,700	pc/h? TYe	s 🗹 No			Is V ₃ or V _{av}	34 > 2,700 pc/h?	Tyes □ No		
Is V ₃ or V _a	_{v34} > 1.5 * '	V ₁₂ /2	s 🗹 No			Is V ₃ or V _{av}	₃₄ > 1.5 * V ₁₂ /2	Yes □ No		
Yes,V _{12a}		13-19)		-16, 13-18, or		If Yes,V _{12a} =	1	pc/h (Equatio 3-19)	n 13-16, 13	3-18, or
Capaci	ty Chec	cks	_			Capacit	y Checks			
		Actual	C	apacity	LOS F?		Actual		pacity	LOS F
						V_{F}		Exhibit 13-	8	
V_{F}	:0	1365	Exhibit 13-8		No	$V_{FO} = V_{F}$	- V _R	Exhibit 13-	8	
						V_R		Exhibit 13	-	
		Maraia In	fluoros A				torina Diva	10		
-iow E	ntering		fluence A	rea Desirable	Violation?	FIOW EI	ntering Dive	Max Des	7	Violation
V _R		Actual 1365	Exhibit 13-8	4600:All	No	V ₁₂	Aciual	Exhibit 13-8	ii diDIC	violatioi
			nination (i		INU	-	 f Service De	<u> </u>	n (if not	<u></u>
			•						_,	<i>r)</i>
		.,	0.0078 V ₁₂ - 0.0	0021 L _A		1	$D_R = 4.252 + 0$	uoo v ₁₂ - u	.009 L _D	
	9.6 (pc/mi/lr	•				1	oc/mi/ln)			
	\ (Exhibit 1	· ·					Exhibit 13-2)			
Speed	Determ	ination				Speed I	Determinati	on		
$M_{\rm S} = 0$).266 (Exib	it 13-11)				$D_s = (E_s)^T$	Exhibit 13-12)			
i _R = 5	58.9 mph (E	Exhibit 13-11)				$S_R = m$	ph (Exhibit 13-12)			
	-					$S_0 = m$	ph (Exhibit 13-12)			
S ₀ = N/A mph (Exhibit 13-11) S = 58.9 mph (Exhibit 13-13)						I '	ph (Exhibit 13-13))		
· = 5	58.9 mph (Exhibit 13-13)					S - 11	ipii (Emilion 10 10			

		RAMP	S AND RAN			JKK5	HEEI			
General Info	ormation			Site Infor	mation					
Analyst Agency or Compa Date Performed	ny Mar	arvin vin Associates 6/2011	J	reeway/Dir of Tr unction urisdiction	avel	EB Off- I-90 Jo MDT	-Ramp hnson Lan	e		
Analysis Time Per		Design Hour		Analysis Year		2010 E	victina			
Project Description				anarysis rear		2010 L	Aisting			
Inputs	. Dillings Dypus									
Upstream Ad	Ramp	Number of Lan		2					Downstrea Ramp	am Adj
☐ Yes	☐ On	Deceleration La	- "	500					Yes	On
✓ No	Off	Freeway Volun	ne, V _F	1300					✓ No	☐ Off
L _{up} =	ft	Ramp Volume,		550					L _{down} =	ft
V _u =	veh/h	Freeway Free- Ramp Free-Flo	Flow Speed, S _{FF} w Speed, S _{FB}	65.0					V _D =	veh/h
	to no/h Hn		· IK							
Conversion	to pc/n Un			1	T	<u> </u>	1			
(pc/h)	(Veh/hr)	PHF	Terrain	%Truck	%Rv		f_{HV}	f_p	v = V/PHF	$x f_{HV} x f_{p}$
Freeway	1300	0.92	Level	15	0	0.	930	0.95	15	99
Ramp	550	0.92	Level	15	0	0.	930	0.95	6	76
UpStream										
DownStream										
		Merge Areas						Diverge Areas		
Estimation	of v ₁₂				Estima	tion o	of v ₁₂			
	V ₁₂ = V _F	(P _{EM})					V ₁₂ =	V _R + (V _F - V _F)P _{ED}	
- _{EQ} =		ation 13-6 or	13-7)		L _{EQ} =			Equation 13-1)
P _{FM} =		g Equation (E	•		P _{FD} =			000 using Equ		
/ ₁₂ =	pc/h	g Equation (E	Milbit 15 0)		L.			599 pc/h	adion (EAIII	DIC 13 7)
	•	(Equation 12	14 or 12 17)		V ₁₂ =			•	40 44	40 47)
/ ₃ or V _{av34}		(Equation 13-	14 01 13-17)		V ₃ or V _{av34}	. 27		pc/h (Equation	n 13-14 or	13-17)
Is V_3 or $V_{av34} > 2$,								Yes ✓ No		
Is V_3 or $V_{av34} > 1$.			10 10 10		is v ₃ or v _a	_{v34} > 1.5		Yes ✓ No	40.40.40	40 40
f Yes,V _{12a} =	pc/n 13-19	(Equation 13-	16, 13-18, or		If Yes,V _{12a}	=	p 19	c/h (Equation	13-16, 13·	·18, or 13
Capacity Cl		')			Capaci	tv Ch		<i>)</i>		
supuony or	Actual	Ca	pacity	LOS F?	Jeapasi	. , 	Actual	Ca	pacity	LOS F
	Actual	1 1	pacity	2031.	V _F		1599	Exhibit 13-8		No
\/		Evhibit 12.0							+	_
V_{FO}		Exhibit 13-8			$V_{FO} = V$		923	Exhibit 13-8		No
					V _R		676	Exhibit 13-1		No
Flow Enteri	ng Merge li				Flow E	nterin	g Dive	rge Influen		
	Actual		esirable	Violation?	<u> </u>		Actual	Max Desirat		Violation
V_{R12}		Exhibit 13-8			V ₁₂		1599	Exhibit 13-8	4400:All	No
Level of Ser	rvice Deteri	mination (i	f not F)		Level o	f Ser	vice De	terminatio	n (if not	F)
D _R = 5.475 +	0.00734 v _R +	0.0078 V ₁₂ -	0.00627 L _A	<u> </u>		$D_R = 4$	1.252 + 0	.0086 V ₁₂ - 0.	009 L _D	
O _R = (pc/mi/	/ln)				D _R = 1	3.5 (pc	/mi/ln)			
**	it 13-2)				I	B (Exhil	oit 13-2)			
Speed Dete					Speed			on .		
•					' ' 		xhibit 13			
3 ,	13-11)				ľ	•		•		
	xhibit 13-11)				I		(Exhibit	-		
•	xhibit 13-11)				$S_0 = N$	I/A mph	(Exhibit	13-12)		
	xhibit 13-11)				1 "		(Exhibit	•		

			WPS AND	RAMP JUN	ICTIONS W		<u>EEI</u>				
Genera	Inform	ation			Site Infor	mation					
Analyst Agency or C Date Perform	med	12/5/	in Associates 2011	J J	Freeway/Dir of Tr Junction Jurisdiction	avel	EB On-Ramp Johnson Lane MDT				
Analysis Tin		PM L llings Bypass	Design Hour	F	Analysis Year		2010 Existing				
Inputs	ліршон ы	шиуз Бураз	S								
Jpstream A	di Domo		Number of Lan		2					Downstre	om Adi
эрѕпеані А	uj Kallip		Acceleration La		1000					Ramp	ani Auj
Yes	☐ On		Deceleration La	- //	1000					☐ Yes	☐ On
☑ No	Off		Freeway Volun	ne, V _F	640					✓ No	Off
-up =	ft		Ramp Volume,	11	210					L _{down} =	ft
,			1	Flow Speed, S _{FF}						V _D =	veh/h
/ _u =	veh/h		Ramp Free-Flo	w Speed, S _{FR}	35.0					v _D –	ven/m
Conver	sion to	pc/h Und	der Base C	Conditions							
(pc/ł	1)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f _{HV}		f _p	v = V/PH	F x f _{HV} x f _p
Freeway		640	0.92	Level	15	4	0.923		0.95		793
Ramp		210	0.92	Level	12	4	0.936		0.95		257
UpStream			\vdash			<u> </u>					
DownStrea	m l		 Merge Areas			 		Divor	ge Areas		
Stimat	ion of v		ivierge Areas			Fstimat	ion of v ₁₂		ge Areas		
		· -	(D)						. () / . \ / .	. D	
		$V_{12} = V_F$				[V ₁₂		+ (V _F - V _R)		
EQ =			ation 13-6 or	•		L _{EQ} =			uation 13-		-
P _{FM} =				on (Exhibit 13-6	5)	P _{FD} =			g Equatio	n (Exhibit 1	3-7)
/ ₁₂ =		793 p				V ₁₂ =		pc/h			
V_3 or V_{av34}				3-14 or 13-17	7)	V ₃ or V _{av34}		-	(Equation 1	3-14 or 13-	17)
0 40	0.	oc/h? TYe				, u.	₃₄ > 2,700 pc/h				
Is V ₃ or V _{av}	₃₄ > 1.5 * V	₁₂ /2		10 10 10		Is V ₃ or V _{av}	₃₄ > 1.5 * V ₁₂ /2			40.40.4	0.40
f Yes,V _{12a} =	=	pc/n 13-19)		-16, 13-18, or		If Yes,V _{12a} =	=	pc/n 13-19	(Equation	1 13-16, 1	3-18, or
Capacit	y Chec		<u>'</u>			Capacit	y Checks		· /		
		Actual	Ca	pacity	LOS F?	Ϊ ΄	Actu	ıal	Cap	acity	LOS F?
				, ,		V _F			Exhibit 13-8		
V		1050	Evhibit 12.0		No	$V_{FO} = V_{F}$	- V _D		Exhibit 13-8	3	
V _F)	1000	Exhibit 13-8		INO		K		Exhibit 13-		+
						V _R			10		
low Er	ntering	Merge In	fluence A			Flow Er	ntering Div	/erge			*
		Actual		esirable	Violation?	<u> </u>	Actual	+	Max Desi	rable	Violation?
V _{R1}		1050	Exhibit 13-8	4600:All	No	V ₁₂			hibit 13-8		
			nination (i				f Service I				t F)
$D_R =$	5.475 + 0.0	00734 v _R + 0	0.0078 V ₁₂ - 0.0	0627 L _A			$D_R = 4.252 + 1.00$	0.008	36 V ₁₂ - 0.	009 L _D	
$O_R = 7.$	3 (pc/mi/ln)					$D_R = (p)$	oc/mi/ln)				
.OS = A	(Exhibit 13	-2)				LOS = (E	Exhibit 13-2)				
Speed L	Determi	nation				Speed L	Determina	tion			
$M_{\rm S} = 0.$	262 (Exibit	13-11)				D _s = (E	Exhibit 13-12)				
Ü	-	thibit 13-11)				,	ph (Exhibit 13-	12)			
	/A mph (Ex					l '`	ph (Exhibit 13-				
-n- IV	ırsınıþii (⊑X					ľ	•				
•	9.0 mnh (Fx	thibit 13-13)				S = m	ph (Exhibit 13-	13)			

	_	RAMP	S AND RAN			JKK5	HEEI			
General In	formation			Site Infor						
Analyst Agency or Comp Date Performed	oany Ma	Marvin arvin Associates /16/2011	J	reeway/Dir of Tr unction urisdiction	avel	WB Off I-90 Jo MDT	-Ramp hnson Lane	Ž		
Analysis Time P		/ Design Hour		analysis Year		2010 E	vistina			
	on Billings Bypa		<u> </u>	a.yo.o . oa.		2010 L	Alsting			
nputs	3 71									
Upstream A	dj Ramp	Number of Lan		2					Downstrea Ramp	am Adj
☐ Yes	☐ On	Deceleration L	- /1	1000					☐ Yes	☐ On
✓ No	☐ Off	Freeway Volur	ne, V _F	650					✓ No	☐ Off
L _{up} =	ft	Ramp Volume		120					L _{down} =	ft
V _u =	veh/h	Freeway Free- Ramp Free-Flo	Flow Speed, S _{FF} IW Speed, S	65.0 35.0					V _D =	veh/h
			. 110	35.0					<u> </u>	
onversio_	n to pc/h U	nder Base (onditions	Т			Т			
(pc/h)	(Veh/hr)	PHF	Terrain	%Truck	%Rv		f _{HV}	f_p	v = V/PHF	x f _{HV} x f _p
Freeway	650	0.90	Level	15	0	0.	930	0.95	8	17
Ramp	120	0.90	Level	25	0	0.	889	0.95	1.	58
UpStream						_				
DownStream		Morgo Arons			-			iliyorgo Arono		
stimation	of v	Merge Areas			Estima	tion o		liverge Areas		
-Sumation					LStilla	tion c			`-	
		V _F (P _{FM})						$V_R + (V_F - V_I)$		
EQ =	(Eq	uation 13-6 or	13-7)		L _{EQ} =		(E	Equation 13-1	2 or 13-13	5)
FM =	usir	ng Equation (E	xhibit 13-6)		P _{FD} =		1.0	000 using Eq	uation (Exhi	bit 13-7)
12 =	pc/h				V ₁₂ =		81	7 pc/h		
$^{\prime}_{3}$ or $\rm V_{av34}$	pc/h	n (Equation 13-	14 or 13-17)		V_3 or V_{av34}		0	pc/h (Equation	on 13-14 oı	r 13-17)
s V_3 or $V_{av34} >$	2,700 pc/h? 🥅 ነ	∕es □ No						Yes 🗹 No		
s V_3 or $V_{av34} >$	1.5 * V ₁₂ /2				Is V ₃ or V _a	_{v34} > 1.5		Yes 🗹 No		
Yes,V _{12a} =	pc/t 13-1	າ (Equation 13- ດາ	16, 13-18, or		If Yes,V _{12a}	=	p 19	c/h (Equation	13-16, 13	-18, or 13
Capacity C		9)			Capaci	tv Ch		9)		
,,	Actual	Ca	pacity	LOS F?		, - · · ·	Actual	Ca	pacity	LOS F
			, ,		V _F		817	Exhibit 13-8		No
V_{FO}		Exhibit 13-8			$V_{FO} = V$		659	Exhibit 13-8	3 4700	No
FO					V _R		158	Exhibit 13-1		No
Elow Ento	ring Morgo	Influence A	roa					ge Influen		110
10W EIILEI	Actual		Desirable	Violation?	jr-10W El	_	Actual	Max Desiral		Violation
V _{R12}	/ iciual	Exhibit 13-8	. COII GNIO	violation:	V ₁₂		817	Exhibit 13-8	4400:All	No
	ervice Dete	rmination (i	f not F					terminatio		
		+ 0.0078 V ₁₂ -						.0086 V ₁₂ - 0.		• /
$O_R = 0.475$		12	LA		D _R = 2	2.3 (pc/r		12 0.	-D	
	bit 13-2)				I ''		oit 13-2)			
•	ermination				Speed I			nn .		
					 ' 					
	it 13-11)				I . "	•	xhibit 13-	,		
	Exhibit 13-11)					-	(Exhibit	•		
$S_0 = mph $	Exhibit 13-11)				$S_0 = N$	I/A mph	(Exhibit 1	13-12)		
	Exhibit 13-13)				S = 5		(Exhibit			

Cana::-!!	Info		MPS AND	NAIVIE JUIN						
General I	ntorma				Site Infor					
Analyst		R Ma			eeway/Dir of Tr	avel	WB On-Ramp			
Agency or Con			in Associates		inction		Johnson Lane			
Date Performe		12/5/			risdiction		MDT			
Analysis Time			Design Hour	Ar	nalysis Year		2010 Existing			
Project Descrip	ption Billi	ngs Bypass	S							
nputs			L						1	
Jpstream Adj	Ramp		Number of Lan		2				Downstre	am Adj
☐ Yes □	On		Acceleration La	ine Length, L _A	1000				Ramp	
res	l On		Deceleration La	ane Length L _n					☐ Yes	☐ On
™ No I	Off		Freeway Volun	ne V	660				✓ No	Off
110	- On			'					IM INO	III OII
- _{up} =	ft		Ramp Volume,	V_R	320				L _{down} =	ft
ир			Freeway Free-	Flow Speed, S _{FF}	65.0					
/ _u =	veh/h		Ramp Free-Flo	w Speed, S _{ED}	35.0				$V_D =$	veh/h
Convorci	ion to n	o/h Hn	der Base C	• 110					<u> </u>	
Juliversi	OII LO P	V		onanions	ı	1		T	Ι	
(pc/h)		v Veh/hr)	PHF	Terrain	%Truck	%Rv	f _{HV}	f _p	V = V/PHI	$= x f_{HV} x f_{p}$
Freeway		660	0.92	Level	15	4	0.923	0.95	1	818
Ramp	_	320	0.92	Level	12	4	0.936	0.95		391
UpStream	$\overline{}$	323	V./2	LOVOI	' <u>'</u>	 	3.733	0.70	 	· / ·
DownStream			 			 	†	i	1	
	1		Merge Areas		ı			Diverge Areas		
Estimatio	on of v					Estimat	tion of v ₁₂	<u> </u>		
			(D)			-		\/ . (\/ \/	\D	
		$V_{12} = V_F$				1.	.=	V _R + (V _F - V _F		
-EQ =		(Equ	ation 13-6 or	13-7)		L _{EQ} =		(Equation 13-	-12 or 13-1	3)
P _{FM} =		1.000	using Equation	on (Exhibit 13-6)		P _{FD} =		using Equation	n (Exhibit 1	3-7)
/ ₁₂ =		818 p	c/h			V ₁₂ =		pc/h		
₃ or V _{av34}		0 pc/l	h (Equation 1	3-14 or 13-17)		V ₃ or V _{av34}		pc/h (Equation	13-14 or 13-1	17)
Is V ₃ or V _{av34}	> 2.700 pc			,			, ₃₄ > 2,700 pc/h?			,
Is V ₃ or V _{av34}							_{/34} > 1.5 * V ₁₂ /2			
	7 1.5 V 12			·16, 13-18, or				pc/h (Equatio		3-18 or
f Yes,V _{12a} =		13-19)		10, 13-10, 01		If Yes,V _{12a} :		13-19)	11 13-10, 1	J-10, UI
Capacity	Check					Capacit	y Checks	/		
, ,	1	Actual	Ca	pacity	LOS F?	T	Actual	Ca	pacity	LOS F?
			1 1	<u> </u>	1	V _F		Exhibit 13-	1	
							\/			
V_{FO}		1209	Exhibit 13-8		No	$V_{FO} = V_{F}$	· · VR	Exhibit 13-		
						V_R		Exhibit 13 10	-	
Flow Ent	erina M	lerge In	fluence A	roa	1	Flow F	ntering Dive		ICA Area	
1044 FIIR		Actual	î	esirable	Violation?	, 10W EI	Actual	Max Des		Violation
V _{R12}	- -	1209	Exhibit 13-8	4600:All	No	V ₁₂	Actual	Exhibit 13-8	ii abic	v ioiatioi1:
	<u> </u>		<u> </u>		INO		f Comdon D	1	n /:£ : :	
			nination (i				f Service De			<u>r)</u>
		/34 V _R + (0.0078 V ₁₂ - 0.0	J62/ L _A			$D_R = 4.252 + 0$	J.0086 V ₁₂ - 0	.009 L _D	
$O_{R} = 8.5$ ((pc/mi/ln)					$D_R = (p$	oc/mi/ln)			
11	xhibit 13-2)				LOS = (F	Exhibit 13-2)			
							Determinati	on		
.OS = A (E	etermin	· · • • •				' 	Exhibit 13-12)			
OS = A (E Speed De		111				ພບຸ - \L				
A = A = A = A = A = A = A = A = A = A =	64 (Exibit 1						nh /Fyhihit 10 10	۸		
A = A (E = Speed De MS = 0.26						$S_R = m$	nph (Exhibit 13-12			
$A = A (E - Speed De M_S = 0.26 + S_R = 58.9 $	64 (Exibit 1	bit 13-11)				$S_R = m$	nph (Exhibit 13-12 nph (Exhibit 13-12			

APPENDIX C

No-Build Alternative Year 2035

Existing Roads & Streets

Capacity Calculations

er.			

	TW	O-WAY STOP	CONTR	OL SU	MMARY			
General Information	1		Site I	nforma	ation			
Analyst	R Marvin)	Interse	ection		Dover Ro	d & Five I	Mile No-
Agency/Co.	Marvin A	ssociates	Jurisdi	otion		build MDT		
Date Performed	10/3/201	1		is Year		2035		
Analysis Time Period	Design F	lour PM	Arialys	is rear		2035		
Project Description Bil	lings Bypass		J_			<u> </u>		
East/West Street: Dove			North/S	South St	reet: Five	Mile Rd		
Intersection Orientation:	East-West		Study F	Period (I	nrs): 0.25			
Vehicle Volumes ar	nd Adjustme	ents						
Major Street		Eastbound				Westbou	ınd	
Movement	1	2	3		4	5	ļ	6
	L	Т	R		L	Т		R
Volume (veh/h)		105	5		5	75		
Peak-Hour Factor, PHF	1.00	0.80	0.80	<u> </u>	0.80	0.80		1.00
Hourly Flow Rate, HFR (veh/h)	0	131	6		6	93		0
Percent Heavy Vehicles	0				3			
Median Type				Undivi	ded			
RT Channelized			0					0
Lanes	0	1	0		0	1	1 (
Configuration			TR		LT			
Upstream Signal		0				0		
Minor Street		Northbound				Southboo	und	
Movement	7	8	9		10	11		12
	L	Т	R		L	T		R
Volume (veh/h)	5		25					
Peak-Hour Factor, PHF	0.60	1.00	0.60	<u>'</u>	1.00	1.00		1.00
Hourly Flow Rate, HFR (veh/h)	8	0	41		0	0		0
Percent Heavy Vehicles	3	0	3		0	0		0
Percent Grade (%)		0				0		
Flared Approach		N				N		
Storage		0				0		
RT Channelized			0					0
Lanes	0	0	0		0	0		0
Configuration		LR						
Delay, Queue Length, a		7	1			_		
Approach	Eastbound	Westbound		Northbo			Southbou	nd
Movement	1	4	7	8	9	10	11	12
Lane Configuration		LT		LR			ļ	
v (veh/h)		6		49				
C (m) (veh/h)		1441		880				
v/c		0.00		0.06				
95% queue length		0.01		0.18				
Control Delay (s/veh)		7.5		9.3				
LOS		Α		Α			İ	1
Approach Delay (s/veh)				9.3				
Approach LOS				A				
Copyright © 2010 University of FI			.,	CS+ TM V	araian E C	Geno	rated: 12/17	7/2011 3:43

HCS+TM Version 5.6

	TW	O-WAY STOP	CONTR	OL SU	MMARY	<u> </u>				
General Information	<u> </u>		Site I	nforma	ation					
Analyst	R Marvin		Interse			Do	over & L	Bitteroc)†	
Agency/Co.	Marvin A		Jurisdi				DT			
Date Performed	12/8/201		Analys	is Year		No	o Build :	2035		
Analysis Time Period	PM Desig	gn Hour								
Project Description Bi	llings Bypass									
East/West Street: Dove	er Road		North/S	South St	reet: <i>Bit</i> t	teroot				
Intersection Orientation:	East-West		Study F	Period (I	hrs): 0.2	5				
Vehicle Volumes ai	nd Adjustme	ents								
Major Street		Eastbound				W	/estbou	ınd		
Movement	1	2	3		4		5			6
	L	T	R		L		T			R
Volume (veh/h)		115	90		25		65	\longrightarrow		
Peak-Hour Factor, PHF	1.00	0.80	0.80	<u>'</u>	0.75		0.75		1.	00
Hourly Flow Rate, HFR (veh/h)	0	143	112		33		86			0
Percent Heavy Vehicles	0				1					
Median Type				Undivi	ded					
RT Channelized			0							0
Lanes	0	1	0		0		1			0
Configuration			TR		LT					
Upstream Signal		0					0			
Minor Street		Northbound				Sc	outhbou	ınd		
Movement	7	8	9		10		11			12
	L	Т	R		L		Т			R
Volume (veh/h)	50		15							
Peak-Hour Factor, PHF	0.75	1.00	0.75		1.00		1.00		1.	00
Hourly Flow Rate, HFR (veh/h)	66	0	20		0		0			0
Percent Heavy Vehicles	1	0	1		0		0			0
Percent Grade (%)		3					0			
Flared Approach		N					Ν			
Storage		0					0			
RT Channelized			0							0
Lanes	0	0	0		0		0			0
Configuration		LR								
Delay, Queue Length, a	and Level of Se	ervice		·						
Approach	Eastbound	Westbound	ľ	Northbo	und		S	Southbo	und	
Movement	1	4	7	8	9	$\neg \vdash$	10	11		12
Lane Configuration		LT		LR		İ				
v (veh/h)		33		86						
C (m) (veh/h)		1316		639					一	
v/c		0.03		0.13					一	
95% queue length		0.08		0.46	_	\neg			\dashv	
Control Delay (s/veh)		7.8		11.5	_				一	
LOS		A		В	\neg				\dashv	
Approach Delay (s/veh)				11.5						
Approach LOS				В						
Copyright © 2010 University of F	orida All Dights Dos				ersion 5.6		Gonor	otod: 12/	17/201	1 4:02 PI

	TW	O-WAY STOP	CONTR	OL SU	IMMARY			
General Information	n		Site I	nform	ation			
Analyst	R Marvir)	Interse	ection		Dover &	Highway	312
Agency/Co.	Marvin A	ssociates	Jurisdi	ction		MDT		
Date Performed	12/8/201		Analys	is Year		No Build	2035	
Analysis Time Period	PM Desi	gn Hour						
Project Description Bil			_					
East/West Street: High					treet: Dover	Road		
Intersection Orientation:	East-West		Study I	Period (hrs): <i>0.25</i>			
Vehicle Volumes ar	nd Adjustme	ents						
Major Street		Eastbound				Westbou	ınd	
Movement	1	2	3		4	5		6
	L	Т	R		L	Т		R
Volume (veh/h)	1 00	990	160		80	35		4.00
Peak-Hour Factor, PHF	1.00	0.95	0.95	<u>'</u>	0.90	0.90		1.00
Hourly Flow Rate, HFR (veh/h)	0	1042	168		88	38		0
Percent Heavy Vehicles	0				4			
Median Type			Two V	Vay Left	t Turn Lane	1		
RT Channelized			0					0
_anes	0	2	0		1	2		0
Configuration		T	TR		L	Т		
Jpstream Signal		0				0		
Minor Street		Northbound				Southboo	und	
Movement	7	8	9		10	11		12
	L	Т	R		L	Т		R
Volume (veh/h)	45		600					
Peak-Hour Factor, PHF	0.92	1.00	0.92		1.00	1.00		1.00
Hourly Flow Rate, HFR (veh/h)	48	0	652		0	0		0
Percent Heavy Vehicles	4	0	4		0	0		0
Percent Grade (%)		2				0		
Flared Approach		N	Î			N		
Storage		0				0		
RT Channelized			0				T i	0
Lanes	1	0	1	o	0	0	$\neg \vdash$	0
Configuration	L		R	$\neg \uparrow$				
Delay, Queue Length, a	and Level of S	ervice						
Approach	Eastbound	Westbound		Vorthbo	und	S	Southbou	nd
Movement	1	4	7	8	9	10	11	12
_ane Configuration		L	L		R	1		1
v (veh/h)		88	48		652			
C (m) (veh/h)		561	193		474	1	1	\neg
//c		0.16	0.25	 	1.38			
95% queue length		0.55	0.20	 	30.32	+	1	+
Control Delay (s/veh)		12.6	29.7	 	205.9			
				 	205.9 F	+	 	+
LOS		В	D	400.1	<u> </u>			
Approach Delay (s/veh)				193.8	5			
Approach LOS				F				

General Information	1		Site Ir	nformati	on				
Analyst	R Marvin		Interse			Mary & F	Bitteroot No	Ruild	
Agency/Co.	Marvin A	ssociates	Jurisdio			MDT	illeroot ivo	Duna	
Date Performed	10/8/201			is Year		Year 203	25		
Analysis Time Period	Design H					1.00200			
Project Description Bil									
ast/West Street: Mary			North/S	outh Stree	et: <i>Bitter</i>	oot			
ntersection Orientation:				Period (hrs					
/ehicle Volumes ar	nd Adjustme	ents		,					
Major Street		Eastbound				Westbou	ınd		
Movement	1 1	2	3		4	5		6	
	Ĺ	T	R		L	T		R	
/olume (veh/h)	60	60	50		10	25		5	
Peak-Hour Factor, PHF	0.70	0.70	0.70		0.60	0.60		0.60	
Hourly Flow Rate, HFR	85	85	71		16	41		8	
veh/h)			ļ						
Percent Heavy Vehicles	0			.,	. 0				
Median Type	+		Î	Undivide	d	1			
RT Channelized	1		0				0		
anes	0	1	0	ļ	0	1		0	
Configuration	LTR				LTR				
Jpstream Signal		0				0			
Minor Street		Northbound				4	outhbound		
Movement	7	8	9		10	11		12	
	L	Т	R		L	Т		R	
/olume (veh/h)	50	110	10		5	60		50	
Peak-Hour Factor, PHF	0.70	0.70	0.70		0.70	0.70		0.70	
Hourly Flow Rate, HFR veh/h)	71	157	14		7	85		71	
Percent Heavy Vehicles	0	0	0		0	0		0	
Percent Grade (%)		0				0			
Flared Approach		N				N			
Storage		0				0			
RT Channelized			0					0	
_anes	0	1	0		0	1		0	
Configuration		LTR				LTR			
Delay, Queue Length, a	nd Level of Se	ervice							
Approach	Eastbound	Westbound	١	Northbound	d	5	Southbound		
Movement	1	4	7	8	9	10	11	12	
_ane Configuration	LTR	LTR	•	LTR	 	+	LTR	 	
/ (veh/h)	85	16		242	+	+	163	\vdash	
<u> </u>					+	+	. 	 	
C (m) (veh/h)	1571	1436		492	-	-	634	 	
//c	0.05	0.01		0.49	-		0.26	<u> </u>	
95% queue length	0.17	0.03		2.68			1.02	<u> </u>	
Control Delay (s/veh)	7.4	7.5		19.2			12.6		
_OS	Α	Α		С			В		
Approach Delay (s/veh)				19.2			12.6		
Approach LOS				С		1	В		

		O-WAI STOP	P CONTROL SUMMARY Site Information								
General Information	า		Site II	nform	ation						
Analyst	R Marvin		Interse	ection			Mary & F	lawthron	e NoBuild		
Agency/Co.	Marvin &	Associates	Jurisdi	ction			MDT				
Date Performed	10/8/201		Analys	is Year	•		2035				
Analysis Time Period	Design H	our PM									
Project Description Bil											
ast/West Street: Mary			North/S				rone				
ntersection Orientation:	East-West		Study F	Period ((hrs):	0.25					
/ehicle Volumes ar	nd Adjustme	nts									
Major Street		Eastbound					Westbou	ınd			
Movement	1	2	3			4	5		6		
	L	Т	R			L	Т		R		
/olume (veh/h)		290	60		5		170				
Peak-Hour Factor, PHF	1.00	0.80	0.80		0.8	30	0.80		1.00		
lourly Flow Rate, HFR veh/h)	0	362	74		ϵ	3	212		0		
ercent Heavy Vehicles	0				0						
/ledian Type				Undiv	rided						
RT Channelized			0						0		
anes	0	1	0		C)	1		0		
Configuration			TR		L	Τ	1				
Jpstream Signal		0					0				
linor Street		Northbound					Southbo	und			
Novement	7	8	9		10		11		12		
	L	Т	R		l	L	T		R		
/olume (veh/h)	40		5								
Peak-Hour Factor, PHF	0.60	1.00	0.60		1.0	00	1.00		1.00		
lourly Flow Rate, HFR veh/h)	66	0	8		C)	0		0		
Percent Heavy Vehicles	0	0	0		C)	0		0		
Percent Grade (%)		0					0				
lared Approach		N					N				
Storage		0					0				
RT Channelized			0						0		
anes	0	0	0		()	0		0		
Configuration		LR							-		
Delay, Queue Length, a	nd Level of Se	rvice	<u>'</u>				*				
pproach	Eastbound	Westbound	ı	Northbo	ound			Southbou	ınd		
Novement	1	4	7	8		9	10	11	12		
ane Configuration		LT	'	LR	\dashv		 '`	 ''	12		
(veh/h)		6		74			+	 	_		
· · · · · · · · · · · · · · · · · · ·		1134		467	_		+	 	+		
C (m) (veh/h)					_		+	 	_		
7/C		0.01		0.16			1	-	_		
95% queue length		0.02		0.56			 	<u> </u>			
Control Delay (s/veh)		8.2		14.2	?		<u> </u>	ļ			
.OS		Α		В				<u></u>			
				14.2	, _ 						
pproach Delay (s/veh)											

HCS+TM Version 5.6

Generated: 12/17/2011 3:45 PM

No Build Alt 2035 HWY 312/Bench Area Type: Non CBD

R Marvin 08/16/2011 Analysis Duration: 15 mins.

PM Design Hour Case: BENCHU-2

	I Design I	Hour							e: BE		HU~2			7 1	iiai y sis	Dur	ation	. 151	111113.
	Lanes					(Geome	etry: Mo	vemer	ıts Se	rviced b	y Lane a	nd Lan	e W	idths (f	eet)			
	Approach (Outbour	nd	Lane	1		Lane	2		Lane	3	L	ane 4		La	ane 5		Lar	ne 6
EB	3	2		L	12.0	7	Γ	12.0	Т		12.0								
WB	3	2		L	12.0	7	Γ	12.0	Т		12.0								
NB	3	1		L	12.0	1	Γ	12.0	R		12.0								
SB	3	1		L	12.0	7	Γ	12.0	R		12.0								
					East				We	st			Nor	th				South	
	Data			L	Т	F	2	L	Т		R	L	Т		R	I		T	R
Move	ement Volun	ne (vph)) 4	190	900		0	140	52	0	0	100	8	0	250	4	-0	40	340
PHF			0	.92	0.92	0.9	90	0.92	0.9	2	0.90	0.92	0.9	2	0.92	0.9	92	0.92	0.92
% He	avy Vehicle	s		3	2		2	1	2	2	2	1		1	1		2	1	3
Lane	Groups			L	T			L	Т			L	Т		R	L		T	R
Arriv	al Type			3	3			3	3			3	3		3	3	;	3	3
RTO	R Vol (vph)				0				C)			10	0				140	
Peds/	Hour				0				C)			()				5	
% Gr	ade				0				0)			()				0	
Buses	s/Hour				0				0				0					0	
Parke	ers/Hour (Le	ft Right)							-									
Signa	ıl Settings: A	Actuated	l	(Operati	onal A	nalysi	s	Cy	ycle L	Length: 1	125.0 Se	ec]	Lost Tin	ne Per	Cycle	: 20.0 S	ec
Phase	e:	1		2	2	3	3	4			5	6			7	8	3	Pe	d Only
EB		L		L'	Γ														
WB		L		L	Γ														
NB		F				LT	TR .	LT	'n										
SB			ξ.				P	LT											
Greei	n	35	.0	29	0.0	22	2.0	19	.0										0
Yello	w All Red	4.0	0.0	4.0	2.0	3.5	1.5	3.5	1.5										

			Capac	city Analysis R	esults				Approa	ch:
App EB	Lane Group Lper	Cap (vph) 104	v/s Ratio 0.113	g/C Ratio 0.280	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh) 109.8	LOS F
LD	* Lpro	491	0.280	0.280	L	0.896	43.4	D	105.0	
	* T	821	0.276	0.232	T	1.191	146.0	F		
		-								
WB	Lper	60	0.000	0.280					39.9	D
	Lpro	500	0.085	0.280	L	0.271	17.5	В		
	T	821	0.160	0.232	T	0.688	45.9	D		
NB	Lper	234	0.000	0.192					17.5	В
	* Lpro	315	0.061	0.176	L	0.199	26.7	С		
	T	692	0.046	0.368	Т	0.126	26.2	C		
	R	1100	0.102	0.688	R	0.148	6.8	A		
SB										
	* L	198	0.033	0.152	L	0.217	46.7	D	18.2	В
	T	286	0.023	0.152	T	0.150	46.1	D		
	R	1077	0.139	0.688	R	0.201	7.1	A		

Intersection: Delay = 71.4 sec/veh SIG/Cinema v3.08

Int. LOS=E

 $X_{c} = 0.77$

* Critical Lane Group

 \geq (v/s)Crit= 0.65

No Build Alt 2035 R Marvin PM Design Hour HWY 312/Bench 08/16/2011 Case: BENCHU~2

App EB	L	Queues Per Lane Avg/Max (veh) 20 / 25	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	40 340 40 • • • • • • • • • • • • • • • • • • •
	T	15 / 19	5.8	0.1	
					- 140
	All		5.3	2.2	
WB	L	4 / 5	7.2	0.0	
	T	9 / 10	7.9	0.0	
					490 —
	All		7.8	0.0	900
NB	L	2 / 4	6.7	0.0	
	T	2/2	18.9	0.0	
	R	2 / 4	14.4	0.0	100 250 80
	All		14.3	0.0	
SB	L	1 / 4	3.0	0.0	1 2 3 4
	Т	2 / 4	16.0	0.0	
	R	3 / 4	16.0	0.0	35 4 0 29 4 2 21 1 4 2 18 4
	All		13.2	0.0	
	Inte	rsect.	7.1		

No Build Alt 2035 Wicks Lane/Main Street Area Type: Non CBD R Marvin 10/12/2011 Analysis Duration: 15 mins. PM Case: WICKSM~1

PM							se: WIC	KSM~1		<i>P</i>	Marysis	Duratio	11. 131	111115.
	Lanes				Geo	metry: M	ovements	Serviced b	y Lane ar	nd Lane W	idths (f	eet)		
	Approach (Outbound	L	ane 1	La	me 2	L	ane 3	La	ne 4	La	ne 5	Lai	ne 6
EB	3	2	L	12.0	Т	12.0	TR	12.0						
WB	3	2	L	12.0	LT	12.0	TR	12.0						
NB	5	3	L	12.0	L	12.0	Т	12.0	Т	12.0	TR	12.0		
SB	4	3	L	12.0	Т	12.0	Т	12.0	TR	12.0				
				East	<u>'</u>		West			North			South	
	Data		L	Т	R	L	Т	R	L	Т	R	L	Т	R
Move	ment Volun	ne (vph)	200	450	250	540	390	70	560	1650	400	150	960	200
PHF			0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
% He	avy Vehicle	es .	0	0	0	0	0	0	0	2	1	0	2	0
Lane	Groups		L	TR		L	LTR		L	TR		L	TR	
Arriv	al Type		5	5		3	3		5	5		4	4	
RTO	R Vol (vph)			80			30			100			80	
Peds/	Hour			0			5			5			5	
% Gr	ade			0			0			0			0	
Buses	s/Hour			0			0			0			0	
Parke	ers/Hour (Le	ft Right)		-			.							
Signa	l Settings: A	Actuated		Operati	ional Anal	ysis	Cyc	le Length:	140.0 Sec	с	Lost Tin	ne Per Cyc	le: 18.0 S	ec
Phase	:	1		2	3		4	5	6		7	8	Pe	d Only
EB						L'	ΓR							
WB					LTP									
NB		L		TP										
SB		L		TP										
Green		24.0		50.0	26.0		2.0							0
Yello	w All Red	3.0	0.0 3	.5 1.5	3.5 1	.5 3.5	1.5							

			Conor	sity. A nalyzaia D	aculta				Annua	oh.
	1		Capac	ity Analysis R	esuits				Approa	CII:
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay	
App	Group	(vph)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB										
	L	284	0.120	0.157	L	0.764	67.1	E	148.2	F
	* TR	544	0.195	0.157	TR	1.239	174.2	F		
WB										
	L	335	0.195	0.186	L	1.051	120.1	F	116.1	F
	* LTR	653	0.200	0.186	LTR	1.075	114.1	F		
NB										
	* L	600	0.174	0.171	L	1.015	90.5	F	115.0	F
	* TR	1773	0.427	0.357	TR	1.195	122.0	F		
SB										
	L	309	0.090	0.171	L	0.528	59.2	Е	40.0	D
	TR	1785	0.235	0.357	TR	0.657	37.3	D		

Intersection: Delay = 103.4 sec/veh SIG/Cinema v3.08

Int. LOS=F $X_c = 1.14$

* Critical Lane Group

 $\sum (v/s)Crit = 1.00$

Page 1

No Build Alt 2035 R Marvin PM Wicks Lane/Main Street 10/12/2011 Case: WICKSM~1

App EB	Lane Group L	Queues Per Lane Avg/Max (veh) 6 / 8	Average Speed (mph) 5.1 5.4	Spillback in Worst Lane (% of Peak Period) 0.0	960 200 150
					→ 390 → 540
	All		5.4	0.0	
WB	L	14 / 17	3.0	0.0	
	LTR	14 / 16	4.7	0.0	
	All		4.1	0.0	450 →
NB	L	14 / 15	3.1	0.0	250 —
	TR	23 / 30	3.7	11.6	
					560 400
	All		3.5	11.6	
SB	L	9 / 11	3.1	0.0	1 2 3 4
	TR	9 / 11	6.9	0.0	
					$\begin{array}{ c c c c c c c c c c c c c c c c c c c$
	All		6.1	0.0	
	Inte	rsect.	4.3		

No Build Alt 2035 Airport Road/Main Street Area Type: Non CBD 10/12/2011 Analysis Duration: 15 mins. R Marvin PM Design Hour Case: AIRPOR~1 Geometry: Movements Serviced by Lane and Lane Widths (feet) Lanes Approach Outbound Lane 1 Lane 2 Lane 3 Lane 4 Lane 5 Lane 6 EB 3 L 12.0 LT 12.0 R 12.0 2 LT WB 2 12.0 R 12.0 NB 4 3 L 12.0 T 12.0 T 12.0 TR 12.0 SB4 3 L 12.0 Т 12.0 T 12.0 TR 12.0 East West North South T T T R T Data L R L R L L R Movement Volume (vph) 850 20 100 30 40 90 230 3500 10 70 2120 400 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 PHF 0.95 % Heavy Vehicles 2 0 2 0 LT LT TR TR Lane Groups L R R L L Arrival Type 3 3 3 3 5 5 RTOR Vol (vph) 20 0 100 30 5 0 5 5 Peds/Hour % Grade 0 0 0 0 Buses/Hour 0 0 0 0 Parkers/Hour (Left|Right) Signal Settings: Actuated Operational Analysis Cycle Length: 160.0 Sec Lost Time Per Cycle: 20.0 Sec Phase: 2 4 5 7 8 Ped Only 6 EB LTP R

			Capac	city Analysis R	esults				Approa	ch:
App EB	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
LD	* L	443	0.280	0.250	L	1.117	138.8	F	108.6	F
	LT	445	0.237	0.250	LT	0.946	88.0	F		
	R	570	0.054	0.369	R	0.147	33.8	С		
WB										
	* LT	81	0.040	0.044	LT	0.914	146.5	F	147.5	F
	R	70	0.039	0.044	R	0.900	148.5	F		
NB										
	L	177	0.137	0.100	L	1.367	263.7	F	175.2	F
	* TR	2732	0.727	0.538	TR	1.352	169.4	F		
SB										
	* L	79	0.041	0.044	L	0.937	158.7	F	45.2	D
	TR	2463	0.511	0.494	TR	1.035	41.9	D		

Intersection: Delay = 121.8 sec/veh SIG/Cinema v3.08

WB

NB SB

Green

Yellow All Red

Int. LOS=F

 $\overline{X}_{c} = 1.24$

LTP

7.0

1.5

3.5

40.0

1.5

3.5

LTP

16.0

0.0

3.0

ΤP

TP

67.0

1.5

3.5

LTR

3.5

7.0

1.5

* Critical Lane Group

 \geq (v/s)Crit= 1.09

Page 1

0

No Build Alt 2035 R Marvin PM Design Hour Airport Road/Main Street 10/12/2011 Case: AIRPOR~1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	2120 400 70
ЕВ	L	21 / 22	3.2	0.0	
	LT	20 / 21	4.8	0.0	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
	R	1 / 3	18.8	0.0	- 30
	All		4.3	0.0	
					
WB	LT	3 / 4	4.3	0.0	
	R	3/3	10.6	0.0	850 -
	All		7.1	0.0	20
NB	L	17 / 20	1.4	0.0	100 —
	TR	29 / 30	5.3	42.1	
					230 10 3500
	All		4.7	42.1	3300
SB	L	6 / 10	2.5	0.0	1 2 3 4 1
	TR	19 / 22	7.8	0.7	
					$\begin{bmatrix} 39 & 4 & 2 & 6 & & 4 & 2 & 16 & & & & & & & & & & & & & & & & & $
	All		7.3	0.7	5 4
	Inte	rsect.	5.4		6 4 2

No Build Alt 2035

R Marvin
PM design Hour

1st Ave N/
10/12/2011
Case: US87MA~1

Area Type: Non CBD
Analysis Duration: 15 mins.

	I design F	Iour						e: US8	7MA~1			z mary si	3 Durane	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	
	Lanes					Geom	etry: Mo	vement	s Serviced	by Lane a	ınd Lane	Widths (feet)		
	Approach	Outbound	La	ne 1		Lane	2	L	ane 3	L	ane 4	L	ane 5	La	ne 6
EB	4	2	L	12.0	I	L	12.0	L	12.0	Т	12.0				
WB	3	2	Т	12.0	7	Γ	12.0	R	12.0						
NB	0	3													
SB	4	0	L	12.0	I	L	12.0	R	12.0	R	12.0				
				East				West			North			South	
	Data		L	Т	I	3	L	Т	R	L	Т	R	L	Т	R
Move	ement Volur	ne (vph)	1800	600		0	0	610	1490	0	0	0	1450	0	670
PHF			0.95	0.95	0.	90	0.90	0.95	0.95	0.90	0.90	0.90	0.95	0.90	0.95
% Не	eavy Vehicle	es	2	2		2	2	2	4	2	2	2	4	2	2
Lane	Groups		L	Т				Т	R				L		R
Arriv	al Type		5	5				3	3				5		5
RTO	R Vol (vph)			0				250			0			0	
Peds/	Hour			5				0			0			0	
% Gr	ade			0				0			0			0	
Buse	s/Hour			0				0			0			0	
Parke	ers/Hour (Le	ft Right)													
Signa	al Settings: A	Actuated		Operat	ional A	Analys	is	Сус	ele Length	: 140.0 Se	ec	Lost Tir	ne Per Cyc	le: 10.0 S	Sec
Phase	e:	1		2		3	4		5	6		7	8	Pe	ed Only
EB		LT													
WB				TP		R									
NB															
SB		R				P									
Gree	n	45.0		20.0	60	0.0	<u> </u>								0
Yello	w All Red	3.5	.5 3.5	1.5	3.5	1.5									

				'. A 1 ' D	1,					,
	1		Capac	city Analysis R	esults	1	1	1	Approa	cn:
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay	
App	Group	(vph)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB										
	* L	1655	0.368	0.321	L	1.145	105.4	F	100.2	F
	T	599	0.339	0.321	T	1.055	84.6	F		
WB										
	T	506	0.181	0.143	Т	1.269	195.9	F	203.3	F
	* R	943	0.840	0.607	R	1.384	206.9	F		
SB										
	L	1443	0.453	0.429	L	1.058	60.5	Е	41.5	D
	R	2190	0.253	0.786	R	0.322	0.4	A		

 $X_c = 1.30$

Intersection: Delay =110.6 sec/veh SIG/Cinema v3.08

Int. LOS=F

* Critical Lane Group

 $\sum (v/s)$ Crit= 1.21

No Build Alt 2035 R Marvin PM design Hour 1st Ave N/ 10/12/2011 Case: US87MA~1

App EB	Lane Group L T	Queues Per Lane Avg/Max (veh) 24 / 30 16 / 25	Average Speed (mph) 3.0 4.8	Spillback in Worst Lane (% of Peak Period) 54.8 2.3	670 1450
	All		3.3	54.8	——————————————————————————————————————
WB	Т	8 / 11	5.6	0.0	
	R	28 / 30	4.6	24.9	
	All		4.9	24.9	1800 → 600 →
	All		6.2	25.4	
SB	L	27 / 30	4.6	25.4	
	R	3 / 5	18.9	0.0	44 4 2 19 4 2 59 4 2
	Inte	rsect.	4.4		

No Build Alt 2035

R Marvin
PM Design Hour

Old US 87/I90 WB On Ramp
10/13/2011
Case: WBRAMP~1

Area Type: Non CBD
Analysis Duration: 15 mins.

	I Design H	Hour	Case: WBRAMP~1													
	Lanes				Ge	eomet	try: Mo	vements :	Serviced b	y Lane ar	nd Lane W	/idths (f	eet)			
Approach Outbound			Lane 1			Lane 2			Lane 3		ne 4	La	ne 5	La	ne 6	
EB	2	2	T	12.0	TR		12.0									
WB	3	2	L	12.0	Т		12.0	Т	12.0							
NB	0	0														
SB	1	1	LTR	12.0												
				East				West			North		South			
	Data		L	Т	R		L	Т	R	L	Т	R	L	Т	R	
Move	ement Volun	ne (vph)	0	1430	480		220	1310	0	0	0	0	20	1	580	
PHF			0.90	0.92	0.92		0.92	0.92	0.90	0.90	0.90	0.90	0.92	0.92	0.92	
% He	avy Vehicle	es .	2	5	5		1	5	2	2	2	2	1	0	5	
Lane	Groups			TR			L	Т						LTR		
Arriv	al Type			2			2	2						3		
RTO	R Vol (vph)		150				0				0		100			
Peds/	Hour			0			5				0		0			
% Gr	ade			0				0		0			0			
Buses	s/Hour			0				0		0						
Parke	ers/Hour (Le	ft Right)														
Signa	l Settings: A	Actuated		Operational Analysis Cycle Length: 90.0 Sec Lost Time Per Cyc								ne Per Cyc	e: 14.0 Sec			
Phase	e:	1		2	3		4		5	6		7	8	Pe	Ped Only	
EB				TR												
WB	WB LT			LT												
NB																
SB					LTR											
Green	ı	8.0		45.0	23.0)				ļ					0	
Yello	w All Red	4.0	0.0 3.5	5 1.5	3.5	1.5				1 1						

	Capacity Analysis Results Approach:													
A		Cap (vph)	V/S	g/C Ratio	Lane		Delay (sec/veh)	1.00	Delay	LOC				
App	Group	(vpn)	Ratio	Rano	Group	Ratio	(sec/ven)	LOS	(sec/veh)	LOS				
EB														
	* TR	1671	0.573	0.500	TR	1.145	100.7	F	100.7	F				
WB	Lper	83	0.533	0.556					26.1	С				
	* Lpro	159	0.089	0.089	L	0.988	82.5	F						
	T	2177	0.414	0.633	Т	0.654	16.7	В						
SB														
	* LTR	402	0.347	0.256	LTR	1.356	209.1	F	209.1	F				

Intersection: Delay = 84.9 sec/veh SIG/Cinema v3.08

Int. LOS=F

 $X_c = 1.19$

* Critical Lane Group

 $\sum (v/s)$ Crit= 1.01

Page 1

No Build Alt 2035 R Marvin PM Design Hour Old US 87/I90 WB On Ramp 10/13/2011 Case: WBRAMP~1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	1 580 20
ЕВ	TR	28 / 30	4.9	38.9	→1310 →220
	All		4.9	38.9	
WB	L	8 / 14	2.4	0.0	
	Т	6 / 10	18.0	0.0	
	All		11.9	0.0	1430
					480 —
	All		4.1	1.3	
					1 2 3
SB	LTR	19 / 26	4.1	1.3	
					8 4 0 44 4 2 22 4 2
	Inte	rsect.	6.2		

No Build 2035 Old US 87/I90 EB Off Ramp Area Type: Non CBD 10/13/2011 R Marvin Analysis Duration: 15 mins. PM Design Hour Case: EBRAMP~1

1 141	Design	ioui		Cusc. Estativi														
Lanes				Geometry: Movements Serviced by Lane and Lane Widths (feet)														
	Approach	Outboun	d	Lane 1 Lane			2	L	ane 3	3	Lane 4 La			ane 5 I		Lar	Lane 6	
EB	3	2		L	12.0	-	Γ	12.0	T		12.0							
WB	2	2		Т	12.0	Т	R	12.0										
NB	2	1		L	12.0	Т	R	12.0										
SB	0	0																
					East			West						South				
	Data			L	T	I	2	L	T		R	L	Т	R	I		T	R
Move	ment Volur	ne (vph)	7	750	700		0	0	780		20	750	1	350		0	0	0
PHF			0	.92	0.92	0.	90	0.90	0.92		0.92	0.92	0.92	0.92	0.9	90	0.90	0.90
% He	avy Vehicle	es		4	1		2	2	2		2	5	0	2		2	2	2
Lane	Lane Groups			L	T				TR			L	TR					
Arriv	al Type			3	3				3			3	3					
RTO	R Vol (vph)			0				5						0				
Peds/	Hour				5		0			0					5			
% Gr	ade				0		0			0			0					
Buses	s/Hour			0			0			0			0					
Parke	rs/Hour (Le	ft Right)																
Signa	l Settings: A	Actuated		Operational Analysis					is Cycle Length: 1			110.0 Sec	ne Per Cycle: 9.0 Sec					
Phase	:	1		2	2	3	3	4	4		5	6		7	8		Ped Only	
EB		LT		L	Γ													
WB			Т	R														
NB					L	ГР												
SB																		
Greer		24.			3.0		9.0				1							0
Yello	w All Red	4.0	0.0	3.5	1.5	3.5	1.5											

	Approa	ch:								
App EB	Lane Cap Group (vph) * Lper 66		(vph) Ratio		Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh) 222.1	LOS F
ED	* Lpci	379	0.218	0.345 0.218	L	1.831	416.0	F	222.1	1
	Т	1982	0.213	0.555	T	0.384	14.4	В		
	1	1982	0.213	0.555	1	0.364	14.4	Б		
WB										
	TR	1059	0.245	0.300	TR	0.816	42.6	D	42.6	D
NB										
	* L	607	0.476	0.355	L	1.343	200.6	F	157.2	F
	TR	562	0.172	0.355	TR	0.486	27.9	C		
T	· D1		1.100.5			* 0 :: 1	I C) G : 207	
ntersecti	ion: Delay =158	8.2 sec/veh	Int. LOS=F	$X_c = 3$.23	* Critical	Lane Group	\geq (v/s	c)Crit= 2.97	

Intersection: Delay = 158.2 sec/veh SIG/Cinema v3.08

Page 1

No Build 2035 R Marvin PM Design Hour Old US 87/I90 EB Off Ramp 10/13/2011 Case: EBRAMP~1

App EB	Lane Group L T	Queues Per Lane Avg/Max (veh) 29 / 29 5 / 9	Average Speed (mph) 2.1 4.5	Spillback in Worst Lane (% of Peak Period) 63.3 57.8
	All	317	3.5	63.3
WB	TR	10 / 11	8.0	0.0
	All		8.0	0.0
NB	L	28 / 29	3.1	56.4
	TR	3 / 5	18.2	0.0
	All		4.3	56.4
	Inte	rsect.	4.6	

No Build Alt 2035 190 EB Off Ramp/Johnson Lane Area Type: Non CBD R Marvin 10/13/2011 Analysis Duration: 15 mins. Design Hour PM Case: EBRAMP~2 Geometry: Movements Serviced by Lane and Lane Widths (feet) Lanes Approach Outbound Lane 1 Lane 2 Lane 3 Lane 4 Lane 5 Lane 6 EB LT 12.0 12.0 0 0 WB NB 1 1 TR 12.0 SB2 1 L 12.0 Т 12.0 East West North South Т T T R T Data L R L R L L R Movement Volume (vph) 110 950 0 0 0 700 250 150 245 0.92 0.92 0.92 0.90 0.90 0.90 0.90 0.92 0.92 0.92 PHF 0.92 0.90 % Heavy Vehicles 4 2 LT TR T Lane Groups R L Arrival Type 3 3 RTOR Vol (vph) 150 0 25 0 0 0 0 5 Peds/Hour % Grade 0 0 0 0 Buses/Hour 0 0 0 0 Parkers/Hour (Left|Right)

4

Cycle Length: 125.0 Sec

6

5

	Capacity Analysis Results											
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS		
EB	-				-							
	LT	696	0.070	0.400	LT	0.174	24.2	C	36.6	D		
	* R	932	0.560	0.600	R	0.933	38.4	D				
NB												
	TR	919	0.569	0.520	TR	1.095	89.0	F	89.0	F		
SB												
	* L	59	0.891	0.320	L	2.763	881.0	F	357.3	F		
	T	585	0.146	0.320	Т	0.455	36.4	D				

Intersection: Delay =115.0 sec/veh SIG/Cinema v3.08

Signal Settings: Actuated

LTP

50.0

1.5

3.5

Phase:

EB

WB

NB SB

Green

Yellow All Red

Int. LOS=F

Operational Analysis

3

TR

LT

3.5

40.0

1.5

2

R

TP

20.0

1.5

3.5

 $X_c = 1.58$

* Critical Lane Group

 $\sum (v/s)$ Crit= 1.45

Lost Time Per Cycle: 10.0 Sec

Ped Only

0

8

7

Page 1

No Build Alt 2035 R Marvin Design Hour PM I90 EB Off Ramp/Johnson Lane 10/13/2011 Case: EBRAMP~2

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	245
ЕВ	LT	5 / 9	9.3	0.0	
	R	11 / 16	12.7	0.0	
	All		12.1	0.0	
]
	All		5.6	25.4	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$
NB	TR	25 / 29	5.6	25.4	
	All		1.7	37.8	
SB	L	14 / 21	0.5	37.8	1 2 3 1
	Т	5 / 10	3.2	25.3	
					49 4 2 19 1 4 2 39 1 4 2
	Inte	rsect.	5.5		

	TW	O-WAY STOP	CONTR	OL SI	JMN	//ARY				
General Informatio	 n		Site II	nform	atio	on .				
Analyst	R Marvin		Interse	ection			Johnson	WB F	Ramps	s Nobuild
Agency/Co.	Marvin A	ssociates	Jurisdi				MDT			
Date Performed	10/10/20		Analys	is Yea	r		2035			
Analysis Time Period	Design H	lour PM								
Project Description Bi			·							
East/West Street: WB I						t: Johnso	n Lane			
Intersection Orientation:	North-South		Study F	Period	(hrs)	: 0.25				
Vehicle Volumes a	nd Adjustme									
Major Street		Northbound	1				Southbou	und		
Movement	1	2	3			4	5			6
	L	T	R			L	T			R
Volume (veh/h)	610	200	4.00			4.00	205			150
Peak-Hour Factor, PHF	0.95	0.95	1.00	<u>'</u>		1.00	0.90			0.90
Hourly Flow Rate, HFR (veh/h)	642	210	0			0	227			166
Percent Heavy Vehicles	8					0				
Median Type				Undiv	/idec	1				
RT Channelized			0							0
Lanes	1	1	0			0	1			1
Configuration	L	T					T			R
Upstream Signal		0					0			
Minor Street		Eastbound					Westbou	ınd		
Movement	7	8	9			10	11			12
	L	T	R			L	Т			R
Volume (veh/h)						190			110	
Peak-Hour Factor, PHF	1.00	1.00	1.00)		0.90	1.00		0.90	
Hourly Flow Rate, HFR (veh/h)	0	0	0			211	0	0		122
Percent Heavy Vehicles	0	0	0			8	0			10
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0							0
Lanes	0	0	0			0	0			0
Configuration							LR			
Delay, Queue Length, a	and Level of Se	rvice								
Approach	Northbound	Southbound	,	Westbo	ound			Eastb	ound	
Movement	1	4	7	8		9	10	1	11	12
Lane Configuration	L			LR						
v (veh/h)	642	ĺ		333	3					
C (m) (veh/h)	1134			55						
v/c	0.57			6.05						
95% queue length	3.69		<u> </u>	38.0						i
Control Delay (s/veh)	12.2	 	<u> </u>	242				\vdash		
LOS	В		 	F				\vdash		1
			-	242						
Approach Delay (s/veh)					1					
Approach LOS Copyright © 2010 University of F			<u> </u>	F CS+ TM						011 3:46 P

HCS+TM Version 5.6

Generated: 12/17/2011 3:46 PM

	TW	O-WAY STOP	CONTR	OL SI	JMN	MARY				
General Information	 n		Site II	nform	atio	on				
Analyst	R Marvin		Interse	ection			Coulson	& Johr	nson	No Build
Agency/Co.	Marvin A	ssociates	Jurisdi	ction			MDT			
Date Performed	10/8/201		Analys	is Yea	r		2035			
Analysis Time Period	Design H	our PM								
Project Description Bi	llings Bypass									
East/West Street: Coul-						t: Johnso	n Lane			
Intersection Orientation:	North-South		Study F	Period	(hrs)	: 0.25				
Vehicle Volumes ar	nd Adjustme									
Major Street		Northbound	Ĩ				Southbou	ınd		
Movement	1	2	3			4	5			6
N/ - 1 / 1 / 1 N	L	T	R			L	T			R
Volume (veh/h)	1.00	10	55			0	30			4.00
Peak-Hour Factor, PHF Hourly Flow Rate, HFR	1.00	0.60	0.60			0.60	0.60	-		1.00
(veh/h)	0	16	91			0	49			0
Percent Heavy Vehicles	0					5				
Median Type				Undi	/idec	1				
RT Channelized			0							0
Lanes	0	1	0			0	1			0
Configuration			TR			LT				
Upstream Signal		0					0			
Minor Street		Eastbound					Westbou	ınd		
Movement	7	8	9			10	11			12
	L	Т	R			L	Т			R
Volume (veh/h)						80				5
Peak-Hour Factor, PHF	1.00	1.00	1.00			0.60	1.00		0.60	
Hourly Flow Rate, HFR (veh/h)	0	0	0		133 0				8	
Percent Heavy Vehicles	0	0	0			5	0			5
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0							0
Lanes	0	0	0			0	0			0
Configuration							LR			
Delay, Queue Length, a	and Level of Se	rvice					<u>'</u>			
Approach	Northbound	Southbound	,	Westbo	ound			Eastbo	ound	
Movement	1	4	7	8		9	10	1		12
Lane Configuration	-	LT	<u> </u>	LR		1	†			
v (veh/h)		0	ĺ	141			†			
C (m) (veh/h)		1465		885						
v/c		0.00		0.16						
95% queue length		0.00		0.5						
Control Delay (s/veh)		7.5		9.8			†			<u> </u>
LOS		A		A						
Approach Delay (s/veh)				9.8	<u> </u>	I.	 			
Approach LOS				A			 			
Copyright © 2010 University of Fl			<u> </u>	CS+ TM			0.		0/47/0/	011 3:42 P

HCS+TM Version 5.6

Generated: 12/17/2011 3:42 PM

General Information	n		Site I	nform	nation						
Analyst	R Marvin		Interse		lation		N Ernta 8	lohnson			
Agency/Co.	Marvin A	ssociates	Jurisd				N Frntg & Johnson MDT				
Date Performed	10/8/201			sis Yea	ır		NoBuild 2035				
Analysis Time Period	Peak PM		<u> </u>	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			1020				
	lings Bypass										
East/West Street: N Fro			North/S	South S	Street: .	Johnso	n Lane				
ntersection Orientation:					(hrs): <i>C</i>						
Vehicle Volumes ar	nd Adiustme	nts	<u> </u>								
Major Street		Northbound					Southbou	ınd			
Movement	1	2	3		4		5	1	6		
	Ĺ		R		L		T		R		
/olume (veh/h)	200	80	30		5		55		30		
Peak-Hour Factor, PHF	0.85	0.85	0.85	5	0.5	0	0.50		0.50		
Hourly Flow Rate, HFR	235	94	35		10		110		60		
veh/h) Percent Heavy Vehicles	10				4						
Median Type	1 '0	<u> </u>		Undi	vided						
RT Channelized	1		0	3.767			T		0		
_anes	1	1	0		1		1	-+	0		
Configuration	† ;	'	TR		Ĺ		 	$\overline{}$	TR		
Jpstream Signal		0	- //				0		,,,		
Minor Street	+	Eastbound	<u> </u>				Westbound				
Movement	7	8	9		10)	11	inu	12		
VIOVOITION	Ĺ	T	R		L	,	T T		R		
Volume (veh/h)	60	25	275		25	,	20		5		
Peak-Hour Factor, PHF	0.85	0.85	0.85		0.5		0.50				
Hourly Flow Rate, HFR	1	1					1				
veh/h)	70	29	323		50		40		10		
Percent Heavy Vehicles	4	4	10		4		4		4		
Percent Grade (%)		0					0				
-lared Approach		N					N				
Storage		0					0				
RT Channelized	1	1	0						0		
_anes	1	1	0		1		1		0		
Configuration	L	1	TR		L		Ì		TR		
Delay, Queue Length, a	and Level of Se	ervice	-		-		-				
Approach	Northbound	Southbound		Westbo	ound			Eastbound			
Movement	1	4	7	8		9	10	11	12		
_ane Configuration	 L	L.	L	ĦŤ		TR	L	 	TR		
/ (veh/h)	235	10	50			50	70	 	352		
C (m) (veh/h)	1360	1444	126	 		314	241	 	749		
					_		+				
//C	0.17	0.01	0.40			0.16	0.29	 	0.47		
95% queue length	0.62	0.02	1.68			0.56	1.16		2.53		
Control Delay (s/veh)	8.2	7.5	51.2		1	8.6	25.9		14.0		
_OS	Α	Α	F			С	D		В		
Approach Delay (s/veh)				34.	9			16.0			
Approach LOS			D					С			

No Build Alt 2035 Old Hardin Road/Johnson lane Area Type: Non CBD

R Marvin 10/13/2011 Analysis Duration: 15 mins.

PM Design Hour Case: OLDHAR~1

	Design F	Hour	Case: OLDHAR~1																
	Lanes					G	eome	etry: Mo	vemer	nts Se	rviced b	y Lane a	nd Lan	e W	idths (f	feet)			
	Approach (Outbound	1	Lane	1]	Lane	2		Lane	3	La	ne 4		La	ane 5		Lar	ne 6
EB	2	1		L	12.0	TR		12.0											
WB	2	1	I	Т	12.0	R		12.0											
NB	2	1		L	12.0	TR		12.0											
SB	3	1		L	12.0	Т		12.0	R		12.0								
	East						We	st		North					South				
	Data			L	T	R		L	Т		R	L	Т		R	L	,	Т	R
Move	ment Volun	ne (vph)	2	270	380	35		35	25	0	570	25	12	0	35	75	60	160	290
PHF			0.	.92	0.92	0.92	:	0.92	0.9	2	0.92	0.92	0.9	2	0.92	0.9	2	0.92	0.92
% He	avy Vehicle	s		10	0	0		0	()	0	1	1	l	0	(0	1	10
Lane	Groups			L	TR				LT	7	R	L	TF	₹		L	,	Т	R
Arriv	al Type			3	3				3		3	3	3			3		3	3
RTO	R Vol (vph)				5				80	O			4	5				20	
Peds/	Hour				5		0					5						5	
% Gr	ade				0			0				0				0			
Buses	/Hour				0				0				0					0	
Parke	rs/Hour (Le	ft Right)								-									
Signa	1 Settings: A	Actuated		(Operati	onal An	alysi	s	C	ycle L	ength: 1	130.0 Se	ec	1	Lost Tin	ne Per (Cycle	: 13.0 S	ec
Phase	:	1		2	2	3		4			5	6			7	8		Pe	d Only
EB		LTP	•	LT	ТР														
WB				LT	R	R													
NB								LT	P										
SB	SB LTP		LT																
Green	ı	23.5	5	22	2.5	55.0)	11	.0							ı			0
Yello	w All Red	4.0	0.0	3.5	1.5	4.0	0.0	3.5	1.5										

	Capacity Analysis Results										
			•					I	Approa	CII.	
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay		
App	Group	(vpĥ)	Ratio		Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS	
EB	Lper	55	0.000	0.212					39.7	D	
	* Lpro	297	0.179	0.181	L	0.832	49.3	D			
	TR	722	0.237	0.385	TR	0.618	33.5	C			
WB											
	* LT	292	0.184	0.173	LT	1.062	123.6	F	53.8	D	
	R	1025	0.330	0.635	R	0.520	13.2	В			
NB											
	L	103	0.022	0.085	L	0.262	56.2	Е	137.3	F	
	TR	153	0.090	0.085	TR	1.065	150.7	F			
SB	* Lper	58	0.107	0.123					44.2	D	
	* Lpro	764	0.423	0.423	L	0.991	60.1	Е			
	T	1013	0.093	0.538	T	0.172	15.3	В			
	R	787	0.201	0.538	R	0.372	17.4	В			

Intersection: Delay = 51.6 sec/veh SIG/Cinema v3.08

Int. LOS=D

 $X_c = 0.99$

* Critical Lane Group

 $\sum (v/s)$ Crit= 0.89

Page 1

No Build Alt 2035 R Marvin PM Design Hour Old Hardin Road/Johnson lane 10/13/2011 Case: OLDHAR~1

App EB	Lane Group L TR	Queues Per Lane Avg/Max (veh) 12 / 22 11 / 12	Average Speed (mph) 2.6 9.6	Spillback in Worst Lane (% of Peak Period) 12.7 0.0	160 290 750
	All		5.8	12.7	
					
WB	LT	9 / 20	7.8	3.3	
	R	5 / 10	11.6	0.0	$\begin{array}{c c} 270 \longrightarrow \\ 380 \longrightarrow \end{array} \qquad \begin{array}{c c} \\ \end{array}$
	All		8.5	3.3	35 —
NB	L	1 / 3	2.2	0.0	
	TR	5 / 7	5.8	0.0	
					25 35
	All		5.3	0.0	
SB	L	19 / 27	5.9	6.2	
	T	3 / 5	15.4	3.7	
	R	2 / 5	18.0	0.0	24 4 0 22 4 2 54 4 0 10
	All		8.4	6.2	
	Inte	rsect.	7.4		

		TWO	D-WAY STOP	CONTR	OL SI	JMI	I ARY				
General Information	n			Site I	nform	natio	on				
Analyst	RΛ	<i>l</i> arvin		Interse	ection			Becraft &	Old F	lardir	n Road
Agency/Co.	Ма	rvin As	sociates	Jurisdi	ction			MDT			
Date Performed	10/.	28/201	1	Analys	is Yea	r	2035 No Build		Build	uild	
Analysis Time Period	Pea	ak PM									
Project Description Bil	llings Byp	ass									
East/West Street: Old F	lardin Ro	ad		North/S	South S	Stree	t: <i>Becraft</i>	Lane			
ntersection Orientation:	East-W	/est		Study F	Period	(hrs)	: 0.25				
Vehicle Volumes ar	nd Adju	stme									
Major Street			Eastbound					Westbou	ınd		
Movement		1	2	3			4	5			6
		L	Т	R			L	Т			R
Volume (veh/h)			560	570			10	600			
Peak-Hour Factor, PHF	1.	00	0.92	0.92			0.92	0.92			1.00
Hourly Flow Rate, HFR veh/h)	(0	608	619			10	652			0
Percent Heavy Vehicles	(0					0				
Median Type					Undiv	/idec	l				
RT Channelized				0							0
_anes	(0	1	0			0	1			0
Configuration				TR			LT				
Jpstream Signal			1					0			
Minor Street			Northbound					Southboo	und		
Movement		7	8	9			10	11			12
		L	Т	R	Î		L	Т			R
/olume (veh/h)	1:	90	1	10							
Peak-Hour Factor, PHF	0.	85	1.00	Î			1.00	1.00		1.00	
Hourly Flow Rate, HFR veh/h)	22	23	0	12			0	0		0	
Percent Heavy Vehicles		0	0	0			0	0			0
Percent Grade (%)	1		0	•				0			
Flared Approach			N					N			
Storage			0					0			
RT Channelized			1	0					$\neg \uparrow$		0
_anes		0	0	0			0	0	\neg		0
Configuration			LR	i i					\neg		
Delay, Queue Length, a	nd Leve	l of Se	rvice								
Approach	Eastbo	1	Westbound	1	Northbo	ound		9	Southb	ound	
Movement	1		4	7	8		9	10	1	1	12
ane Configuration			LT		LR				†		Ì
/ (veh/h)			10		235			İ			İ
C (m) (veh/h)		$\neg \uparrow$	420		72						
//c			0.02		3.26			1			
95% queue length			0.07		24.0				†		\vdash
Control Delay (s/veh)			13.8		114				1		
					F	'		 	\vdash		\vdash
LOS			В								
Approach Delay (s/veh)					114	1					
Approach LOS					F						

HCS+TM Version 5.6

	BASIC FR	EEWAY SE	GMENTS WORKSHEE	Т		
General Information			Site Information			
Analyst Agency or Company Date Performed Analysis Time Period	R Marvin Marvin Asso 12/5/2011 PM Design F		Highway/Direction of Trave From/To Jurisdiction Analysis Year	l EB N 27th to Lockwood MDT 2035 No Build		
· · · · · ·	gs Bypass		N (A1)	□ DI-		
Oper.(LOS)		L	Des.(N)	III Plai	nning Data	
Flow Inputs	20.10		B 1 11 E 1 B11E			
Volume, V AADT	2240	veh/h veh/day	Peak-Hour Factor, PHF %Trucks and Buses, P _T	0.92 15		
Peak-Hr Prop. of AADT, K Peak-Hr Direction Prop, D DDHV = AADT x K x D		veh/h	%RVs, P _R General Terrain: Grade % Length Up/Down %	4 Level mi		
Calculate Flow Adjus	tments					
f _p	0.95 1.5		E _R	1.2		
E _T	1.0		$f_{HV} = 1/[1 + P_T(E_T - 1) + P_R(E_R - 1)]$			
Speed Inputs			Calc Speed Adj and	ггэ		
Lane Width		ft				
Rt-Side Lat. Clearance	•	ft	f_{LW}		mph	
Number of Lanes, N	2	, .	f _{LC}		mph	
Total Ramp Density, TRD		ramps/mi	TRD Adjustment		mph	
FFS (measured) Base free-flow Speed, BFFS	65.0	mph mph	FFS	65.0	mph	
LOS and Performanc	e Measures	<u> </u>	Design (N)			
Operational (LOS) v _p = (V or DDHV) / (PHF x	N v f		Design (N) Design LOS			
x t _p)		pc/h/ln	$v_p = (V \text{ or DDHV}) / (PHF x x f_p)$	N x f _{HV}	pc/h/ln	
S D - v / S	65.0	mph	s		mph	
$D = v_p / S$	21.4	pc/mi/ln	$D = v_p / S$		pc/mi/ln	
LOS	С		Required Number of Lanes	s, N		
Glossary			Factor Location			
N - Number of lanes V - Hourly volume v _p - Flow rate LOS - Level of service speed DDHV - Directional design	BFFS - Ba		E_R - Exhibits 11-10, 11-12 E_T - Exhibits 11-10, 11-11, f_p - Page 11-18 LOS, S, FFS, v_p - Exhibits 11-3	11-13	f _{LW} - Exhibit 11-8 f _{LC} - Exhibit 11-9 TRD - Page 11-1	

HCS 2010TM Version 6.1

Generated: 12/18/2011 3:21 PM

	BASIC FR	EEWAY SE	GMENTS WORKSHEE	Т			
General Information			Site Information				
Analyst Agency or Company Date Performed Analysis Time Period	R Marvin Marvin Asso 12/5/2011 PM Design F		Highway/Direction of Trave From/To Jurisdiction Analysis Year	Lockwo MDT	vood to Johnson No Build		
Project Description Billing Oper.(LOS)	gs Bypass) o (N)	□ Dlos	oning Data		
Flow Inputs		L	Des.(N)	- Piai	nning Data		
Volume, V AADT Peak-Hr Prop. of AADT, K Peak-Hr Direction Prop, D DDHV = AADT x K x D	1960	veh/h veh/day veh/h	Peak-Hour Factor, PHF %Trucks and Buses, P _T %RVs, P _R General Terrain: Grade % Length	0.92 15 4 Level mi			
Calculate Flow Adjus	tments		Up/Down %				
f _p E _T	0.95 1.5		E_R $f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	1.2)] 0.923			
Speed Inputs			Calc Speed Adj and	FFS			
Lane Width Rt-Side Lat. Clearance Number of Lanes, N Total Ramp Density, TRD FFS (measured) Base free-flow Speed, BFFS	2 65.0	ft ft ramps/mi mph mph	f _{LW} f _{LC} TRD Adjustment FFS	65.0	mph mph mph mph		
LOS and Performanc	e Measures	<u> </u>	Design (N)				
Operational (LOS) v _p = (V or DDHV) / (PHF x l x f _p) S D = v _p / S LOS	N x f _{HV} 1214 65.0 18.7 C	pc/h/ln mph pc/mi/ln	Design (N) Design LOS $v_p = (V \text{ or DDHV}) / (PHF \text{ x} \text{ x } f_p)$ S $D = v_p / S$ Required Number of Lanes		pc/h/ln mph pc/mi/ln		
Glossary			Factor Location				
N - Number of lanes V - Hourly volume v _p - Flow rate LOS - Level of service speed DDHV - Directional design	BFFS - Ba		E_R - Exhibits 11-10, 11-12 E_T - Exhibits 11-10, 11-11, f_p - Page 11-18 LOS, S, FFS, v_p - Exhibits 11-3	11-13	f _{LW} - Exhibit 11-8 f _{LC} - Exhibit 11-9 TRD - Page 11-1		

HCS 2010TM Version 6.1

Generated: 12/18/2011 3:24 PM

	BASIC FR	EEWAY SE	GMENTS WORKSHEE	Т	
General Information			Site Information		
Analyst Agency or Company Date Performed Analysis Time Period Project Description Billing	R Marvin Marvin Asso 12/5/2011 PM Design F		Highway/Direction of Trave From/To Jurisdiction Analysis Year		n to Pinehills o Build
✓ Oper.(LOS)	gs Bypass		Des.(N)	□ Dlor	oning Data
Flow Inputs			Jes.(IN)	III Piai	nning Data
Volume, V AADT Peak-Hr Prop. of AADT, K Peak-Hr Direction Prop, D DDHV = AADT x K x D	1270	veh/h veh/day veh/h	Peak-Hour Factor, PHF %Trucks and Buses, P _T %RVs, P _R General Terrain: Grade % Length	0.92 22 4 Level mi	
			Up/Down %		
Calculate Flow Adjus	0.95		E _R	1.2	
E _T	1.5		$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$		
Speed Inputs			Calc Speed Adj and	FFS	
Lane Width Rt-Side Lat. Clearance Number of Lanes, N Total Ramp Density, TRD FFS (measured) Base free-flow Speed, BFFS	2 65.0	ft ft ramps/mi mph mph	f _{LW} f _{LC} TRD Adjustment FFS	65.0	mph mph mph mph
LOS and Performanc	e Measures	 S	Design (N)		
Operational (LOS) v _p = (V or DDHV) / (PHF x l x f _p) S D = v _p / S LOS	N x f _{HV} 812 65.0 12.5 B	pc/h/ln mph pc/mi/ln	Design (N) Design LOS $v_p = (V \text{ or DDHV}) / (PHF \text{ x} \text{ x f}_p)$ S $D = v_p / S$ Required Number of Lanes		pc/h/ln mph pc/mi/ln
Glossary			Factor Location		
N - Number of lanes V - Hourly volume v _p - Flow rate LOS - Level of service speed DDHV - Directional design	BFFS - Ba		E_R - Exhibits 11-10, 11-12 E_T - Exhibits 11-10, 11-11, f_p - Page 11-18 LOS, S, FFS, v_p - Exhibits 11-3	11-13	f _{LW} - Exhibit 11-8 f _{LC} - Exhibit 11-9 TRD - Page 11-1

HCS 2010TM Version 6.1

Generated: 12/18/2011 3:26 PM

		RAMP	S AND RAM			JKKSI	1661			
General In	formation			Site Infor	mation					
Analyst Agency or Comp Date Performed Analysis Time Po	any Ma	Marvin Arvin Associates /16/2011 // Design Hour	Ji Ji	reeway/Dir of Tr unction urisdiction nalysis Year	avel	EB Off-F I-90 Loc MDT 2035 No	kwood			
	on Billings Bypa					2000 110	, Dana			
Inputs	<u> </u>									
Upstream A	dj Ramp	Number of Lar Acceleration La		2					Downstrea Ramp	am Adj
Yes	☐ On	Deceleration L	- /1	500					☐ Yes	☐ On
✓ No	☐ Off	Freeway Volur	ne, V _F	2240					✓ No	☐ Off
L _{up} =	ft	Ramp Volume	V_R Flow Speed, S_{FF}	1100 65.0					L _{down} =	ft
$V_u =$	veh/h	Ramp Free-Flo		35.0					V _D =	veh/h
Conversio	n to pc/h U	nder Base (Conditions							
(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f	HV	f _p	v = V/PHF	x f _{HV} x f _p
Freeway	2240	0.92	Level	15	0	0.9	30	0.95	27	'55
Ramp	1100	0.92	Level	10	0	0.9	52	0.95	13	322
UpStream				-	<u> </u>	_				
DownStream		Merge Areas			 		Г	Diverge Areas		
Estimation	of v.s	Weige Areas			Estima	tion of		nverge Areas		
		/ (D)						\/ . (\) \/	\D	
		V _F (P _{FM}))		l.			$V_R + (V_F - V_F)$		
EQ =		uation 13-6 or	•		L _{EQ} =			Equation 13-1		-
) _{FM} =		ng Equation (E	xhibit 13-6)		P _{FD} =			000 using Equ	uation (Exhi	bit 13-7)
/ ₁₂ =	pc/h				V ₁₂ =			755 pc/h		
V_3 or V_{av34}		n (Equation 13-	14 or 13-17)		V_3 or V_{av34}			pc/h (Equation	on 13-14 oi	r 13-17)
	2,700 pc/h? 🥅 Y							Yes 🗹 No		
Is V_3 or $V_{av34} >$	1.5 * V ₁₂ /2				Is V ₃ or V _a	_{/34} > 1.5 ¹		Yes ✓ No		
f Yes,V _{12a} =	pc/h 13-1	n (Equation 13-	16, 13-18, or		If Yes,V _{12a}	=		oc/h (Equation 9)	13-16, 13	-18, or 13
Capacity C		3)			Capaci	tv Che		3)		
oupuony c	Actual	Ca	apacity	LOS F?		1	Actual	Ca	pacity	LOS F
		1 1	, ,		V _F		2755	Exhibit 13-8		No
V_{FO}		Exhibit 13-8			V _{FO} = V		1433	Exhibit 13-8	3 4700	No
rU					V _R	_	1322	Exhibit 13-1		No
Flow Ento	ina Morae	Influence A	roa					rge Influen		INU
10W EIILEI	Actual		Desirable	Violation?	jr-IOW EI		ctual	Max Desirab		Violation
V _{R12}	/ total	Exhibit 13-8	. con abio	violation:	V ₁₂		755	Exhibit 13-8	4400:All	No
	rvice Dete	rmination (i	f not F)	<u>I</u>				terminatio		
		+ 0.0078 V ₁₂ -			+			.0086 V ₁₂ - 0.	<u> </u>	• /
$D_{R} = 0.475^{\circ}$. 5.5575 \$ 12				3.4 (pc/i			<u>-</u> D	
					l ''		,			
	bit 13-2)					(Exhib		<u> </u>		
	ermination				Speed					
5 ,	it 13-11)				_ ~	,	thibit 13	•		
$S_R = mph ($	Exhibit 13-11)				I		(Exhibit	•		
								40.40\		
	Exhibit 13-11) Exhibit 13-13)				1 "	I/A mph (Exnibit (Exhibit	-		

			WPS AND	RAMP JUN	CTIONS W		EEI			
General	Informa	tion	· · ·		Site Infor	mation				
Analyst Agency or Co Date Perform	ed	R Ma Marvi 12/5/	in Associates	Ji	reeway/Dir of Tr unction urisdiction	avel	EB On-Ramp Lockwood MDT			
Analysis Time			esign Hour	A	nalysis Year		2035 No Build			
Project Descr	iption Billin	gs Bypass	5							
nputs			l							
Jpstream Adj Yes	Ramp On		Number of Lan Acceleration La		2 1000				Downstre Ramp	am Adj
	□ Off		Deceleration La	- 0	1000				☐ Yes	☐ On
INO	Ull		Freeway Volun	'	1200				☑ No	Off
up =	ft		Ramp Volume,		770				L _{down} =	ft
				Flow Speed, S _{FF}	65.0				,	uah/h
/ _u =	veh/h		Ramp Free-Flo	w Speed, S _{FR}	35.0				$V_D =$	veh/h
Convers	ion to po	c/h Und	der Base C	Conditions						
(pc/h)	()	V /eh/hr)	PHF	Terrain	%Truck	%Rv	f _{HV}	f _p	v = V/PH	F x f _{HV} x f _p
Freeway		1200	0.92	Level	15	4	0.923	0.95		1487
Ramp		770	0.92	Level	4	4	0.973	0.95		906
UpStream DownStream			 				+			
Downsueam			Merge Areas		ļ	 		<u>I</u> Diverge Areas	<u> </u>	
Estimation	on of v ₁₂		go 7 ou o			Estimat	tion of v ₁₂	2.1.0. go 7.1. ouc		
	12	V ₁₂ = V _F	/ D \					V _R + (V _F - V _R	\D	
_		12 1		12.7\		L _	v ₁₂ –			13)
-EQ =			ation 13-6 or	· ·	`	L _{EQ} =		(Equation 13-		· ·
P _{FM} =				on (Exhibit 13-6)	P _{FD} =		using Equation	n (Exnibit i	3-7)
/ ₁₂ =		1487		0.4.4.4.0.4.7		V ₁₂ =		pc/h	0.14 10	17\
V ₃ or V _{av34}	2 700/			3-14 or 13-17)	V ₃ or V _{av34}	2 700 /-2	pc/h (Equation 1	3-14 Or 13-	17)
Is V ₃ or V _{av34}						, u.	_{/34} > 2,700 pc/h?			
Is V ₃ or V _{av34} f Yes,V _{12a} =	₁ > 1.5 V ₁₂ /.		(Equation 13	·16, 13-18, or		If Yes,V _{12a} =		Pc/h (Equatio	n 13-16, 1	3-18, or
Capacity	Checks					Capacit	y Checks			
		Actual	Ca	pacity	LOS F?		Actual	Ca	oacity	LOS F?
						V_{F}		Exhibit 13-	3	
V_{FO}		2393	Exhibit 13-8		No	$V_{FO} = V_{F}$	- V _R	Exhibit 13-	3	
- FO		2373	EXHIBIT 13 0		110	V _R		Exhibit 13	-	
						<u>.</u>		10		
Flow Ent			fluence A		1	Flow Er	ntering Dive	1		7
		Actual	1	esirable	Violation?		Actual	Max Des	rable	Violation?
V _{R12}		2393	Exhibit 13-8	4600:All	No	V ₁₂	10 / -	Exhibit 13-8	<u> </u>	<u> </u>
			nination (i				f Service De			(<i>F</i>)
• • • • • • • • • • • • • • • • • • • •		/34 V _R + (0.0078 V ₁₂ - 0.0	J62/ L _A		1	$D_R = 4.252 + 0$).UU86 V ₁₂ - 0	.009 L _D	
14	5 (pc/mi/ln)						oc/mi/ln)			
.OS = B(I)	Exhibit 13-2)						Exhibit 13-2)			
_	etermina	ation				' 	Determinati	on		
Speed D		441				$D_s = (E_s)^T$	Exhibit 13-12)			
•	94 (Exibit 13	-11)								
5	94 (Exibit 13 2 mph (Exhil					$S_R = m$	nph (Exhibit 13-12)		
$M_{\rm S} = 0.2$ $S_{\rm R} = 58$.	-	oit 13-11)				l '`	nph (Exhibit 13-12 nph (Exhibit 13-12			

Concret	Info		MPS AND							
General	Intorn				Site Infor					
Analyst		R Ma			eeway/Dir of Tr	avel	WB On-Ramp			
Agency or C			in Associates		ınction		Lockwood			
Date Perforn		12/5/			ırisdiction		MDT			
Analysis Tim			Design Hour	Al	nalysis Year		2035 No Build			
	ription B	illings Bypas:	S							
nputs			I						1	
Jpstream Ac	dj Ramp		Number of Lan		2				Downstre	am Adj
□ Vaa	□ On		Acceleration La	ane Length, L _A	1000				Ramp	
Yes	☐ On		Deceleration L	ane Length L					☐ Yes	☐ On
™ No	Off		Freeway Volun	0 0	770					
110	i Oii		1	'					✓ No	Off
up =	ft		Ramp Volume,	V_R	700				L _{down} =	ft
up			Freeway Free-	Flow Speed, S _{FF}	65.0				down	
/ _u =	veh/h		Ramp Free-Flo	w Speed, S _{EB}	35.0				$V_D =$	veh/h
				• 110						
Jonvers	sion to	<i>pc/n Unc</i> ∀	der Base (Conditions	1	т	_	1	ı	
(pc/h)	v (Veh/hr)	PHF	Terrain	%Truck	%Rv	f _{HV}	f _p	V = V/PH	$F \times f_{HV} \times f_{p}$
Freeway		770	0.92	Level	15	4	0.923	0.95		954
Ramp		700	0.92	Level	4	4	0.973	0.95		823
UpStream		700	0.92	Level	4	4	0.973	0.95		023
DownStrear	n		+ +		 		+	+		
Downstream			Merge Areas		<u> </u>			Diverge Areas		
Estimati	ion of		g			Estimat	ion of v ₁₂			
			<u> </u>					., ., .,	, _	
		$V_{12} = V_F$	(P _{FM})				V ₁₂ =	$V_R + (V_F - V_F)$	P _{FD}	
-EQ =		(Equ	ation 13-6 or	13-7)		L _{EQ} =		(Equation 13	-12 or 13-1	13)
P _{FM} =		1.000	using Equati	on (Exhibit 13-6)		P _{FD} =		using Equation	n (Exhibit 1	3-7)
I ₁₂ =		954 p	c/h			V ₁₂ =		pc/h		
/ ₃ or V _{av34}		•		3-14 or 13-17)		V ₃ or V _{av34}		pc/h (Equation	13 ₋₁₄ or 13 ₋	17)
	. 2 700	pc/h? TYe		3-14-01-13-17)	•		₃₄ > 2,700 pc/h?		13 14 01 13	17)
							0.1			
is v ₃ or v _{av3}	₃₄ > 1.5 " \	/ ₁₂ /2 □ Ye		10 10 10		is v ₃ or v _{av}	$v_{34} > 1.5 * V_{12}/2$			0.40
f Yes,V _{12a} =		pc/h 13-19)		-16, 13-18, or		If Yes,V _{12a} :	= ,	pc/h (Equatio 13-19)	n 13-16, 1	3-18, or
Capacity	v Choc						y Checks	13-19)		
Japacit	y Once	Actual	C.	npacity	LOS F?	Toupacit	Actual	l Co	pacity	LOS F?
	_	Actual	1	ірасіту	LUST:	\/	Actual			LUSTE
						V _F		Exhibit 13-		
V_{FC}	,	1777	Exhibit 13-8		No	$V_{FO} = V_{F}$	- V _R	Exhibit 13-	8	
						V_R		Exhibit 13	-	
			<u></u>		<u> </u>	,		10		
low En	tering		fluence A			Flow Er	ntering Dive	7 -		
	-+	Actual)esirable	Violation?		Actual	Max Des	irable	Violation?
V _{R12}		1777	Exhibit 13-8	4600:All	No	V ₁₂		Exhibit 13-8		
Level of	Servic	e Deterr	nination (i	f not F)		Level o	f Service D	eterminatio	n (if not	: F)
D _R =	5.475 + 0	.00734 v _R + 0	0.0078 V ₁₂ - 0.0	0627 L _A			$D_R = 4.252 + 0$	0.0086 V ₁₂ - 0	.009 L _D	
	2.7 (pc/mi/l		.2			L	oc/mi/ln)	14	2	
	(Exhibit 13					1 ., ,,	Exhibit 13-2)			
	-	-						ion		
Speed D						' ' 	Determinati	UII		
$M_{\rm S} = 0.2$	274 (Exibit	13-11)				3 .	Exhibit 13-12)			
$S_R = 58$	8.7 mph (E	xhibit 13-11)				$S_R = m$	nph (Exhibit 13-12	2)		
						I.	nph (Exhibit 13-12	<u>'</u>)		
So= N/	Amnh (Fy	(NIDII 13-11)								
0	A mph (Ex 3.7 mph (F	xhibit 13-11)				ľ	·			

		RAMPS	S AND RAM	P JUNCTI	ONS WO	RKSHEET	•		
General In	formation			Site Infor					
Analyst		Marvin	Fr	eeway/Dir of Tr		WB Off-Ramp			
Agency or Comp	oany Ma	rvin Associates		nction		I-90 Lockwood			
Date Performed	11/	16/2011	Ju	risdiction		MDT			
Analysis Time Pe	eriod PM	l Design Hour	Ar	nalysis Year		2035 No Build			
Project Description	on Billings Bypa	ISS							
Inputs								i	
Upstream A		Number of Lar Acceleration L	nes, N ane Length, L₄	2				Downstrea Ramp	ım Adj
☐ Yes	☐ On	Deceleration L	- A	1000				Yes	☐ On
✓ No	☐ Off	Freeway Volur	ne, V _F	1470				✓ No	☐ Off
L _{up} =	ft	Ramp Volume		600				L _{down} =	ft
		Freeway Free-	Flow Speed, S _{FF}	65.0					
$V_u =$	veh/h	Ramp Free-Flo	ow Speed, S _{FR}	35.0				$V_D =$	veh/h
Conversio	n to pc/h Ui	nder Base (Conditions						
(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f _{HV}	f _p	v = V/PHF	x f _{HV} x f _p
Freeway	1470	0.92	Level	15	0	0.930	0.95	180	08
Ramp	600	0.92	Level	10	0	0.952	0.95	72	21
UpStream									
DownStream									
		Merge Areas			<u> </u>		Diverge Areas		
Estimation	of v ₁₂				Estimat	ion of v ₁₂			
	V ₁₂ = V	/ _F (P _{FM})				V ₁₃	$= V_R + (V_F - V_I)$	P _{ED}	
-EQ =	(Ear	uation 13-6 or	13-7)		L _{EQ} =		(Equation 13-1)
P _{FM} =		g Equation (E	•		P _{FD} =		1.000 using Eq		
гм / ₁₂ =	pc/h		Allient 10 0)		V ₁₂ =		1808 pc/h	dation (EXIII	511 15 7)
	•		44 0= 42 47\				•		40.47)
V ₃ or V _{av34}		(Equation 13-	14 01 13-17)		V ₃ or V _{av34}		0 pc/h (Equation	on 13-14 or	13-17)
	2,700 pc/h?					0.1	Yes Mo		
	1.5 * V ₁₂ /2				Is V ₃ or V _{av}	$_{34} > 1.5 ^ V_{12}/2$	☐ Yes ☑ No		
f Yes,V _{12a} =	pc/h 13-1	(Equation 13- 9)	·16, 13-18, or		If Yes,V _{12a} =	:	pc/h (Equation 19)	13-16, 13-	18, or 13
Capacity C		<u> </u>			Capacit	y Checks	10)		
	Actual	C	apacity	LOS F?		Actu	al Ca	pacity	LOS F
					V _F	1808	Exhibit 13-8	3 4700	No
V_{FO}		Exhibit 13-8			$V_{FO} = V_{F}$	- V _R 1087	Exhibit 13-8	3 4700	No
FU					V _R	721	Exhibit 13-1		No
Flow Entor	<u> </u>	Influence ^	roa	<u> </u>			erge Influen		INU
10W LINE	Actual		Desirable	Violation?	, IOW EI	Actual	Max Desiral		Violation ²
V _{R12}		Exhibit 13-8			V ₁₂	1808	Exhibit 13-8	4400:All	No
	ervice Deter		f not F)	<u> </u>			eterminatio		
	+ 0.00734 v _R -				` 		0.0086 V ₁₂ - 0.		/
$D_R = 0.473$		· 0.0070 v ₁₂ -	0.00021 LA		1		0.0000 v ₁₂ - 0.	-D	
2D - 1131:/11	•				l '').8 (pc/mi/ln)	`		
					 	(Exhibit 13-2	-		
OS = (Exhi					isbeed L	Determinat	ION		
OS = (Exhi	ermination				' ' 		0.40\		
$Speed\ Dete$ $M_S = (Exib)$	ermination oit 13-11)				$D_S = 0.$	493 (Exhibit 1	•		
$Speed\ Dete$ $M_S = (Exib)$	ermination				$D_{S} = 0.$ $S_{R} = 53$	493 (Exhibit 1 3.7 mph (Exhib	it 13-12)		
$Speed\ Deto$ $Speed\ Deto$	ermination bit 13-11) Exhibit 13-11) Exhibit 13-11)				$D_{S} = 0.$ $S_{R} = 53$ $S_{0} = N_{A}$	493 (Exhibit 1 3.7 mph (Exhib /A mph (Exhib	it 13-12) t 13-12)		
$S_{\rm COS} = (Exhi)$ $S_{\rm COS} = (Exhi)$	ermination bit 13-11) Exhibit 13-11)				$D_{S} = 0.$ $S_{R} = 53$ $S_{0} = N_{A}$	493 (Exhibit 1 3.7 mph (Exhib	it 13-12) t 13-12)		

		KAMP	S AND RAI			JKK5	пссі			
General In	formation			Site Infor						
Analyst Agency or Comp Date Performed	oany Ma	Marvin Irvin Associates 116/2011	J	Freeway/Dir of Tr lunction lurisdiction	avel	EB Off- I-90 Jo MDT	-Ramp hnson Lane	Ş		
Analysis Time P		1 Design Hour		Analysis Year		2035 N	lo Build			
	on Billings Bypa		<u> </u>	inarjoio roui		2000 11	o Bullu			
nputs	<u> </u>									
Upstream A	dj Ramp	Number of Lan Acceleration La		2					Downstrea Ramp	ım Adj
☐ Yes	☐ On	Deceleration L	- 71	500					☐ Yes	□ On
✓ No	☐ Off	Freeway Volun	ne, V _F	1960					✓ No	☐ Off
L _{up} =	ft	Ramp Volume,	10	1060					L _{down} =	ft
V _u =	veh/h	Freeway Free- Ramp Free-Flo	Flow Speed, S _{FF} ow Speed, S	5.0 35.0					V _D =	veh/h
			. 117	30.0						
	n to pc/n UI │	nder Base (1	1	Т	ı			
(pc/h)	(Veh/hr)	PHF	Terrain	%Truck	%Rv		f_{HV}	f_p	v = V/PHF	$x f_{HV} x f_{p}$
Freeway	1960	0.92	Level	15	0	0.	930	0.95	24	11
Ramp	1060	0.92	Level	15	0	0.	930	0.95	13	04
UpStream										
DownStream		Morgo Arono			<u> </u>			iverge Areas		
Estimation	of v	Merge Areas			Estima	tion o		iverge Areas		
_Stimation					LStilla	uon c				
		/ _F (P _{FM})						$V_R + (V_F - V_I)$		
EQ =		uation 13-6 or	•		L _{EQ} =			Equation 13-1		
FM =	usin	g Equation (E	xhibit 13-6)		P _{FD} =		1.	000 using Eq	uation (Exhi	bit 13-7)
/ ₁₂ =	pc/h				V ₁₂ =		24	11 pc/h		
V_3 or V_{av34}	pc/h	(Equation 13-	14 or 13-17)		V_3 or V_{av34}		0	pc/h (Equation	on 13-14 or	13-17)
Is V_3 or $V_{av34} >$	2,700 pc/h? 🥅 Y	es 🗌 No						Yes 🗹 No		
Is V_3 or $V_{av34} >$	1.5 * V ₁₂ /2				Is V ₃ or V _a	_{v34} > 1.5		Yes Vo		
f Yes,V _{12a} =	pc/h 13-1	ı (Equation 13- 9)	16, 13-18, or		If Yes,V _{12a}	=	p 19	c/h (Equation 9)	13-16, 13-	·18, or 13
Capacity C		- /			Capaci	ty Ch				
	Actual	Ca	apacity	LOS F?			Actual	Ca	pacity	LOS F
					V _F		2411	Exhibit 13-8	3 4700	No
V_{FO}		Exhibit 13-8			V _{FO} = V	F - V _R	1107	Exhibit 13-8	3 4700	No
					V _R		1304	Exhibit 13-1	0 2000	No
Flow Enter	ring Merge	Influence A	rea					rge Influen		
	Actual		Desirable	Violation?			Actual	Max Desiral		Violation
V _{R12}		Exhibit 13-8			V ₁₂	1	2411	Exhibit 13-8	4400:All	No
	ervice Deter	rmination (i	f not F)	1	 			terminatio		
		+ 0.0078 V ₁₂ -						.0086 V ₁₂ - 0.	_ •	,
O _R = (pc/m		12	^		$D_R = 2$	0.5 (pc		12	D	
	bit 13-2)				''		oit 13-2)			
•	ermination				Speed			on		
							xhibit 13-			
	it 13-11)				1.	•	(Exhibit	•		
	Exhibit 13-11)					•		· ·		
$S_0 = mph ($	Exhibit 13-11)				1 -	-	(Exhibit ' (Exhibit	•		
	Exhibit 13-13)				S = 5					

Ca# = #=	1 lmf		MPS AND								
Genera	ııntorn				Site Infor						
Analyst Agency or C Date Perfor		R Ma Marvi 12/5/:	in Associates	Ju	eeway/Dir of Tr inction irisdiction			n-Ramp on Lane			
nalysis Tir	me Period	PM D	esign Hour	Ar	nalysis Year		2035 N	No Build			
Project Des	cription E	Billings Bypass	3								
nputs											
Jpstream A			Number of Lan Acceleration La		2 1000					Downstre Ramp	am Adj
Yes	☐ On		Deceleration La	ane Length L _D						☐ Yes	☐ On
✓ No	☐ Off		Freeway Volum	'	870					™ No	C Off
up =	ft		Ramp Volume, Freeway Free-	V_R Flow Speed, S_{FF}	400 65.0					L _{down} =	ft
/ _u =	veh/h		Ramp Free-Flo		35.0					V _D =	veh/h
Conver	sion to	pc/h Und	der Base C	Conditions							
(pc/l	h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv		f_{HV}	f _p	v = V/PHF	x f _{HV} x f _p
Freeway		870	0.92	Level	15	4	0	.923	0.95	1	078
Ramp		400	0.92	Level	12	4	0	.936	0.95		489
UpStream			\vdash				_				
DownStrea	im		Morgo Arons					-	Divorgo Arono		
Ectimat	tion of		Merge Areas			Estimat	ion		Diverge Areas		
Suma	tion of					Estimat	ion				
		$V_{12} = V_{F}$	(P _{FM})					V ₁₂ =	$V_R + (V_F - V_R)$	P _{FD}	
EQ =		(Equa	ation 13-6 or	13-7)		L _{EQ} =			(Equation 13-	-12 or 13-1	3)
) _{FM} =		1.000	using Equati	on (Exhibit 13-6)		P _{FD} =			using Equatio	n (Exhibit 1	3-7)
′ ₁₂ =		1078	pc/h			V ₁₂ =			pc/h		
or V _{av34}		0 pc/h	n (Equation 1	3-14 or 13-17)		V ₃ or V _{av34}			pc/h (Equation 1	13-14 or 13-1	7)
s V ₃ or V _{av}		pc/h? TYes	s 🗹 No	,		Is V ₃ or V _{av}		700 pc/h? [Yes No		,
is V ₃ or V _{av}	_{/34} > 1.5 ^ \	V ₁₂ /2		10 10 10		Is V ₃ or V _{av}	₃₄ > 1.5		Yes No		0.40
f Yes,V _{12a} :	=	pc/h (13-19)		-16, 13-18, or		If Yes, V _{12a} =	=		pc/h (Equatio 3-19)	n 13-16, 1	3-18, or
Canacit	ty Chec					Capacit	v Ch		3 13)		
зараст	iy Onec	Actual		apacity	LOS F?	Capacit	y 0	Actual	Cal	pacity	LOS F?
		Actual		траспу	LOST:	V _F		Actual	Exhibit 13-		1031:
V		1547	Eyhihit 12 0		No	$V_{FO} = V_F$	- V _D		Exhibit 13-		+
V _F	0	1567	Exhibit 13-8		INO		K		Exhibit 13		+
		Mayara Ira	ofluence A			V _R	-4	na Diva	10	4 ***	<u> </u>
10W EI	Titering	Actual	fluence A	Desirable	Violation?	FIOW EI	Ti Ti	Actual	rge Influer Max Des		Violation
V _{R1}	10	1567	Exhibit 13-8	4600:All	No	V ₁₂	1		Exhibit 13-8		· ioiation
			nination (i		1.10		f Sar	vice De	eterminatio	n (if not	F)
			· ·			†				<u> </u>	•)
	= 5.475 + 0 1.2 (pc/mi/		0.0078 V ₁₂ - 0.0	0021 LA		1			.0086 V ₁₂ - 0	.oos ∟ _D	
	1.2 (pc/m// 3 (Exhibit 1:					1 ., ,,	oc/mi/l =xhibi	ın) t 13-2)			
	•	ination				Speed L			<u> </u>		
_									<i>)</i>		
5	.270 (Exibi	•				,	Exhibit 1	,			
		Exhibit 13-11)				L'`		hibit 13-12)			
	1/A mnh /F	xhibit 13-11)				$S_0 = m$	ıph (Exl	hibit 13-12)			
0		Exhibit 13-13)				ľ		, (hibit 13-13			

		RAMPS	S AND RAN	IP JUNCTI	ONS WO	RKS	HEET			
General Inf	formation			Site Infor						
Analyst Agency or Compa	R M	larvin vin Associates	Jı	reeway/Dir of Tr unction	avel	WB Off I-90 Job	-Ramp nnson Lan	e		
Date Performed		16/2011		urisdiction		MDT				
Analysis Time Pe		Design Hour	A	nalysis Year		2035 N	o Build			
Project Description	on Billings Bypas	SS								
Inputs		h							_	
Upstream A	dj Ramp On	Number of Lar Acceleration L	nes, N ane Length, L _A	2					Downstrea Ramp	ım Adj
		Deceleration L	0 0	1000					Yes	☐ On
™ No	☐ Off	Freeway Volur	•	950					✓ No	Off
L _{up} =	ft	Ramp Volume	, V _R Flow Speed, S _{FF}	300 65.0					L _{down} =	ft
V _u =	veh/h	Ramp Free-Flo		35.0					V _D =	veh/h
Conversion	n to pc/h Un	der Base (Conditions							
(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv		f _{HV}	f _p	v = V/PHF	x f _{HV} x f _p
Freeway	950	0.90	Level	15	0	0.0	930	0.95	11	94
Ramp	300	0.90	Level	25	0	0.8	389	0.95	39	95
UpStream										
DownStream		<u> </u>								
Cating ation	-f	Merge Areas			Catinast			Diverge Areas		
Estimation	or v ₁₂				Estimat	ion o	T V ₁₂			
	$V_{12} = V_{1}$	_F (P _{FM})					V ₁₂ =	$= V_R + (V_F - V_F)$	R)P _{FD}	
L _{EQ} =	(Equ	ation 13-6 or	13-7)		L _{EQ} =		(Equation 13-1	2 or 13-13)
P _{FM} =	using	g Equation (E	xhibit 13-6)		P _{FD} =		1.	000 using Equ	uation (Exhil	bit 13-7)
V ₁₂ =	pc/h	,			V ₁₂ =			194 pc/h	•	,
V ₃ or V _{av34}	•	(Equation 13-	14 or 13-17)		V ₃ or V _{av34}			pc/h (Equation	n 13-14 or	13-17)
	2,700 pc/h?		,			> 2.71		Yes Vo	711 10 14 01	10 17)
	1.5 * V ₁₂ /2				0 4.	0.		Yes No		
		Equation 13-	.16 13-18 or		" "	0.		oc/h (Equation	13-16 13-	.18 or 13.
If Yes,V _{12a} =	13-19		10, 10 10, 01		If Yes,V _{12a} =	=		9)	10 10, 10	10, 01 10
Capacity C	hecks				Capacit	y Che	ecks			
	Actual	C	apacity	LOS F?			Actual	Ca	pacity	LOS F?
					V_{F}		1194	Exhibit 13-8	4700	No
V_{FO}		Exhibit 13-8			$V_{FO} = V_{F}$	- V _D	799	Exhibit 13-8	3 4700	No
10					V _R		395	Exhibit 13-1	0 2000	No
Flow Entor	ing Merge li	nfluonoo A	<u></u>					rge Influen		140
FIOW LINE	Actual		Desirable	Violation?	FIOW EI		Actual	Max Desirat		Violation?
V _{R12}	Actual	Exhibit 13-8	Desirable	Violation:	V ₁₂		194	Exhibit 13-8	4400:All	No
	ervice Deter		f not E)					eterminatio		
		•			` 				<u> </u>	<u>-) </u>
	+ 0.00734 v _R +	· 0.0078 V ₁₂ -	0.00627 L _A		1			.0086 V ₁₂ - 0.	009 L _D	
	ıı/In)				l ''	.5 (pc/ n	,			
15.5						-	oit 13-2)			
LOS = (Exhil	bit 13-2)					7-4	minatio			
					Speed L	Jeteri	IIIIIau)ri		
LOS = (Exhit					 		xhibit 13			
$LOS = (Exhibit)$ Speed Dete $M_S = (Exibit)$	ermination it 13-11)				$D_S = 0.$.464 (E		-12)		
$LOS = (Exhibit)$ $Speed Dete$ $M_S = (Exibit)$ $S_R = mph (Exibit)$	ermination it 13-11) Exhibit 13-11)				$D_{S} = 0.$ $S_{R} = 54$.464 (E: 4.3 mph	xhibit 13	-12) 13-12)		
$LOS = (Exhibit)$ $Speed Dete$ $M_S = (Exibit)$ $S_R = mph (Exibit)$ $S_0 = mph (Exibit)$	ermination it 13-11)				$D_{S} = 0.$ $S_{R} = 54$ $S_{0} = N_{0}$.464 (E: 4.3 mph /A mph	xhibit 13 (Exhibit	-12) 13-12) 13-12)		

0	I		MPS AND	NAIVIE JUIN			<u> </u>			
General	inform				Site Infor					
Analyst		R Ma			eeway/Dir of Tr	avel	WB On-Ramp			
Agency or Co			vin Associates		inction		Johnson Lane			
Date Perform		12/5/			risdiction		MDT			
Analysis Time			Design Hour	Ar	nalysis Year		2035 No Build			
	ription B	llings Bypass	S							
Inputs			I						ſ	
Jpstream Adj	lj Ramp		Number of Lan		2				Downstre	am Adj
☐ Yes	On		Acceleration La	ane Length, L _A	1000				Ramp	
res	I On		Deceleration La	ane Length L _D						☐ On
✓ No	☐ Off		Freeway Volun	ne V	710				✓ No	Off
140	. 011		1	'					IM INO	III OII
- _{up} =	ft		Ramp Volume,	V_R	760				L _{down} =	ft
ир			Freeway Free-	Flow Speed, S _{FF}	65.0					
/ _u =	veh/h		Ramp Free-Flo	w Speed, S _{ED}	35.0				$V_D =$	veh/h
Convore	ion to	no/h I In	<u> </u>	. 110					<u> </u>	
		<i>pc/n Uni</i> √	der Base (Jonaldons	l .	1	1 .	Γ	1 .	
(pc/h))	v (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f _p	v = V/PHI	$= x f_{HV} x f_{p}$
Freeway	- 	710	0.92	Level	15	4	0.923	0.95		880
Ramp		760	0.92	Level	12	4	0.936	0.95		929
UpStream	- 	, 55	V.72	20101		† 	3.750	0.70		,
DownStream	n T		† †			1	1		1	
			Merge Areas		ı			Diverge Areas		
Estimati	on of v					Estimat	ion of v ₁₂	<u> </u>		
			(D)			-		\/ . (\/ \/	\D	
		$V_{12} = V_{F}$	1 141			1.	.=	$V_R + (V_F - V_R)$		
EQ =		(Equ	ation 13-6 or	13-7)		L _{EQ} =		(Equation 13-	-12 or 13-1	3)
P _{FM} =		1.000	using Equati	on (Exhibit 13-6)		P _{FD} =		using Equation	n (Exhibit 1	3-7)
/ ₁₂ =		880 p	oc/h			V ₁₂ =		pc/h		
/ ₃ or V _{av34}		0 pc/	h (Equation 1	3-14 or 13-17)		V ₃ or V _{av34}		pc/h (Equation 1	13-14 or 13-1	17)
	. > 2.700	oc/h? 🔲 Ye		,			₃₄ > 2,700 pc/h?			•
	•	₁₂ /2					₃₄ > 1.5 * V ₁₂ /2			
	•			-16, 13-18, or			**	pc/h (Equatio		3-18 or
f Yes,V _{12a} =		13-19)		10, 10 10, 01		If Yes,V _{12a} :		3-19)	11 10 10, 1	5 10, 01
Capacity	/ Chec	ks				Capacit	y Checks	,		
		Actual	Ca	apacity	LOS F?	1	Actual	Ca	pacity	LOS F?
				·	1	V _F		Exhibit 13-	1	
.,							- \/	Exhibit 13-		
V_{FO})	1809	Exhibit 13-8		No	$V_{FO} = V_{F}$	r V R			+
						V_R		Exhibit 13 10	-	
Flow Fn	terina	Merge Ir	nfluence A	rea		Flow Fr	ntering Dive		ice Area)
1011 LIII		Actual	i	Desirable	Violation?	, ,5 \\ L 1	Actual	Max Des		Violation
V _{R12}		1809	Exhibit 13-8	4600:All	No	V ₁₂	/ totadi	Exhibit 13-8		VIOIGIOIT
			nination (i		110		 f Service De	<u> </u>	n (if not	(E)
										<i>r)</i>
		.,	0.0078 V ₁₂ - 0.0	0027 L _A			$D_R = 4.252 + 0$	ט.טטט V ₁₂ - 0	.009 L _D	
$O_{R} = 12.$.9 (pc/mi/li	1)				$D_R = (p)$	oc/mi/ln)			
,	(Exhibit 13	-2)				LOS = (I	Exhibit 13-2)			
.OS = B(etermi	nation				Speed I	Determinati	on		
,						' 	Exhibit 13-12)			
Speed D		10 11\				ı-c (L				
Speed D M _S = 0.2	275 (Exibit	•					nh (Evhihit 12 12)		
Speed D $M_{S} = 0.2$ $S_{R} = 58$	275 (Exibit .7 mph (Ex	khibit 13-11)				S _R = m	nph (Exhibit 13-12			
Speed D $M_{S} = 0.2$ $S_{R} = 58.$ $S_{0} = N/H$	275 (Exibit .7 mph (Ex A mph (Ex	•				S _R = m	nph (Exhibit 13-12 nph (Exhibit 13-12			

APPENDIX D

Mary Street Alignment Option 1

Year 2035

Existing Street System

Capacity Calculations

er.			

Mary Option 1 Alt 2035

R Marvin
PM

Wicks Lane/Main Street
Area Type: Non CBD
Analysis Duration: 15 mins.
Case: WICKSM~1

PM.	viarviii [2/2011 e: WIC	KSM~1		P	marysis	Durano	13 1	mns.
	Lanes					Geom	etry: Mo	ovements	Serviced l	y Lane ar	nd Lane W	/idths (fe	eet)		
	Approach (Outbound	L	ane 1		Lane	e 2	La	ane 3	Laı	ne 4	La	ne 5	La	ne 6
EB	3	2	L	12.0	-	Γ	12.0	TR	12.0						
WB	3	2	L	12.0	L	Т	12.0	TR	12.0						
NB	5	3	L	12.0	J	L	12.0	Т	12.0	Т	12.0	TR	12.0		
SB	4	3	L	12.0	-	Г	12.0	Т	12.0	TR	12.0				
				East	<u> </u>			West			North			South	
	Data		L	Т	I	2	L	Т	R	L	Т	R	L	Т	R
Move	ement Volun	ne (vph)	320	450	1	50	520	390	80	350	1370	350	140	820	360
PHF			0.92	0.92	0.	92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
% He	avy Vehicle	es	0	0		0	0	0	0	0	2	1	0	2	0
Lane	Groups		L	TR			L	LTR		L	TR		L	TR	
Arriv	al Type		5	5			3	3		5	5		4	4	
RTO	R Vol (vph)			80				30			100			120	
Peds/	Hour			0				5			5			5	
% Gr	ade			0				0			0			0	
Buses	s/Hour			0				0			0			0	
Parke	ers/Hour (Le	ft Right)		-											
Signa	l Settings: A	Actuated		Opera	tional A	Analys	is	Cycl	e Length:	125.0 Sec	2	Lost Tim	e Per Cyc	le: 18.0 S	ec
Phase) :	1		2	(3	4	-	5	6		7	8	Pe	d Only
EB							LT	R							
WB					L	ГР									
NB		L		TP											
SB		L		TP											
Greei	1	16.0		38.0		4.0	29								0
Yello	w All Red	3.0	0.0 3.	5 1.5	3.5	1.5	3.5	1.5							

			Capac	city Analysis R	esults				Approa	ch:
App EB	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
ED	* L	419	0.193	0.232	L	0.831	53.6	D	45.0	D
	TR	821	0.160	0.232	TR	0.688	39.7	D		
WB										
	* L	347	0.219	0.192	L	1.138	141.8	F	100.3	F
	LTR	675	0.184	0.192	LTR	0.960	74.9	Е		
NB										
	* L	448	0.109	0.128	L	0.848	65.9	Е	105.1	F
	* TR	1509	0.355	0.304	TR	1.167	113.5	F		
SB										
	L	231	0.084	0.128	L	0.658	65.7	Е	45.2	D
	TR	1507	0.232	0.304	TR	0.764	42.5	D		

Intersection: Delay = 79.5 sec/veh SIG/Cinema v3.08

Int. LOS=E

 $X_c = 1.02$

* Critical Lane Group

 \sum (v/s)Crit= 0.87

Page 1

Mary Option 1 Alt 2035 R Marvin PM Wicks Lane/Main Street 10/12/2011 Case: WICKSM~1

App EB	Lane Group L TR	Queues Per Lane Avg/Max (veh) 8 / 13 3 / 6	Average Speed (mph) 4.9	Spillback in Worst Lane (% of Peak Period) 0.0	820 360 140
	All		8.9	0.0	
WB	L	12 / 13	3.8	0.0	
	LTR	12 / 15	5.4	0.0	
					320 -
	All		4.9	0.0	450 →
NB	L	7 / 9	3.9	0.0	
	TR	20 / 29	4.0	7.3	
					350 350
	All		3.9	7.3	
SB	L	8 / 10	3.2	0.0	1 2 1 3 4
	TR	9 / 15	7.7	0.0	
					16 3 0 37 4 2 23 4 2 28 4 2
	All		6.7	0.0	
	Inte	rsect.	5.2		

Mary Opt 1 Alt 2035 Airport Road/Main Street Area Type: Non CBD R Marvin 10/12/2011 Analysis Duration: 15 mins. PM Design Hour Case: AIRPOR~1 Geometry: Movements Serviced by Lane and Lane Widths (feet) Lanes Approach Outbound Lane 1 Lane 2 Lane 3 Lane 4 Lane 5 Lane 6 EB 3 L 12.0 LT 12.0 R 12.0 2 LT WB 2 12.0 R 12.0 NB 4 3 L 12.0 T 12.0 T 12.0 TR 12.0 SB4 3 L 12.0 Т 12.0 T 12.0 TR 12.0 East West North South T T T R T Data L R L R L L R Movement Volume (vph) 850 20 100 30 40 90 230 2890 10 70 1700 400 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 PHF 0.95 % Heavy Vehicles 2 0 2 0 0 2 LT LT TR TR Lane Groups L R R L L Arrival Type 3 3 3 3 5 5 RTOR Vol (vph) 20 0 100 30 5 0 5 5 Peds/Hour % Grade 0 0 0 0 Buses/Hour 0 0 0 0 Parkers/Hour (Left|Right) Signal Settings: Actuated Operational Analysis Cycle Length: 150.0 Sec Lost Time Per Cycle: 20.0 Sec Phase: 2 4 5 7 8 Ped Only 6 EB LTP R WBLTP LTP TP NB

			Capac	ity Analysis R	esults				Approa	ch:	
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay		
App	Group	(vph)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS	
EB											
	* L	460	0.278	0.260	L	1.070	117.3	F	92.5	F	
	LT	462	0.238	0.260	LT	0.918	76.8	Е			
	R	639	0.054	0.413	R	0.131	27.3	С			
WB											
	* LT	74	0.040	0.040	LT	1.000	176.6	F	177.5	F	
	R	64	0.039	0.040	R	0.984	178.5	F			
NB											
	L	236	0.137	0.133	L	1.025	123.7	F	80.8	F	
	* TR	2677	0.601	0.527	TR	1.140	77.4	Е			
SB											
	* L	72	0.041	0.040	L	1.028	184.0	F	34.0	C	
	TR	2219	0.424	0.447	TR	0.949	28.7	С			

ΤP

56.0

1.5

3.5

LTR

3.5

6.0

1.5

Intersection: Delay = 69.2 sec/veh SIG/Cinema v3.08

SB

Green

Yellow All Red

39.0

1.5

3.5

6.0

1.5

3.5

20.0

0.0

3.0

Int. LOS=E

 $X_c = 1.11$ * Critical Lane Group

 \geq (v/s)Crit= 0.96

Page 1

0

Mary Opt 1 Alt 2035 R Marvin PM Design Hour Airport Road/Main Street 10/12/2011 Case: AIRPOR~1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	1700 400 70
EB	L	18 / 19	4.1	0.0	4 ' 4
	LT	17 / 19	5.6	0.0	$\begin{array}{c c} & & & & & & & & & & & & & & & & & & &$
	R	1 / 2	18.6	0.0	
	All		5.2	0.0	
					<u> </u>
WB	LT	3 / 3	5.1	0.0	
	R	3 / 4	9.6	0.0	850 -
	All		7.4	0.0	20
NB	L	13 / 16	2.8	0.0	100 —
	TR	24 / 30	7.1	11.1	
					230 10 2890
	All		6.5	11.1	2890
SB	L	4 / 7	4.2	0.0	1 2 3 4 1
	TR	13 / 18	9.4	0.0	
					$\begin{bmatrix} 38 & 4 & 2 & 5 & & 4 & 2 & 20 & & & & & & & & & & & & & & & $
	All		9.0	0.0	5 4,
	Inte	rsect.	6.9		5 4 2

Mary Option 1 Alt 2035

R Marvin

PM design Hour

1st Ave N/

10/12/2011

Case: US87MA~1

Area Type: Non CBD

Analysis Duration: 15 mins.

	l design H	lour	Case: US87MA~1											
	Lanes				Geo	metry: N	Iovements	Serviced b	y Lane ar	nd Lane W	/idths (fe	eet)		
	Approach (Outbound	I	ane 1	La	me 2	La	ine 3	La	ne 4	La	ne 5	La	ne 6
EB	4	2	L	12.0	L	12.0	L	12.0	Т	12.0				
WB	3	2	Т	12.0	Т	12.0	R	12.0						
NB	0	3												
SB	4			12.0	L	12.0	R	12.0	R	12.0				
				East			West			North			South	
Data		L	Т	R	L	Т	R	L	Т	R	L	Т	R	
Movement Volume (vph)		ne (vph)	1800	600	0	0	610	850	0	0	0	820	0	670
PHF			0.95	0.95	0.90	0.90	0.95	0.95	0.90	0.90	0.90	0.95	0.90	0.95
% He	% Heavy Vehicles		2	2	2	2	2	4	2	2	2	4	2	2
Lane	Groups		L	Т			Т	R				L		R
Arriv	al Type		5	5			3	3				5		5
RTOI	R Vol (vph)			0			250			0			0	
Peds/	Hour			5			0			0			0	
% Gr	ade			0			0			0			0	
Buses	s/Hour			0			0			0			0	
Parke	kers/Hour (Left Right)					-								
Signa	l Settings: A	Actuated	Operational A		tional Anal	ysis	Cycl	e Length:	130.0 Sec	2	Lost Tim	e Per Cyc	le: 15.0 S	lec
Phase	: :	1	2 3		3		4	5	6		7	8	Pe	ed Only
EB		LT												
WB				TP	R									
NB														
SB	SB R				LP									
Greer	1	52.0		26.0	37.0									0
Yello	w All Red	3.5	1.5 3	3.5 1.5	3.5 1	.5								

			Canac	city Analysis R	esults				Approa	ch:
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
EB										
	* L	2060	0.368	0.400	L	0.920	28.7	C	29.4	C
	T	745	0.339	0.400	T	0.848	31.2	С		
WB										
	* T	708	0.181	0.200	Т	0.907	65.9	Е	47.8	D
	R	812	0.407	0.523	R	0.778	29.4	С		
SB										
	* L	958	0.256	0.285	L	0.901	46.0	D	25.6	С
	R	2015	0.253	0.723	R	0.350	0.5	A		
			-							
								1		1

Intersection: Delay = 32.6 sec/veh SIG/Cinema v3.08

Int. LOS=C

 $X_c = 0.91$

* Critical Lane Group

 $\sum (v/s)$ Crit= 0.81

Page 1

Mary Option 1 Alt 2035 R Marvin PM design Hour 1st Ave N/ 10/12/2011 Case: US87MA~1

App EB	Lane Group L T	Queues Per Lane Avg/Max (veh) 17 / 26 12 / 17	Average Speed (mph) 4.7 6.8	Spillback in Worst Lane (% of Peak Period) 1.2 0.2	670 820
	All		5.1	1.2	
					<u> </u>
WB	Т	11 / 13	5.9	0.0	 -
	R	13 / 15	9.6	0.0	
	All		7.6	0.0	1800 —
					600
	All		6.4	0.0	
SB	L	16 / 18	4.0	0.0	
					<u>↑</u>
	R	0 / 1	21.6	0.0	51 4 2 25 4 2 36 4 2
	Inte	rsect.	6.0		

Mary Op1 Alt 2035 Old US 87/I90 WB On Ramp Area Type: Non CBD R Marvin 10/13/2011 Analysis Duration: 15 mins. PM Design Hour Case: WBRAMP~1 Geometry: Movements Serviced by Lane and Lane Widths (feet) Lanes Approach Outbound Lane 1 Lane 2 Lane 3 Lane 4 Lane 5 Lane 6 EB 2 T 12.0 TR 12.0 Т 12.0 WB 3 2 12.0 12.0 NB 0 0 SB1 1 LTR 12.0 East West North South T T T R Т Data L R L R L L R Movement Volume (vph) 0 890 420 220 1000 0 0 0 20 310 1 PHF 0.90 0.92 0.92 0.92 0.92 0.90 0.90 0.90 0.90 0.92 0.92 0.92 % Heavy Vehicles 5 0 5 TR LTR Lane Groups L T 2 Arrival Type 2 3 RTOR Vol (vph) 150 0 0 100 0 5 0 0 Peds/Hour % Grade 0 0 0 0 Buses/Hour 0 0 0 0 Parkers/Hour (Left|Right) Signal Settings: Actuated Operational Analysis Cycle Length: 80.0 Sec Lost Time Per Cycle: 14.0 Sec Phase: 2 3 4 5 7 8 Ped Only 6 EB TR WB LT LT NB

		1	Capac	city Analysis R	lesults	ı	1	I	Approa	ch:
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
EB	1	\ 1 /			1					
	* TR	1493	0.380	0.450	TR	0.844	29.1	C	29.1	C
WB	Lper	94	0.087	0.512					16.4	В
	* Lpro	223	0.125	0.125	L	0.754	33.2	C		
	T	2149	0.316	0.625	T	0.506	12.7	В		
SB										
	* LTR	395	0.159	0.250	LTR	0.635	29.3	C	29.3	C

Intersection: Delay = 23.2 sec/veh SIG/Cinema v3.08

SB

Green

Yellow All Red

10.0

0.0

4.0

36.0

1.5

3.5

Int. LOS=C

LTR

20.0

1.5

3.5

 $X_{c} = 0.80$

* Critical Lane Group

 \sum (v/s)Crit= 0.66

Page 1

0

Mary Op1 Alt 2035 R Marvin PM Design Hour Old US 87/I90 WB On Ramp 10/13/2011 Case: WBRAMP~1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	1 310 20 V
ЕВ	TR	10 / 13	12.3	0.0	-1000
	All		12.3	0.0	
WB	L	5 / 7	4.6	0.0	
	Т	4 / 5	18.3	0.0	
	All		14.3	0.0	890 → 420 →
					-
	All		14.7	0.0	
					$\frac{}{1}$ $\frac{}{2}$ $\frac{}{3}$ $\frac{}{ }$
SB	LTR	3 / 5	14.7	0.0	
					10 4 0 35 4 2 19 4 2
	Inte	rsect.	13.3		

Mary Opt 1 2035 Old US 87/I90 EB Off Ramp Area Type: Non CBD R Marvin 10/13/2011 Analysis Duration: 15 mins. PM Design Hour Case: EBRAMP~1 Geometry: Movements Serviced by Lane and Lane Widths (feet) Lanes Approach Outbound Lane 1 Lane 2 Lane 3 Lane 4 Lane 5 Lane 6 EB 3 2 L 12.0 T 12.0 Т 12.0 2 T WB 2 12.0 TR 12.0 NB 2 1 L 12.0 TR 12.0 SB0 0 East West North South T T T R Т R Data L R L R L L Movement Volume (vph) 470 440 0 0 600 20 620 350 350 PHF 0.92 0.92 0.90 0.90 0.92 0.92 0.92 0.92 0.92 0.90 0.90 0.90 % Heavy Vehicles 4 2 5 0 Т TR Lane Groups L TR L Arrival Type 3 3 3 RTOR Vol (vph) 0 5 100 0 5 0 0 5 Peds/Hour % Grade 0 0 0 0 Buses/Hour 0 0 0 0 Parkers/Hour (Left|Right) Signal Settings: Actuated Operational Analysis Cycle Length: 120.0 Sec Lost Time Per Cycle: 9.0 Sec Phase: 2 3 4 5 7 8 Ped Only 6 EB LT LT WB TR

EB * Lper 61 0.197 0.250 43.4 I * Lpro 463 0.267 0.267 L 0.975 68.0 E T 1817 0.134 0.508 T 0.263 17.1 B WB TR 735 0.189 0.208 TR 0.909 63.6 E 63.6 I NB NB				Conor	nity Analysis D	loculte				Approx	oh:
EB * Lper 61 0.197 0.250 43.4 I * Lpro 463 0.267 0.267 L 0.975 68.0 E T 1817 0.134 0.508 T 0.263 17.1 B WB TR 735 0.189 0.208 TR 0.909 63.6 E 63.6 I NB * L 699 0.393 0.408 L 0.964 59.9 E 54.1 I											CII.
EB * Lper 61 0.197 0.250 43.4 I * Lpro 463 0.267 0.267 L 0.975 68.0 E T 1817 0.134 0.508 T 0.263 17.1 B WB TR 735 0.189 0.208 TR 0.909 63.6 E 63.6 I NB * L 699 0.393 0.408 L 0.964 59.9 E 54.1 I		Lane	Cap	_v/s	g/C	Lane		Delay		Delay	
* Lpro 463 0.267 0.267 L 0.975 68.0 E T 1817 0.134 0.508 T 0.263 17.1 B WB TR 735 0.189 0.208 TR 0.909 63.6 E 63.6 I NB * L 699 0.393 0.408 L 0.964 59.9 E 54.1 I	App		(vph)			Group	Ratio	(sec/veh)	LOS		LOS
T 1817 0.134 0.508 T 0.263 17.1 B WB TR 735 0.189 0.208 TR 0.909 63.6 E 63.6 I NB * L 699 0.393 0.408 L 0.964 59.9 E 54.1 I	EB	* Lper	61	0.197	0.250					43.4	D
WB TR 735 0.189 0.208 TR 0.909 63.6 E 63.6 I NB * L 699 0.393 0.408 L 0.964 59.9 E 54.1 I		* Lpro	463	0.267	0.267	L	0.975	68.0	E		
NB * L 699 0.393 0.408 L 0.964 59.9 E 54.1 I		T	1817	0.134	0.508	T	0.263	17.1	В		
NB * L 699 0.393 0.408 L 0.964 59.9 E 54.1 I											
NB											
NB * L 699 0.393 0.408 L 0.964 59.9 E 54.1 I	WB										
NB * L 699 0.393 0.408 L 0.964 59.9 E 54.1 I											
* L 699 0.393 0.408 L 0.964 59.9 E 54.1 I		TR	735	0.189	0.208	TR	0.909	63.6	Е	63.6	Е
* L 699 0.393 0.408 L 0.964 59.9 E 54.1 I											
* L 699 0.393 0.408 L 0.964 59.9 E 54.1 I											
E 077 0.375 0.400 E 0.704 37.7 E 34.1 I	NB										
TR 720 0.370 0.408 TR 0.906 48.0 D		* L	699	0.393	0.408	L	0.964	59.9	Е	54.1	D
		TR	720	0.370	0.408	TR	0.906	48.0	D		

 $X_{c} = 0.93$

Intersection: Delay = 52.7 sec/veh SIG/Cinema v3.08

NB SB Green

Yellow All Red

32.0

0.0

4.0

25.0

1.5

3.5

Int. LOS=D

LTP

49.0

1.5

3.5

* Critical Lane Group

 \sum (v/s)Crit= 0.86

0

Mary Opt 1 2035 R Marvin PM Design Hour Old US 87/I90 EB Off Ramp 10/13/2011 Case: EBRAMP~1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	
EB	L	20 / 26	2.9	31.2	
	Т	5 / 7	11.5	0.3	<u></u> 20 ← 600
	All		6.4	31.2	
WB	TR	9 / 11	6.9	0.0	
					470 —
	All		6.9	0.0	440
NB	L	24 / 27	4.4	2.3	
	TR	25 / 28	4.2	5.4	
					620 350 350
	All		4.3	5.4	
					1 2 3
					32 4 0 24 4 2 48 4 2
	Inte	rsect.	5.3		

APPENDIX E

Mary Street Alignment Option 2

Year 2035

Existing Street System

Capacity Calculations

er.			

Mary Option 2 Alt 2035 Wicks Lane/Main Street Area Type: Non CBD

R Marvin 10/12/2011 Analysis Duration: 15 mins.

PM Case: WICK SM~1

PM									2/201 e: WIC		I~ 1		A	maiysis	Duratio	n: 15 i	nins.
	Lanes						Geom	etry: Mo	ovement	s Servi	ced b	y Lane an	d Lane W	idths (fe	eet)		
	Approach	Outbound	d	Lane	1		Lane	e 2	I	ane 3		Lar	ne 4	La	ne 5	Laı	ne 6
EB	3	2]	L	12.0	-	Γ	12.0	TR	12	2.0						
WB	3	2]	L	12.0	L	т	12.0	TR	12	2.0						
NB	5	3]	L	12.0	I	.	12.0	Т	12	2.0	Т	12.0	TR	12.0		
SB	4	3]	L	12.0	-	Г	12.0	Т	12	2.0	TR	12.0				
					East				West				North			South	
Data]	L	T	I	2	L	Т	I	R	L	Т	R	L	Т	R	
Move	ement Volui	me (vph)	3	20	450	1	50	520	390		80	350	1350	350	140	810	360
PHF			0.	.92	0.92	0.	92	0.92	0.92	0.	92	0.92	0.92	0.92	0.92	0.92	0.92
% Heavy Vehicles			0	0		0	0	0		0	0	2	1	0	2	0	
Lane	Groups]	L	TR			L	LTR			L	TR		L	TR	
Arriv	al Type		:	5	5			3	3			5	5		4	4	
RTO	R Vol (vph)	ı			80				30				100			120	
Peds/	Hour				0				5				5			5	
% Gr	ade				0				0				0			0	
Buses	s/Hour				0				0				0			0	
Parke	rs/Hour (Le	eft Right)															
Signa	l Settings: A	Actuated	uated Operational Analysis Cycle				le Len	gth: 1	25.0 Sec	;	Lost Tim	e Per Cyc	le: 18.0 S	ec			
Phase: 1		2	2	3	3	4	ļ	5		6		7	8	Pe	d Only		
EB								LT	R								
WB						Ľ	ГР										
NB		L			P												
SB		L			Ρ												
Green		16.0	С		3.0		4.0	29									0
Yello	w All Red	3.0	0.0	3.5	1.5	3.5	1.5	3.5	1.5								

Capacity Analysis Results										Approach:	
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS	
EB											
	* L	419	0.193	0.232	L	0.831	53.6	D	45.0	D	
	TR	821	0.160	0.232	TR	0.688	39.7	D			
WB											
	* L	347	0.219	0.192	L	1.138	141.8	F	100.3	F	
	LTR	675	0.184	0.192	LTR	0.960	74.9	Е			
NB											
	* L	448	0.109	0.128	L	0.848	65.9	Е	100.3	F	
	* TR	1508	0.350	0.304	TR	1.153	107.8	F			
SB											
	L	231	0.084	0.128	L	0.658	65.7	Е	45.0	D	
	TR	1506	0.230	0.304	TR	0.758	42.3	D			

Intersection: Delay = 77.6 sec/veh SIG/Cinema v3.08

Int. LOS=E

 $X_c = 1.02$

* Critical Lane Group

 \sum (v/s)Crit= 0.87

Page 1

Mary Option 2 Alt 2035 R Marvin PM Wicks Lane/Main Street 10/12/2011 Case: WICKSM~1

App EB	Lane Group L TR	Queues Per Lane Avg/Max (veh) 9 / 14 3 / 8	Average Speed (mph) 4.7 13.6	Spillback in Worst Lane (% of Peak Period) 0.0 0.0	810 360 140
	All		9.0	0.0	
WB	L	12 / 15	3.9	0.0	
	LTR	11 / 14	6.1	0.0	
					320 -
	All		5.4	0.0	450 →
NB	L	7 / 10	3.9	0.0	
	TR	17 / 29	4.2	2.8	
					350 350
	All		4.2	2.8	
SB	L	8 / 10	3.1	0.0	1 2 1 3 4
	TR	9 / 20	6.7	0.0	
					16 3 0 37 4 2 23 4 2 28 4
	All		6.0	0.0	
	Intersect.		5.3		

Mary Opt 2 Alt 2035 Airport Road/Main Street Area Type: Non CBD R Marvin 10/12/2011 Analysis Duration: 15 mins. PM Design Hour Case: AIRPOR~1 Geometry: Movements Serviced by Lane and Lane Widths (feet) Lanes Approach Outbound Lane 1 Lane 2 Lane 3 Lane 4 Lane 5 Lane 6 EB 3 L 12.0 LT 12.0 R 12.0 2 LT WB 2 12.0 R 12.0 NB 4 3 L 12.0 T 12.0 T 12.0 TR 12.0 SB4 3 L 12.0 Т 12.0 T 12.0 TR 12.0 East West North South T T T R T Data L R L R L L R Movement Volume (vph) 850 20 100 30 40 90 230 2910 10 70 1710 400 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 PHF 0.95 % Heavy Vehicles 2 0 2 0 0 LT LT TR TR Lane Groups L R R L L Arrival Type 3 3 3 3 5 5 RTOR Vol (vph) 20 0 100 30 5 0 5 5 Peds/Hour % Grade 0 0 0 0 Buses/Hour 0 0 0 0 Parkers/Hour (Left|Right) Signal Settings: Actuated Operational Analysis Cycle Length: 150.0 Sec Lost Time Per Cycle: 20.0 Sec Phase: 2 4 5 7 8 Ped Only 6 EB LTP R WBLTP

Cap (vph)	v/s		Capacity Analysis Results											
(vph)	Lane Cap v/s g/C Lane v/c Delay													
App Group (vph) Ratio Ratio Group Ratio (sec/veh)														
	Rauo	Rauo	Group	Rano	(sec/ven)	LOS	(sec/veh)	LOS						
160	0.279	0.260	т	1.070	117.2	E	02.5	F						
	+						92.5	Г						
					76.8									
639	0.054	0.413	R	0.131	27.3	C								
74	0.040	0.040	LT	1.000	176.6	F	177.5	F						
64	0.039	0.040	R	0.984	178.5	F								
236	0.137	0.133	L	1.025	123.7	F	83.9	F						
2677	0.605	0.527	TR	1.148	80.7	F								
72	0.041	0.040	L	1.028	184.0	F	34.6	С						
2219	0.426	0.447	TR	0.954	29.4	С								
	236 2677 72	462 0.238 639 0.054 74 0.040 64 0.039 236 0.137 2677 0.605 72 0.041	462 0.238 0.260 639 0.054 0.413 74 0.040 0.040 64 0.039 0.040 236 0.137 0.133 2677 0.605 0.527 72 0.041 0.040	462 0.238 0.260 LT 639 0.054 0.413 R 74 0.040 0.040 LT 64 0.039 0.040 R 236 0.137 0.133 L 2677 0.605 0.527 TR	462 0.238 0.260 LT 0.918 639 0.054 0.413 R 0.131 74 0.040 0.040 LT 1.000 64 0.039 0.040 R 0.984 236 0.137 0.133 L 1.025 2677 0.605 0.527 TR 1.148 72 0.041 0.040 L 1.028	462 0.238 0.260 LT 0.918 76.8 639 0.054 0.413 R 0.131 27.3 74 0.040 0.040 LT 1.000 176.6 64 0.039 0.040 R 0.984 178.5 236 0.137 0.133 L 1.025 123.7 2677 0.605 0.527 TR 1.148 80.7 72 0.041 0.040 L 1.028 184.0	462 0.238 0.260 LT 0.918 76.8 E 639 0.054 0.413 R 0.131 27.3 C 74 0.040 0.040 LT 1.000 176.6 F 64 0.039 0.040 R 0.984 178.5 F 236 0.137 0.133 L 1.025 123.7 F 2677 0.605 0.527 TR 1.148 80.7 F 72 0.041 0.040 L 1.028 184.0 F	462 0.238 0.260 LT 0.918 76.8 E 639 0.054 0.413 R 0.131 27.3 C 74 0.040 0.040 LT 1.000 176.6 F 177.5 64 0.039 0.040 R 0.984 178.5 F 236 0.137 0.133 L 1.025 123.7 F 83.9 2677 0.605 0.527 TR 1.148 80.7 F 72 0.041 0.040 L 1.028 184.0 F 34.6						

 $X_c = 1.11$

Intersection: Delay = 70.9 sec/veh

Int. LOS=E

LTP

20.0

0.0

3.0

TP

ΤP

56.0

1.5

3.5

LTR

3.5

6.0

1.5

* Critical Lane Group

 $\sum (v/s)$ Crit= 0.96

SIG/Cinema v3.08

NB SB

Green

Yellow All Red

39.0

1.5

3.5

6.0

1.5

3.5

0

Mary Opt 2 Alt 2035 R Marvin PM Design Hour Airport Road/Main Street 10/12/2011 Case: AIRPOR~1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	1710 400 70
EB	L	18 / 19	4.0	0.0	
	LT	17 / 19	5.3	0.0	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
	R	1 / 2	17.9	0.0	30
	All		5.0	0.0	
WB	LT	3 / 3	5.1	0.0	
	R	3 / 4	9.5	0.0	850 -
	All		7.4	0.0	20
NB	L	13 / 16	2.9	0.0	100 —
	TR	25 / 30	7.0	12.9	
					$oxed{ \begin{array}{c cccccccccccccccccccccccccccccccccc$
	All		6.4	12.9	
SB	L	4 / 6	7.2	0.0	
	TR	11 / 18	10.0	0.0	
					38 4 2 5 4 2 20 3 5 4
	All		9.8	0.0	5 4,
	Inte	rsect.	6.9		5 4 2

Mary Option 2 Alt 2035

R Marvin

PM design Hour

1st Ave N/

10/12/2011

Case: US87MA~1

Area Type: Non CBD

Analysis Duration: 15 mins.

	l design H	Iour					2/2011 e: US87	MA~1		F	marysis	Durano	11: 131	mns.
	Lanes				Geor	netry: Mo	ovements	Serviced b	y Lane ar	nd Lane W	idths (fe	eet)		
	Approach (Outbound	L	ane 1	Lar	ne 2	La	ne 3	Laı	ne 4	La	ne 5	Laı	ne 6
EB	4	2	L	12.0	L	12.0	L	12.0	Т	12.0				
WB	3	2	T	12.0	Т	12.0	R	12.0						
NB	0	3												
SB	4	0	L	12.0	L	12.0	R	12.0	R	12.0				
				East			West			North			South	
	Data		L			L	Т	R	L	Т	R	L	Т	R
Move	ment Volun	ne (vph)	1800	600	0	0	610	880	0	0	0	840	0	670
PHF			0.95	0.95	0.90	0.90	0.95	0.95	0.90	0.90	0.90	0.95	0.90	0.95
% He	avy Vehicle	es	2	2 2 2		2	2	4	2	2	2	4	2	2
Lane	Groups		L	Т			Т	R				L		R
Arriv	al Type		5	5			3	3				5		5
RTOI	R Vol (vph)			0			250			0			0	
Peds/	Hour			5			0			0			0	
% Gr	ade			0			0		0				0	
Buses	s/Hour			0			0			0			0	
Parke	rs/Hour (Le	ft Right)		-										
Signa	l Settings: A	Actuated		Operat	ional Analy	sis	Cycle	e Length:	130.0 Sec	2	Lost Tim	e Per Cyc	le: 15.0 S	ec
Phase	: :	1		2	3	4		5	6		7	8	Pe	d Only
EB		LT												
WB				TP	R									
NB														
SB		R			LP									
Greer	1	52.0		26.0	37.0									0
Yello	w All Red	3.5	1.5 3.	5 1.5	3.5 1.5	5								

Lane Cap				Canac	city Analysis R	esults				Approa	ch:
EB * L 2060 0.368 0.400 L 0.920 28.7 C 29.4 C T 745 0.339 0.400 T 0.848 31.2 C WB * T 708 0.181 0.200 T 0.907 65.9 E 48.6 D R 812 0.427 0.523 R 0.817 31.9 C SB * L 958 0.263 0.285 L 0.923 48.7 D 27.3 C		Lane	Can				v/c	Delay			CII.
EB * L 2060 0.368 0.400 L 0.920 28.7 C 29.4 C T 745 0.339 0.400 T 0.848 31.2 C WB * T 708 0.181 0.200 T 0.907 65.9 E 48.6 D R 812 0.427 0.523 R 0.817 31.9 C SB * L 958 0.263 0.285 L 0.923 48.7 D 27.3 C	App	Group	(vph)		Ratio	Group		(sec/veh)	LOS	(sec/veh)	LOS
T 745 0.339 0.400 T 0.848 31.2 C WB ** T 708 0.181 0.200 T 0.907 65.9 E 48.6 D R 812 0.427 0.523 R 0.817 31.9 C SB * L 958 0.263 0.285 L 0.923 48.7 D 27.3 C	EB	1				•					
WB		* L	2060	0.368	0.400	L	0.920	28.7	С	29.4	C
* T 708 0.181 0.200 T 0.907 65.9 E 48.6 D R 812 0.427 0.523 R 0.817 31.9 C SB * L 958 0.263 0.285 L 0.923 48.7 D 27.3 C		T	745	0.339	0.400	T	0.848	31.2	С		
* T 708 0.181 0.200 T 0.907 65.9 E 48.6 D R 812 0.427 0.523 R 0.817 31.9 C SB * L 958 0.263 0.285 L 0.923 48.7 D 27.3 C											
* T 708 0.181 0.200 T 0.907 65.9 E 48.6 D R 812 0.427 0.523 R 0.817 31.9 C SB * L 958 0.263 0.285 L 0.923 48.7 D 27.3 C											
R 812 0.427 0.523 R 0.817 31.9 C SB * L 958 0.263 0.285 L 0.923 48.7 D 27.3 C	WB										
R 812 0.427 0.523 R 0.817 31.9 C SB * L 958 0.263 0.285 L 0.923 48.7 D 27.3 C											
SB * L 958 0.263 0.285 L 0.923 48.7 D 27.3 C		* T	708	0.181	0.200	Т	0.907	65.9	Е	48.6	D
* L 958 0.263 0.285 L 0.923 48.7 D 27.3 C		R	812	0.427	0.523	R	0.817	31.9	С		
* L 958 0.263 0.285 L 0.923 48.7 D 27.3 C											
* L 958 0.263 0.285 L 0.923 48.7 D 27.3 C	SB										
		* L	958	0.263	0.285	L	0.923	48.7	D	27.3	С
R 2015 0.253 0.723 R 0.350 0.5 A											
		R	2015	0.253	0.723	R	0.350	0.5	A		

Intersection: Delay = 33.4 sec/veh SIG/Cinema v3.08

Int. LOS=C

 $X_{c} = 0.92$

* Critical Lane Group

 \geq (v/s)Crit= 0.81

Page 1

Mary Option 2 Alt 2035 R Marvin PM design Hour 1st Ave N/ 10/12/2011 Case: US87MA~1

App EB	Lane Group L T	Queues Per Lane Avg/Max (veh) 17 / 24 12 / 17	Average Speed (mph) 4.6 6.8	Spillback in Worst Lane (% of Peak Period) 1.7 0.2	670 840
	All		5.0	1.7	
WB	Т	11 / 14	5.6	0.0	
	R	22 / 27	5.4	2.6	
	All		5.5	2.6	1800 → 600 →
	All		6.5	0.0	
SB	L	16 / 18	4.0	0.0	
	R	1 / 3	22.0	0.0	51 4 2 25 4 2 36 4 2
	Inte	rsect.	5.5		

Mary Op2 Alt 2035 Old US 87/I90 WB On Ramp Area Type: Non CBD R Marvin 10/13/2011 Analysis Duration: 15 mins. PM Design Hour Case: WBRAMP~1 Geometry: Movements Serviced by Lane and Lane Widths (feet) Lanes Approach Outbound Lane 1 Lane 2 Lane 3 Lane 4 Lane 5 Lane 6 EB 2 T 12.0 TR 12.0 T Т 12.0 WB 3 2 12.0 12.0 NB 0 0 SB1 1 LTR 12.0 East West North South T T T R Т Data L R L R L L R Movement Volume (vph) 0 920 420 220 1020 0 0 0 20 320 1 PHF 0.90 0.92 0.92 0.92 0.92 0.90 0.90 0.90 0.90 0.92 0.92 0.92 % Heavy Vehicles 5 5 0 5 TR LTR Lane Groups L T 2 Arrival Type 2 3 RTOR Vol (vph) 150 0 0 100 0 5 0 0 Peds/Hour % Grade 0 0 0 0 Buses/Hour 0 0 0 0 Parkers/Hour (Left|Right) Signal Settings: Actuated Operational Analysis Cycle Length: 80.0 Sec Lost Time Per Cycle: 14.0 Sec Phase: 2 3 4 5 7 8 Ped Only 6 EB TR WB LT LT NB

			Capac	city Analysis R	lesults				Approa	ch:
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
EB										
	* TR	1494	0.389	0.450	TR	0.865	30.4	С	30.4	С
WB	Lper	94	0.087	0.512					16.5	В
	* Lpro	223	0.125	0.125	L	0.754	33.4	С		
	T	2149	0.323	0.625	T	0.516	12.9	В		
SB										
	* LTR	395	0.166	0.250	LTR	0.663	30.3	С	30.3	C

Intersection: Delay = 24.0 sec/veh SIG/Cinema v3.08

SB

Green

Yellow All Red

10.0

0.0

4.0

36.0

1.5

3.5

Int. LOS=C

LTR

20.0

1.5

3.5

 $X_{c} = 0.82$

* Critical Lane Group

 \geq (v/s)Crit= 0.68

Page 1

0

Mary Op2 Alt 2035 R Marvin PM Design Hour Old US 87/I90 WB On Ramp 10/13/2011 Case: WBRAMP~1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	1 320 20 ,
ЕВ	TR	10 / 14	12.1	0.0	→1020 →220
	All		12.1	0.0	
WB	L	5 / 6	5.0	0.0	
	T	4 / 6	17.6	0.0	
	All		14.5	0.0	920 → 420 →
	All		13.1	0.0	
					1 2 3
SB	LTR	4 / 7	13.1	0.0	$\begin{bmatrix} 1 & & & \\ & & & \\ & & & \end{bmatrix}^2 \longrightarrow \begin{bmatrix} 3 & & \\ & & & \end{bmatrix}$
					10 4 0 35 4 2 19 4 2
	Inte	rsect.	13.1		

Mary Opt 2 2035 Old US 87/I90 EB Off Ramp Area Type: Non CBD R Marvin 10/13/2011 Analysis Duration: 15 mins. PM Design Hour Case: EBRAMP~1 Geometry: Movements Serviced by Lane and Lane Widths (feet) Lanes Approach Outbound Lane 1 Lane 2 Lane 3 Lane 4 Lane 5 Lane 6 EB 3 2 L 12.0 T 12.0 Т 12.0 2 T WB 2 12.0 TR 12.0 NB 2 1 L 12.0 TR 12.0 SB0 0 East West North South T R T T R Т R Data L L R L L Movement Volume (vph) 480 460 0 0 620 20 620 5 350 PHF 0.92 0.92 0.90 0.90 0.92 0.92 0.92 0.92 0.92 0.90 0.90 0.90 % Heavy Vehicles 4 2 5 0 Т TR Lane Groups L TR L Arrival Type 3 3 3 3 RTOR Vol (vph) 0 5 100 0 5 0 0 5 Peds/Hour % Grade 0 0 0 0 Buses/Hour 0 0 0 0 Parkers/Hour (Left|Right) Signal Settings: Actuated Operational Analysis Cycle Length: 120.0 Sec Lost Time Per Cycle: 9.0 Sec Phase: 2 3 4 5 7 8 Ped Only 6 EB LT LT WB TR

	Capacity Analysis Results											
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Approa Delay (sec/veh)	LOS		
EB	* Lper	61	0.242	0.250	Group	Tuilo	(BCC/ VCII)	LOD	45.9	D		
	* Lpro	463	0.267	0.267	L	0.996	73.3	Е				
	T	1817	0.140	0.508	Т	0.275	17.2	В				
WB												
	TR	735	0.196	0.208	TR	0.939	68.0	Е	68.0	Е		
NB												
	* L	699	0.393	0.408	L	0.964	59.9	Е	49.9	D		
	TR	648	0.174	0.408	TR	0.427	25.6	С				

Intersection: Delay = 53.0 sec/veh SIG/Cinema v3.08

NB SB Green

Yellow All Red

32.0

0.0

4.0

25.0

1.5

3.5

Int. LOS=D

LTP

49.0

1.5

3.5

*

 $X_{c} = 0.98$

* Critical Lane Group

 $\sum (v/s)$ Crit= 0.90

Page 1

0

Mary Opt 2 2035 R Marvin PM Design Hour Old US 87/I90 EB Off Ramp 10/13/2011 Case: EBRAMP~1

				T	
App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	
EB	L	24 / 28	2.8	42.9	
	Т	6 / 11	7.7	8.6	<u>↑ 20</u> ← 620
	All		5.2	42.9	←
WB	TR	9 / 11	6.8	0.0	<u></u>
					480 —
	All		6.8	0.0	460
NB	L	17 / 24	6.2	0.8	
	TR	4/9	16.5	0.0	
					620 350
	All		8.0	0.8	
					1 2 3
					32 4 0 24 4 2 48
	Inte	rsect.	6.5		

APPENDIX F

Five Mile Road Alignment

Year 2035

Existing Street System

Capacity Calculations

er.			

Five Mile Alt 2035 Wicks Lane/Main Street Area Type: Non CBD R Marvin 10/12/2011 Analysis Duration: 15 mins. PM Case: WICKSM~1

PM	viarvin [Т			10/12/2011 Case: WICKSM~1							Analysis Duration: 15 mins.					
	Lanes						Geom	etry: Mo	vement	s Serv	iced b	y Lane an	d Lane W	idths (fe	eet)				
	Approach	Outbound	d	Lane	1		Lane	2	I	Lane 3		Lar	ne 4	La	ne 5	Laı	ne 6		
EB	3	2		L	12.0	7	Γ	12.0	TR	1	2.0								
WB	3	2		L	12.0	L	Т	12.0	TR	1	2.0								
NB	5	3		L	12.0	I		12.0	Т	1	2.0	Т	12.0	TR	12.0				
SB	4	3		L	12.0	7	Γ	12.0	Т	1	2.0	TR	12.0						
					East		West			North			South						
	Data			L	T	F	2	L	Т		R	L	Т	R	L	Т	R		
Move	ment Volur	ne (vph)	2	260	450	10	60	520	390		80	400	1450	380	140	920	290		
PHF			0	.92	0.92	0.9	92	0.92	0.92	C).92	0.92	0.92	0.92	0.92	0.92	0.92		
% He	avy Vehicle	es		0	0		0	0	0		0	0	2	1	0	2	0		
Lane	Groups			L	TR			L	LTR			L	TR		L	TR			
Arriv	al Type			5	5			3	3			5	5		4	4			
RTO	R Vol (vph)				80				30				100			100			
Peds/	Hour				0				5				5			5			
% Gr	ade				0				0				0			0			
Buses	s/Hour				0				0				0			0			
Parke	rs/Hour (Le	eft Right)																	
Signa	l Settings: A	Actuated			Operati	onal A	nalys	is	Сус	cle Lei	ngth: 1	30.0 Sec	;	Lost Tim	e Per Cyc	le: 18.0 S	ec		
Phase	: :	1		2	2	3	3	4		5		6		7	8	Pe	d Only		
EB								LT	R										
WB				-		L	ГР												
NB		L		Т	P														
SB		L		T	P														
Green	1	19.0	0		3.0		5.0	25	.0								0		
Yello	w All Red	3.0	0.0	3.5	1.5	3.5	1.5	3.5	1.5										

			Capac	city Analysis R	lesults				Approa	ch:
App EB	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
EB	L	347	0.157	0.192	L	0.816	61.0	Е	57.2	Е
	* TR	678	0.163	0.192	TR	0.850	55.3	E	37.2	L
	110	0.0	0.103	0.172	110	0.050	33.3			
WB										
	* L	347	0.219	0.192	L	1.138	143.8	F	102.0	F
	LTR	676	0.184	0.192	LTR	0.959	76.5	Е		
NB										
	* L	512	0.124	0.146	L	0.850	64.0	Е	95.4	F
	* TR	1640	0.379	0.331	TR	1.146	102.7	F		
SB										
	L	264	0.084	0.146	L	0.576	60.6	Е	42.3	D
	TR	1638	0.244	0.331	TR	0.737	40.0	D		

 $X_c = 1.03$

Intersection: Delay = 77.8 sec/veh SIG/Cinema v3.08

Int. LOS=E

* Critical Lane Group

 $\sum (v/s)$ Crit= 0.89

Five Mile Alt 2035 R Marvin PM Wicks Lane/Main Street 10/12/2011 Case: WICKSM~1

App EB	Lane Group L TR	Queues Per Lane Avg/Max (veh) 9 / 14 4 / 6	Average Speed (mph) 4.1 11.1	Spillback in Worst Lane (% of Peak Period) 0.0	920 290 140
	All		7.8	0.0	
	All		7.0	0.0	
WB	L	12 / 13	3.6	0.0	
	LTR	11 / 13	6.2	0.0	
					260 -
	All		5.3	0.0	250 450 →
NB	L	8/9	3.5	0.0	160 —
	TR	15 / 28	5.0	2.1	
					400 380
	All		4.6	2.1	1450
SB	L	9 / 11	3.1	0.0	
	TR	9 / 14	7.2	0.0	
					$\begin{array}{ c c c c c c c c c c c c c c c c c c c$
	All		6.4	0.0	
	Inte	rsect.	5.5		

Five Mile Alt 2035 Airport Road/Main Street Area Type: Non CBD 10/12/2011 Analysis Duration: 15 mins. R Marvin PM Design Hour Case: AIRPOR~1 Geometry: Movements Serviced by Lane and Lane Widths (feet) Lanes Approach Outbound Lane 1 Lane 2 Lane 3 Lane 4 Lane 5 Lane 6 EB 3 L 12.0 LT 12.0 R 12.0 2 LT WB 2 12.0 R 12.0 NB 4 3 L 12.0 T 12.0 T 12.0 TR 12.0 SB4 3 L 12.0 Т 12.0 \mathbf{T} 12.0 TR 12.0 East West North South T T T R T Data L R L R L L R Movement Volume (vph) 850 20 100 30 40 90 230 3050 10 70 1820 400 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 PHF 0.95 % Heavy Vehicles 2 0 2 0 LT LT TR TR Lane Groups L R R L L Arrival Type 3 3 3 3 5 5 RTOR Vol (vph) 20 0 100 30 5 0 5 5 Peds/Hour % Grade 0 0 0 0 Buses/Hour 0 0 0 0 Parkers/Hour (Left|Right) Signal Settings: Actuated Operational Analysis Cycle Length: 150.0 Sec Lost Time Per Cycle: 20.0 Sec Phase: 2 4 5 7 8 Ped Only 6 EB LTP R WB LTP LTP NB TP SBTP LTR

	Capacity Analysis Results											
App EB	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS		
LD	* L	460	0.278	0.260	L	1.070	117.3	F	92.7	F		
	LT	462	0.238	0.260	LT	0.918	76.8	Е				
	R	608	0.054	0.393	R	0.138	29.2	С				
WB												
	* LT	74	0.040	0.040	LT	1.000	176.6	F	177.5	F		
	R	64	0.039	0.040	R	0.984	178.5	F				
NB												
	L	201	0.137	0.113	L	1.204	190.1	F	110.6	F		
	* TR	2677	0.634	0.527	TR	1.204	104.6	F				
SB												
	* L	72	0.041	0.040	L	1.028	184.0	F	32.7	C		
	TR	2322	0.449	0.467	TR	0.961	27.7	C				

 $X_c = 1.15$

Intersection: Delay = 83.3 sec/veh SIG/Cinema v3.08

Green

Yellow All Red

39.0

1.5

3.5

1.5

3.5

Int. LOS=F

17.0

0.0

3.0

59.0

1.5

3.5

6.0

1.5

3.5

* Critical Lane Group

 $\sum (v/s)$ Crit= 0.99

0

Five Mile Alt 2035 R Marvin PM Design Hour Airport Road/Main Street 10/12/2011 Case: AIRPOR~1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	1820 400 70
EB	L	17 / 18	4.3	0.0	
	LT	16 / 17	5.8	0.0	
	R	1 / 2	17.9	0.0	
	All		5.4	0.0	
WB	LT	3 / 3	5.1	0.0	
	R	3 / 4	9.4	0.0	850 -
	All		7.4	0.0	20
NB	L	17 / 20	1.7	0.0	100 —
	TR	28 / 30	6.0	28.3	
					230 10 3050
	All		5.2	28.3	
SB	L	6/9	2.8	0.0	1 2 3 4 1
	TR	11 / 17	10.5	0.0	
					38 4 2 5 4 2 17 3 0 58
	All		9.6	0.0	5 4
	Inte	rsect.	6.3		5 4 2

Mary Five Mile Alt 2035

1st Ave N/

R Marvin

10/12/2011

Analysis Duration: 15 mins.

PM design Hour

Case: US87M4~1

	⁄Iarvın İ design H						10/12/2011 Case: US87MA~1							Analysis Duration: 15 mins.				
	Lanes						Geom	etry: Mo	vemen	ts Sei	rviced b	y Lane aı	nd Lane '	Widths	(feet)			
	Approach (Outbound	1	Lane	1		Lane	2	I	Lane	3	La	ne 4	I	ane 5		Lar	ne 6
EB	4	2		L	12.0	I		12.0	L		12.0	Т	12.0					
WB	3	2		Т	12.0	-	Γ	12.0	R		12.0							
NB	0	3																
SB	4	0		L	12.0	I	L 12.0		R 12.0		12.0	R	12.0					
	East								Wes	t			North	•		South		
		L	T	I	2	L	Т		R	L	Т	R]	L	T	R		
Movement Volume (vph)			18	300	600		0	0	610)	1000	0	0	0	9	70	0	670
PHF			0.	.95	0.95	0.	90	0.90	0.95	5	0.95	0.90	0.90	0.90	0.	95	0.90	0.95
% He	avy Vehicle	es		2	2		2	2	2		4	2	2	2		4	2	2
Lane	Groups			L	T				T		R]	L		R
Arriva	al Type			5	5				3		3					5		5
RTOI	R Vol (vph)				0				250)			0				0	
Peds/	Hour				5				0				0				0	
% Gra	ade				0		0				0			0				
Buses	/Hour				0				0			0			0			
Parke	rs/Hour (Le	ft Right)								-								
Signa	l Settings: A	Actuated		(Operati	ional A	analysi	is	Cy	cle L	ength: 1	140.0 Sec	c	Lost Ti	me Per	Cycle	: 10.0 S	ec
Phase	:	1		2	2	3	3	4			5	6		7		8	Pe	d Only
EB		LT																
WB				T	P		R											
NB																		
SB	17			P														
Green		54.0			3.0		3.0				1					1		0
Yello	w All Red	3.5	1.5	3.5	1.5	3.5	1.5											

	Capacity Analysis Results											
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Approa Delay (sec/veh)	LOS		
EB												
	* L	1986	0.368	0.386	L	0.954	36.2	D	36.6	D		
	T	719	0.339	0.386	T	0.879	37.6	D				
WB												
	T	708	0.181	0.200	Т	0.907	69.8	Е	57.2	Е		
	* R	843	0.508	0.543	R	0.936	47.0	D				
SB												
	L	1034	0.303	0.307	L	0.987	59.1	Е	35.2	D		
	R	2031	0.253	0.729	R	0.347	0.5	Α				

Intersection: Delay = 41.3 sec/veh SIG/Cinema v3.08

Int. LOS=D

 $X_{c} = 0.94$

* Critical Lane Group

 \sum (v/s)Crit= 0.88

Page 1

Mary Five Mile Alt 2035 R Marvin PM design Hour 1st Ave N/ 10/12/2011 Case: US87MA~1

App EB	Lane Group L T	Queues Per Lane Avg/Max (veh) 20 / 30 13 / 21	Average Speed (mph) 4.3 6.5	Spillback in Worst Lane (% of Peak Period) 15.2 0.0	670 970
	All		4.8	15.2	
					<u> </u>
WB	T	11 / 13	6.0	0.0	
	R	28 / 30	4.0	28.4	<u></u>
	All		4.6	28.4	1800 —
					600
	All		5.8	0.0	
SB	L	20 / 22	3.6	0.0	
	R	1 / 1	22.4	0.0	53 4 2 27 4 2 42 4 2
	Inte	rsect.	5.0		

Five Mile Alt 2035

R Marvin
PM Design Hour

Case: WBRAMP~1

Lanes

Old US 87/I90 WB On Ramp
Area Type: Non CBD
Analysis Duration: 15 mins.
Case: WBRAMP~1

Geometry: Movements Serviced by Lane and Lane Widths (feet)

PM	I Design I	Hour						Case	e: WBR	AMP~1						
	Lanes					(eome	etry: Mo	vements	Serviced b	y Lane ar	nd Lane W	idths (fe	eet)		
	Approach	Outbound		Lane	: 1		Lane	2	La	ne 3	La	ne 4	La	ne 5	La	ne 6
EB	2	2	Т		12.0	TF	1	12.0								
WB	3	2	L		12.0	Т		12.0	Т	12.0						
NB	0	0														
SB	1	1	LTF	R	12.0											
					East				West			North			South	
	Data		L		T	R		L	Т	R	L	Т	R	L	Т	R
Move	ement Volur	ne (vph)	0)	990	46	0	220	1130	0	0	0	0	20	1	320
PHF			0.90	0	0.92	0.9	2	0.92	0.92	0.90	0.90	0.90	0.90	0.92	0.92	0.92
% He	avy Vehicle	es	2	2	5	- 5	5	1	5	2	2	2	2	1	0	5
Lane	Groups				TR			L	Т						LTR	
Arriv	al Type				2			2	2						3	
RTO	R Vol (vph)				150				0			0			100	
Peds/	Hour				0				5			0			0	
% Gr	ade				0				0			0			0	
Buse	s/Hour				0				0			0			0	
Parke	ers/Hour (Le	ft Right)	-													
Signa	al Settings: A	Actuated		(Operati	onal A	nalysi	is	Cycl	e Length:	80.0 Sec	с	Lost Tim	ne Per Cyc	le: 14.0 S	ec
Phase	e:	1		2		3		4		5	6		7	8	Pe	d Only
EB				T	R											
WB		LT		LT	Γ											
NB																
SB	B LTR															
Greei		10.0		37		19.		ļ			ļ.,					0
Yello	w All Red	4.0	0.0	3.5	1.5	3.5	1.5									

	Capacity Analysis Results											
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Approa Delay (sec/veh)	LOS		
EB	Огоцр	(*P11)	Tutio	Tutto	Group	Tutio	(Bee/ Veil)	LOD	(Bee/ Veil)	Los		
	* TR	1533	0.426	0.463	TR	0.922	34.7	C	34.7	C		
WB	Lper	94	0.089	0.525					16.5	В		
	* Lpro	223	0.125	0.125	L	0.754	34.3	C				
	T	2192	0.357	0.637	Т	0.560	13.1	В				
SB												
	* LTR	375	0.166	0.237	LTR	0.699	32.7	C	32.7	C		

Intersection: Delay = 26.1 sec/veh SIG/Cinema v3.08

Int. LOS=C

 $X_{c} = 0.87$

* Critical Lane Group

 \sum (v/s)Crit= 0.72

Page 1

Five Mile Alt 2035 R Marvin PM Design Hour Old US 87/I90 WB On Ramp 10/13/2011 Case: WBRAMP~1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	320 20
ЕВ	TR	10 / 14	12.5	0.0	→1130 →220
	All		12.5	0.0	
WB	L	5 / 7	4.8	0.0	
	Т	6 / 7	17.5	0.0	
	All		14.3	0.0	990 → 460 →
					400 —
	All		12.0	0.0	
					1 2 3
SB	LTR	4 / 7	12.0	0.0	
					10 4 0 36 4 2 18 4 2
	Inte	rsect.	13.1		

Five Mile Alt 2035 Old US 87/I90 EB Off Ramp Area Type: Non CBD R Marvin 10/13/2011 Analysis Duration: 15 mins. PM Design Hour Case: EBRAMP~1 Geometry: Movements Serviced by Lane and Lane Widths (feet) Lanes Approach Outbound Lane 1 Lane 2 Lane 3 Lane 4 Lane 5 Lane 6 EB 3 2 L 12.0 T 12.0 Т 12.0 2 T WB 2 12.0 TR 12.0 NB 2 1 L 12.0 TR 12.0 SB0 0 East West North South T T T R Т Data L R L R L L R Movement Volume (vph) 480 530 0 0 690 20 660 5 350 0.92 0.92 0.90 0.90 0.92 0.92 0.92 0.92 0.92 0.90 0.90 PHF 0.90 % Heavy Vehicles 4 2 5 0 Т TR Lane Groups L TR L Arrival Type 3 3 3 RTOR Vol (vph) 0 5 100 0 5 0 0 5 Peds/Hour % Grade 0 0 0 0 Buses/Hour 0 0 0 0 Parkers/Hour (Left|Right) Signal Settings: Actuated Operational Analysis Cycle Length: 120.0 Sec Lost Time Per Cycle: 9.0 Sec

4

3

LTP

46.0

1.5

3.5

5

7

6

8

Ped Only

0

			Capac	city Analysis R	lesults				Approa	ch:		
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay			
App	Group	(vph)	Ratio	Ratio	Group	Ratio	Delay (sec/veh)	LOS	(sec/veh)	LOS		
EB	* Lper	61	0.267	0.275					43.4	D		
	* Lpro	463	0.267	0.267	L	0.996	73.7	Е				
	T	1906	0.161	0.533	T	0.302	16.0	В				
WB												
	TR	823	0.217	0.233	TR	0.931	63.5	Е	63.5	Е		
NB												
	* L	656	0.419	0.383	L	1.093	100.2	F	80.0	F		
	TR	609	0.174	0.383	TR	0.455	27.8	С				
		1			1		1					

Intersection: Delay = 61.5 sec/veh SIG/Cinema v3.08

Phase:

EB

WB

NB SB Green

Yellow All Red

Int. LOS=E $X_c = 1.03$

2

LT

TR

28.0

1.5

3.5

LT

32.0

0.0

4.0

* Critical Lane Group

 \geq (v/s)Crit= 0.95

Page 1

Five Mile Alt 2035 R Marvin PM Design Hour Old US 87/I90 EB Off Ramp 10/13/2011 Case: EBRAMP~1

App EB	Lane Group L	Queues Per Lane Avg/Max (veh) 26 / 29 5 / 8	Average Speed (mph) 2.3 8.3	Spillback in Worst Lane (% of Peak Period) 49.6 7.3	<u>↑</u> 20 ↓ 690
	All		5.2	49.6	
WB	TR	10 / 12	7.0	0.0	480 -
	All		7.0	0.0	$\begin{bmatrix} 480 \\ 530 \end{bmatrix} \longrightarrow \begin{bmatrix} 480 \\ 1 \end{bmatrix}$
NB	L	25 / 29	4.1	23.6	
	TR	5 / 10	14.1	0.0	
					660 350
	All		5.4	23.6	
					1 2 3
					32 4 0 27 4 2 45
	Inte	rsect.	5.7		

APPENDIX G

Alternative Alignment

Intersection Designs

Year 2035 Capacity Calculations

er.			

		TW	O-WA	Y STOP	CONTR	OL S	UMI	MARY					
General Information	n				Site I	nforn	natio	on					
Analyst		R Marvin			Inters	ection			Mary	Opt	1 & Jo	hnsc	n N
Agency/Co.	/	Marvin As	ssociat	es	Jurisd	iction			MDT				
Date Performed		10/8/201 ⁻	1		Analy	sis Yea	ar		2035	,			
Analysis Time Period		Design H	our PN	1									
Project Description Bil					•								
East/West Street: Mary	Optioi	n 1			North/	South S	Stree	t: Johnso	n Lane	Ν			
Intersection Orientation:	East	t-West			Study	Period	(hrs)	: 0.25					
Vehicle Volumes ar	nd Ad	ljustme											
Major Street			Ea	astbound					Wes	tbou	nd		
Movement		1		2	3			4	ļ	5			6
		L		T	R			L	ļ	Τ			R
Volume (veh/h)	┷	10		1010						730			5
Peak-Hour Factor, PHF	_	0.90	\bot	0.90	1.00)		1.00	0	.90		C	.90
Hourly Flow Rate, HFR (veh/h)		11		1122	0			0	ε	311			5
Percent Heavy Vehicles		4						0					
Median Type						Undi	vided	1					
RT Channelized					0								0
Lanes		1		2	0			0		2			0
Configuration		L		T	1					T			TR
Upstream Signal				0	1					0			
Minor Street	T		No	rthbound					Soutl	hbou	nd		
Movement	\top	7		8	9			10	î	11	Ī		12
		L		Т	R			L	ĺ	Т			R
Volume (veh/h)			\neg		1			0			$\overline{}$		30
Peak-Hour Factor, PHF	\top	1.00	\top	1.00	1.00)		0.60	1	.00	\neg		.60
Hourly Flow Rate, HFR (veh/h)		0		0	0			0		0			49
Percent Heavy Vehicles	\top	0	\top	0	0			5		0	\neg		5
Percent Grade (%)	\neg			0	•					0			
Flared Approach	+		\top	N	1					N	Т		
Storage	+		\top	0	1					0	$\neg \dagger$		
RT Channelized	_		\top		0						$\overline{}$		0
Lanes	_	0	+	0	0			0		0	_		0
Configuration	+		十一		 					<u>L</u> R	o		
Delay, Queue Length, a	nd Le	vel of Se	rvice										
Approach		bound	1	stbound		Northb	ound			S	outhbo	ound	
Movement		1		4	7	8		9	10	_	11		12
Lane Configuration		L		•		 					LR		
v (veh/h)		<u> </u>				 					49		
C (m) (veh/h)		95									632		
v/c		.01				\vdash					0.08	_	
95% queue length		.04	 			\vdash			\vdash		0.2	_	
Control Delay (s/veh)		9.6				\vdash			\vdash		11.2		
LOS		7.0 A				\vdash			\vdash		11.2 B		
						<u> </u>							
Approach Delay (s/veh)											11.2		
Approach LOS		 I Rights Res				ıcs.TM					Bated: 12		

HCS+TM Version 5.6

		TW	O-WA	Y STOP	CONTR	OL S	UMI	MARY					
General Information	n				Site I	nforn	natio	on					
Analyst	F	R Marvin			Inters	ection			Mary	Opt	1 & C	oulsc	n Rd
Agency/Co.	۸	/Jarvin As	sociate	s	Jurisd	iction			MDT				
Date Performed	1	0/8/2011	1		Analy	sis Yea	ar		2035				
Analysis Time Period	Ĺ	Design H	our PM										
Project Description Bi	llings B	ypass											
East/West Street: Mary					North/	South S	Stree	t: Coulso	n Road				
Intersection Orientation:	East-	-West			Study	Period	(hrs)	: 0.25					
Vehicle Volumes a	าd Ad	justme											
Major Street			Ea	stbound					West	bou	nd		
Movement		1		2	3			4		5			6
		L		Т	R			L		Т			R
Volume (veh/h)		55		955					+	50			5
Peak-Hour Factor, PHF	4	0.90	_	0.90	1.00)		1.00	0.	90	_	C	.90
Hourly Flow Rate, HFR (veh/h)		61		1061	0			0	7.	22			5
Percent Heavy Vehicles		4						0					
Median Type					,	Undi	vided	1					
RT Channelized					0								0
Lanes		1		2	0			0		2			0
Configuration		L		T					ĺ	Т			TR
Upstream Signal	1			0	1					0			
Minor Street			Nor	thbound	,				South	nbou	nd		
Movement		7		8	9			10	1	11			12
	1	L		T	R			L	ĺ	Т			R
Volume (veh/h)	1							5					80
Peak-Hour Factor, PHF		1.00		1.00	1.00)		0.70	1.	00	\neg	C	.70
Hourly Flow Rate, HFR (veh/h)		0		0	0			7		0		1	114
Percent Heavy Vehicles		0		0	0			5		0	\neg		5
Percent Grade (%)			<u> </u>	0						0			
Flared Approach	+			N	1					N			
Storage	+			0	†					0	\dashv		
RT Channelized	+-		_		0						\rightarrow		0
	_	0		0	0			0		0	\rightarrow		0
Lanes Configuration	_			0	0			U		.R	\dashv		0
		1 - (0 -	<u></u>							.గ			
Delay, Queue Length, a Approach		oound		bound		Northb	ound		Γ	-	outhbo	und	
Movement		1		4	7	8		9	10		11	-	12
Lane Configuration		<u>'</u>		4	,	-	'	9	10		LR		12
v (veh/h)		<u>-</u> 51								_	121		
		59				├			-	_			
C (m) (veh/h) v/c		07				\vdash					534	-	
						 					0.2	_	
95% queue length		23				-			-		0.8		
Control Delay (s/veh)		.5				├					13.		
LOS		4							<u> </u>		В		
Approach Delay (s/veh)	,										13.7	<i>'</i>	
Approach LOS											В		

HCS+TM Version 5.6

Generated: 12/19/2011 3:28 PM

LANE SUMMARY

Site: Mary Alignment Option 1 Intersection with Five Mile adn Mary Street

Mary Alignment Option 1 Intersection of Mary Alignment with Mary Street & Five Mile Road Roundabout

Lane Use	and Pe	rform	ance													
	. [Deman	d Flows		HV	Can	Deg.	Lane	Average	Level of	95% Back		Lane	SL	Cap. I	
	L veh/h	Veh/h	R veh/h	Total veh/h	пv %	Cap.	Satn v/c	Util. %	Delay sec	Service	Vehicles veh	Distance ft	Length ft	Туре	Adj. E %	Block. %
South: Mary			VC11/11	V C 1 1/11	70	VOII/II	V/ O	/0	300		VO11	- 10	- 10		70	/0
Lane 1	5	54	22	82	0.0	681	0.120	100	8.2	LOS A	0.5	12.0	1600		0.0	0.0
Approach	5	54	22	82	0.0		0.120		8.2	LOS A	0.5	12.0				
East: Mary	Alignmeı	nt WB														
Lane 1	22	460	0	482	3.8	1335	0.361	100	5.1	LOS A	2.6	67.0	1600	_	0.0	0.0
Lane 2	0	301	250	551	3.1	1528	0.361	100	5.3	LOS A	2.6	67.6	1600	_	0.0	0.0
Approach	22	761	250	1033	3.4		0.361		5.2	LOS A	2.6	67.6				
North: Five	Mile Roa	ad SB														
Lane 1	185	11	5	201	1.9	627	0.321	100	15.9	LOS B	1.4	35.0	1600		0.0	0.0
Approach	185	11	5	201	1.9		0.321		15.9	LOS B	1.4	35.0				
West: Mary	Alignme	nt EB														
Lane 1	5	220	0	226	3.9	1101	0.205	100	5.8	LOS A	1.2	31.5	1600	_	0.0	0.0
Lane 2	0	247	5	252	3.9	1231	0.205	100	5.4	LOS A	1.3	32.2	1600		0.0	0.0
Approach	5	467	5	478	3.9		0.205		5.6	LOS A	1.3	32.2				
Intersection				1793	3.2		0.361		6.6	LOS A	2.6	67.6				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Monday, December 19, 2011 11:58:46 AM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Traffic Study\Capacity\Calculations\Mary Street\Mary Opt 1\Mary Align Mary_5 Mile Opt1 PM 2035.sip 8001325, MARVIN & ASSOCIATES, SINGLE



	TW	O-WAY STOP	CONTR	OL SU	MMARY			
General Information	n		Site I	nforma	tion			
Analyst	R Marvin		Interse	ection		Dover & I	Five Mile N	lary Opt
Agency/Co.	Marvin A	ssociates	⊣			1		
Date Performed	10/3/201		Jurisdi			MDT		
Analysis Time Period	Design H	our PM	Analys	sis Year		2035		
Project Description Bil	llings Bypass							
East/West Street: Dove			North/S	South Str	eet: Five M	lile Road		
Intersection Orientation:					rs): 0.25	no rioda		
Vehicle Volumes ar		nts	Je sa ay s	(1)				
Major Street		Northbound				Southbou	ınd	
Movement	1	2	3		4	5		6
	Ĺ		R		L	Ť		R
Volume (veh/h)	30	240	50		5	160		5
Peak-Hour Factor, PHF	0.90	0.90	0.90	,	0.90	0.90		0.90
Hourly Flow Rate, HFR (veh/h)	33	266	55		5	177		5
Percent Heavy Vehicles	3				3			
Median Type				Undivid	led			
RT Channelized			0					0
Lanes	0	1	0		0	1		0
Configuration	LTR				LTR			
Jpstream Signal		0				0		
Minor Street		Eastbound				Westbou	ınd	
Movement	7	8	9		10	11		12
	L	Т	R		L	Т		R
Volume (veh/h)	5	90	20		30	60		5
Peak-Hour Factor, PHF	0.80	0.80	0.80		0.80	0.80		0.80
Hourly Flow Rate, HFR (veh/h)	6	112	24		37	74		6
Percent Heavy Vehicles	0	3	0		0	3		0
Percent Grade (%)		0				0		
Flared Approach		N				N		
Storage		0	ļ			0		
RT Channelized			0					0
Lanes	0	1	0		0	1		0
Configuration		LTR				LTR		
Delay, Queue Length, a		1						
Approach	Northbound	Southbound		Westbou			Eastbound	
Movement	1	4	7	8	9	10	11	12
Lane Configuration	LTR	LTR		LTR			LTR	
v (veh/h)	33	5		117			142	
C (m) (veh/h)	1387	1233		385			449	
//c	0.02	0.00		0.30			0.32	
95% queue length	0.07	0.01		1.26			1.34	
Control Delay (s/veh)	7.7	7.9		18.4		1	16.7	1
LOS	Α	Α		С		1	С	ĺ
Approach Delay (s/veh)				18.4		1	16.7	1
Approach LOS				С		†	С	
Copyright © 2010 University of FI		J	L	CS+ TM Ve		0-:	rated: 12/19/2	011 2:46

	TW	O-WAY STOP	CONTR	OL SU	IMN	//ARY				
General Information	n		Site I	nform	atic	n				
Analyst	R Marvin		Interse	ection			Mary & H	awthro	ne O	ption 1
Agency/Co.	Marvin As	ssociates	Jurisdi	ction			MDT			
Date Performed	10/8/201	1	Analys	is Year			Year 203	5		
Analysis Time Period	Design H	our PM								
Project Description Bil										
East/West Street: Mary						t: <i>Bitteroo</i>	t			
Intersection Orientation:	North-South		Study F	Period (hrs)	: 0.25				
Vehicle Volumes ar	nd Adjustme									
Major Street		Northbound					Southbou	ınd		
Movement	1	2	3	\rightarrow		4	5			6
\/_l / - / - \	L L	T	R 5				T			R
Volume (veh/h) Peak-Hour Factor, PHF	5 0.60	20 0.60	0.60	. 		10 0.60	35 0.60	-+		10 .60
Hourly Flow Rate, HFR		1	1	' 				\dashv		
(veh/h)	8	33	8			16	58			16
Percent Heavy Vehicles	0					0				
Median Type				Undiv	idea	1				
RT Channelized			0							0
Lanes	0	1	0			0	1			0
Configuration	LTR					LTR				
Upstream Signal		0					0			
Minor Street		Eastbound					Westbou	nd		
Movement	7	8	9			10	11			12
	L	Т	R			L	Т			R
Volume (veh/h)	15	95	30			5	65	\longrightarrow		10
Peak-Hour Factor, PHF	0.70	0.70	0.70)		0.70	0.70	-+	0	.70
Hourly Flow Rate, HFR (veh/h)	21	135	42			7	92			14
Percent Heavy Vehicles	0	0	0			0	0			0
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0							0
Lanes	0	1	0			0	1			0
Configuration		LTR					LTR			
Delay, Queue Length, a	nd Level of Se	rvice								
Approach	Northbound	Southbound	,	Westbo	und		l l	Eastbo	und	
Movement	1	4	7	8		9	10	11		12
Lane Configuration	LTR	LTR		LTR				LTF		
v (veh/h)	8	16		113	_		1	198		
C (m) (veh/h)	1538	1581		742	_			766	_	
v/c	0.01	0.01		0.15	-			0.20	_	
95% queue length	0.02	0.03		0.54				1.03	_	
Control Delay (s/veh)	7.4	7.3		10.7			 	11.3	\rightarrow	
LOS	7. - А	A	 	B	\dashv		 	В		
Approach Delay (s/veh)				10.7	, 		 	11.3		
Approach LOS				10.7 B			-	11.3 B	'	
Copyright © 2010 University of FI		<u></u>	<u> </u>	CS+ TM \					140/25	11 2:52 P

HCS+TM Version 5.6

Generated: 12/19/2011 2:52 PM

	TW	O-WAY STOP	CONTR	OL SU	JMN	//ARY				
General Information	<u> </u>		Site II	nform	atic	on .				
Analyst	R Marvin	1	Interse	ection			Mary Alig	n & Ha	awth	orne Opt
Agency/Co.	Marvin &	Assoc	I. min ali	ation			City Dillin	~~		
Date Performed	9/28/201	1	Jurisdi				City Billin	gs		
Analysis Time Period	Peak PN	1	Analys	is Year			2035			
Project Description Bil	lings Bypass E	IS								
East/West Street: Mary			North/S	South S	tree	t: Hawtho	rne			
Intersection Orientation:			Study F	Period ((hrs)	: 0.25				
Vehicle Volumes ar	nd Adjustme	ents								
Major Street		Eastbound					Westbou	nd		
Movement	1	2	3			4	5			6
	L	Т	R			L	Т			R
Volume (veh/h)		420	5			50	640			
Peak-Hour Factor, PHF	1.00	0.90	0.90			0.90	0.90			1.00
Hourly Flow Rate, HFR (veh/h)	0	466	5			55	711			0
Percent Heavy Vehicles	0					0				
Median Type			Two V	Vay Lef	ft Tu	rn Lane				
RT Channelized			0							0
Lanes	0	1	0			1	1			0
Configuration			TR			L	Т			
Upstream Signal		0					0			
Minor Street		Northbound					Southbound			
Movement	7	8	9			10	11			12
	L	T	R			L	Т			R
Volume (veh/h)	5		40					_		
Peak-Hour Factor, PHF	0.80	1.00	0.80	'		1.00	1.00	\rightarrow		1.00
Hourly Flow Rate, HFR (veh/h)	6	0	49			0	0			0
Percent Heavy Vehicles	0	0	0	ļ		0	0			0
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0	ļ				0			
RT Channelized			0							0
Lanes	0	0	0			0	0			0
Configuration		LR								
Delay, Queue Length, a		7								
Approach	Eastbound	Westbound	.	Northbo	ound			outhb		1
Movement	1	4	7	8		9	10	1.	1	12
Lane Configuration		L		LR						<u> </u>
v (veh/h)		55		55			ļ			
C (m) (veh/h)		1101		541	_			ļ		
v/c		0.05		0.10)					
95% queue length		0.16		0.34	1			<u> </u>		
Control Delay (s/veh)		8.4		12.4	1					
LOS		Α		В						
Approach Delay (s/veh)				12.4	1					
Approach LOS				В						
Copyright © 2010 University of Fl	orida. All Rights Res	served		S+ TM Ve	ersion	56	Genera	ted: 12/	19/20°	I1 11:55 A

Generated: 12/19/2011 11:55 AM

General Information	า		Site Infe	ormation			
Analyst	R Marvin		Intersecti		Mont On	t 2 & Johns	on M
Agency/Co.	Marvin As	esociatos	Jurisdicti		MDT	2 & JUIIIS	OHIV
Date Performed	10/8/201		Analysis		2035		
Analysis Time Period	Design H		- I thatyold	1 001	2000		
	lings Bypass						
East/West Street: Mary			North/Sou	uth Street: Joh	nson Lane N		
ntersection Orientation:			_	riod (hrs): 0.25			
Vehicle Volumes ar		nte	1	(-)			
Major Street		Eastbound		1	Westbou	ınd	
Movement	1	2	3	4	5	1	6
	L	T	R	Ĺ	T		R
/olume (veh/h)	10	995		İ	705		5
Peak-Hour Factor, PHF	0.90	0.90	1.00	1.00	0.90		0.90
Hourly Flow Rate, HFR veh/h)	11	1105	0	0	783		5
Percent Heavy Vehicles	4			0			
Median Type			L	Individed			
RT Channelized			0				0
_anes	1	2	0	0	2		0
Configuration	L	T			T		TR
Jpstream Signal		0			0		
Minor Street		Northbound			Southboo	und	
Movement	7	8	9	10	11		12
	L	Т	R	L	Т		R
/olume (veh/h)			1	0			30
Peak-Hour Factor, PHF	1.00	1.00	1.00	0.60	1.00		0.60
Hourly Flow Rate, HFR (veh/h)	0	0	0	0	0		49
Percent Heavy Vehicles	0	0	0	5	0		5
Percent Grade (%)		0			0		
-lared Approach		N			N		
Storage	1	0			0		
RT Channelized	1	1	0		<u> </u>	$\overline{}$	0
Lanes	0	0	0	0	0	- 	0
Configuration	1	1	<u> </u>	<u> </u>	LR		-
Delay, Queue Length, a	nd Level of Se	rvice				ji ji	
Approach	Eastbound	Westbound	No	rthbound	.5	Southbound	1
Movement	1	4	7	8 9	10	11	12
Lane Configuration	L	r	'	- 	10	LR	
					-		╁
/ (veh/h)	11				_	49	\vdash
C (m) (veh/h)	814				_	644	
//c	0.01					0.08	<u> </u>
95% queue length	0.04					0.25	$oxed{oxed}$
Control Delay (s/veh)	9.5					11.0	
_OS	Α					В	
Approach Delay (s/veh)						11.0	•
Approach LOS					- 	В	

		TW	O-WA	Y STOP	CONTR	OL S	UMI	MARY					
General Information	n				Site I	nforn	natio	on					
Analyst	F	R Marvin			Inters	ection			Mary	Opt	2 & C	oulsc	n Rd
Agency/Co.	۸	Marvin As	ssociate	s	Jurisd	iction			MDT				
Date Performed	1	10/8/2011	1		Analy	sis Yea	ar		2035				
Analysis Time Period	L	Design H	our PM										
Project Description Bil					•								
East/West Street: Mary	Option	า 1			North/	South S	Stree	t: Coulso	n Road				
Intersection Orientation:	East-	-West			Study	Period	(hrs)	: 0.25					
Vehicle Volumes ar	าd Ad	justme	nts										
Major Street			Eas	stbound					West	bou	nd		
Movement		1		2	3			4		5			6
		L		Т	R			L		Τ			R
Volume (veh/h)		55	_	940	_					25	_		5
Peak-Hour Factor, PHF	-	0.90		0.90	1.00)		1.00	0.	.90	_	0	.90
Hourly Flow Rate, HFR (veh/h)		61	1	1044	0			0	6	94			5
Percent Heavy Vehicles		4						0					
Median Type						Undi	vided	1					
RT Channelized					0								0
Lanes		1		2	0			0		2			0
Configuration		L		T						Τ			TR
Upstream Signal				0						0			
Minor Street			Nor	thbound					South	nbou	nd		
Movement		7		8	9			10		11			12
		L		Т	R			L		Т			R
Volume (veh/h)								5					80
Peak-Hour Factor, PHF		1.00		1.00	1.00)		0.70	1.	.00		C	.70
Hourly Flow Rate, HFR (veh/h)		0		0	0			7		0		1	114
Percent Heavy Vehicles		0		0	0			5		0			5
Percent Grade (%)				0						0			
Flared Approach				Ν						N			
Storage				0						0			
RT Channelized					0								0
Lanes	1	0		0	0			0		0			0
Configuration					1				L	.R			
Delay, Queue Length, a	and Lev	vel of Se	rvice				·						
Approach		oound	1	bound		Northb	ound			S	outhbo	ound	
Movement		1		4	7	8		9	10		11		12
Lane Configuration	I	L									LR	?	
v (veh/h)	6	61									12	1	
C (m) (veh/h)	88	80									548	3	
v/c		07									0.2	_	
95% queue length		22				<u> </u>			 		0.8	_	
Control Delay (s/veh)		.4	 			\vdash			\vdash		13.		
LOS		4				\vdash			\vdash		13. B		
						<u> </u>			 				
Approach Delay (s/veh)											13.4	+	
Approach LOS		 Rights Res				ıcs.TM				eners	В		

HCS+TM Version 5.6

Generated: 12/19/2011 3:31 PM

LANE SUMMARY

Site: Mary Alignment Option 2 Intersection with Five Mile & Mary Street

Mary Alignment Option 2 Intersection of Mary Alignment with Mary Street & Five Mile Road Roundabout

Lane Use	and Pe	rform	ance													
	. [Deman	d Flows		HV	Cap.	Deg.	Lane	Average	Level of	95% Back		Lane	SL	Cap. I	
	veh/h	veh/h	R veh/h	Total veh/h	%	veh/h	Satn v/c	Util. %	Delay sec	Service	Vehicles veh	Distance ft	Length ft	Туре	Adj. I %	Block. %
South: Mary																
Lane 1	5	54	22	82	0.0	676	0.121	100	8.2	LOS A	0.5	12.1	1600		0.0	0.0
Approach	5	54	22	82	0.0		0.121		8.2	LOS A	0.5	12.1				
East: Mary A	Alignmer	nt WB														
Lane 1	22	450	0	471	3.8	1335	0.353	100	5.1	LOS A	2.5	65.1	1600	_	0.0	0.0
Lane 2	0	289	250	539	3.1	1527	0.353	100	5.3	LOS A	2.6	65.7	1600		0.0	0.0
Approach	22	739	250	1011	3.4		0.353		5.2	LOS A	2.6	65.7				
North: Five I	Mile Roa	ad SB														
Lane 1	185	11	5	201	1.9	634	0.317	100	15.8	LOS B	1.4	34.3	1600		0.0	0.0
Approach	185	11	5	201	1.9		0.317		15.8	LOS B	1.4	34.3				
West: Mary	Alignme	nt EB														
Lane 1	5	225	0	231	3.9	1101	0.210	100	5.8	LOS A	1.3	32.3	1600	_	0.0	0.0
Lane 2	0	253	5	258	3.9	1232	0.210	100	5.4	LOS A	1.3	33.1	1600	_	0.0	0.0
Approach	5	478	5	489	3.9		0.210		5.6	LOS A	1.3	33.1				
Intersection				1783	3.2		0.353		6.6	LOS A	2.6	65.7				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Monday, December 19, 2011 2:35:40 PM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Traffic Study\Capacity\Calculations\Mary Street\Mary Opt 2\Mary Align Mary_5 Mile Opt2 PM 2035.sip 8001325, MARVIN & ASSOCIATES, SINGLE



	TW	O-WAY STOP	CONTR	OL SU	MMARY			
General Information	n		Site I	nforma	ation			
Analyst	R Marvin		Interse	ection		Dover &	Five Mile I	Mary Opt
Agency/Co.	Marvin As		Jurisdi	ction		MDT		
Date Performed	10/3/2011			is Year		2035		
Analysis Time Period	Design H	our PM		no rour		2000		
Project Description Bil			J			, 		
East/West Street: Dove	r Road				reet: <i>Five</i>	Mile Road		
Intersection Orientation:	North-South		Study F	Period (h	nrs): <i>0.25</i>			
Vehicle Volumes ar	nd Adjustme							
Major Street		Northbound				Southbo	und	
Movement	1	2	3		4	5		6
	L	Т	R		L	T		R
Volume (veh/h)	30	200	50		5	150		5
Peak-Hour Factor, PHF	0.90	0.90	0.90		0.90	0.90		0.90
Hourly Flow Rate, HFR (veh/h)	33	222	55		5	166		5
Percent Heavy Vehicles	3				3			
Median Type		,		Undivi	ded			
RT Channelized			0					0
Lanes	0	1	0		0	1		0
Configuration	LTR				LTR			
Upstream Signal		0				0		
Minor Street		Eastbound				Westbou	ınd	
Movement	7	8	9		10	11		12
	L	Т	R		L	Т		R
Volume (veh/h)	5	90	20		30	60		5
Peak-Hour Factor, PHF	0.80	0.80	0.80	·	0.80	0.80		0.80
Hourly Flow Rate, HFR (veh/h)	6	112	24		37	74		6
Percent Heavy Vehicles	0	3	0		0	3		0
Percent Grade (%)		0	•			0	·	
Flared Approach		N				N		
Storage		0				0		
RT Channelized			0					0
Lanes	0	1	0		0	1		0
Configuration		LTR				LTR		
Delay, Queue Length, a	nd Level of Se	rvice						
Approach	Northbound	Southbound	'	Westboo	und		Eastbound	t l
Movement	1	4	7	8	9	10	11	12
Lane Configuration	LTR	LTR		LTR			LTR	
v (veh/h)	33	5		117			142	
C (m) (veh/h)	1400	1280		419			481	
v/c	0.02	0.00		0.28			0.30	1
95% queue length	0.07	0.01		1.13			1.22	
Control Delay (s/veh)	7.6	7.8		16.9			15.6	
LOS	Α	Α		С			С	
Approach Delay (s/veh)				16.9			15.6	
Approach LOS				С			С	
Copyright © 2010 University of FI	orida All Rights Rese	erved	ப	CS+ TM V	ersion 5.6	Gene	rated: 12/19/2	2011 2:49

	TW	O-WAY STOP	CONTRO	OL SUM	IMARY			
General Information	n		Site Ir	nformat	ion			
Analyst	R Marvin		Interse	ction		Mary & H	lawthrone	Option 2
Agency/Co.	Marvin A	ssociates	Jurisdi	ction		MDT		
Date Performed	10/8/201		Analys	is Year		Year 203	5	
Analysis Time Period	Design H	our PM						
Project Description Bil	llings Bypass							
East/West Street: Mary					et: <i>Bittero</i>	ot		
Intersection Orientation:	North-South		Study F	Period (hr	s): <i>0.25</i>			
Vehicle Volumes ar	nd Adjustme							
Major Street		Northbound				Southbou	ınd	
Movement	11	2	3		4	5		6
	L	T	R		L	T		R
Volume (veh/h)	5	20	5		10	35		10
Peak-Hour Factor, PHF	0.60	0.60	0.60		0.60	0.60		0.60
Hourly Flow Rate, HFR (veh/h)	8	33	8		16	58		16
Percent Heavy Vehicles	0				0			
Median Type				Undivide	ed			
RT Channelized			0				0	
Lanes	0	1	0		0	1		0
Configuration	LTR				LTR			
Upstream Signal		0				0		
Minor Street		Eastbound				Westbou	nd	
Movement	7	8	9		10	11		12
	L	Т	R		L	Т		R
Volume (veh/h)	15	95	30		5	65		10
Peak-Hour Factor, PHF	0.70	0.70	0.70		0.70	0.70		0.70
Hourly Flow Rate, HFR (veh/h)	21	135	42		7	92		14
Percent Heavy Vehicles	0	0	0		0	0		0
Percent Grade (%)		0				0		
Flared Approach		N				N		
Storage		0	1			0		
RT Channelized			0					0
Lanes	0	1	0		0	1		0
Configuration		LTR				LTR		
Delay, Queue Length, a	nd Level of Se	rvice					· · · · · · · · · · · · · · · · · · ·	
Approach	Northbound	Southbound	\	Nestboun	ıd	1	Eastbound	
Movement	1	4	7	8	9	10	11	12
Lane Configuration	LTR	LTR		LTR			LTR	
v (veh/h)	8	16		113			198	
C (m) (veh/h)	1538	1581		742		†	766	
v/c	0.01	0.01		0.15	1	<u> </u>	0.26	1
95% queue length	0.02	0.03		0.13	+	†	1.03	+
Control Delay (s/veh)	7.4	7.3		10.7	+	+	11.3	+
, ,					-	+		+
LOS	Α	Α		B		+	B 11.0	1
Approach Delay (s/veh)				10.7		 	11.3	
Approach LOS		erved		B North			В	

HCS+TM Version 5.6

Generated: 12/19/2011 2:54 PM

	TW	O-WAY STOP	CONTR	OL SI	JMN	IARY				
General Information	n		Site I	nform	atio	on				
Analyst	R Marvin		Interse	oction			Mary Alig	n & Ha	wtho	rne Opt
Agency/Co.	Marvin &						2			
Date Performed	9/28/201		Jurisdi				City Billin	gs		
Analysis Time Period	Peak PM		Analys	is Yea	r		2035			
Project Description Bill East/West Street: Mary		<u>S</u>	North/9	South C	troo	t: <i>Hawtho</i>	rno			
Intersection Orientation:						<u> памию</u> : 0.25	orrie			
			Joludy I	enou	(1113)	. 0.23				
Vehicle Volumes ar	ia Aajustme			1			\\/ 4	l		
Major Street Movement	1	Eastbound	3			4	Westbou 5	na T		6
Movement	 	2 	R				T			R
Volume (veh/h)	<u> </u>	410	5			50	610			1
Peak-Hour Factor, PHF	1.00	0.90	0.90	,		0.90	0.90		1.	.00
Hourly Flow Rate, HFR (veh/h)	0	455	5			55	677			0
Percent Heavy Vehicles	0					0				
Median Type			Two V	Vay Le	ft Tu	rn Lane				
RT Channelized	İ		0							0
Lanes	0	1	0			1	1			0
Configuration			TR			L	Т			
Upstream Signal		0	1				0			
Minor Street		Northbound					Southbou	ınd		
Movement	7	8	9			10	11	Ĭ	12	
	L	Т	R			L	Т			R
Volume (veh/h)	5		40							
Peak-Hour Factor, PHF	0.80	1.00	0.80	·		1.00	1.00		1.	.00
Hourly Flow Rate, HFR (veh/h)	6	0	49			0	0			0
Percent Heavy Vehicles	0	0	0			0	0			0
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0							0
Lanes	0	0	0			0	0			0
Configuration		LR								
Delay, Queue Length, a	nd Level of Se	rvice								
Approach	Eastbound	Westbound		Northbo	ound		S	outhbo	und	
Movement	1	4	7	8		9	10	11		12
Lane Configuration		L		LR)					
v (veh/h)		55		55						
C (m) (veh/h)		1112		551	1				$\neg \uparrow$	
v/c		0.05		0.10	0				\neg	
95% queue length		0.16		0.33					\neg	
Control Delay (s/veh)		8.4		12.3						
LOS		A		B			1		\dashv	
Approach Delay (s/veh)				12.3				<u> </u>		
Approach LOS		 		B						
Copyright © 2010 University of FI		<u></u>		CS+ TM						1 2:39 F

HCS+TM Version 5.6

Generated: 12/19/2011 2:39 PM

	TW	O-WAY STOP	CONTR	OL S	UMI	MARY				
General Information	n		Site I	nforn	natio	on				
Analyst	R Marvin		Interse				5 Mile Ali	an & Joh	nson N	
Agency/Co.	Marvin A			Jurisdiction MDT						
Date Performed	10/8/201	10/8/2011		Analysis Year			2035			
Analysis Time Period	Design H	Design Hour PM								
	llings Bypass		•							
East/West Street: Five						t: Johnso	n Lane N			
Intersection Orientation:	East-West		Study F	Period	(hrs)	: 0.25				
Vehicle Volumes ar	nd Adjustme									
Major Street		Eastbound	1 0				Westbou	nd		
Movement	1	2	3			4	5	_	6	
\/ala /a h /h \	10	T	R			L	T 505		R	
Volume (veh/h) Peak-Hour Factor, PHF	0.90	835 0.90	1.00	,		1.00	595 0.90		5 0.90	
Hourly Flow Rate, HFR										
(veh/h)	11	927	0			0	661		5	
Percent Heavy Vehicles	4					0				
Median Type		Undivided								
RT Channelized			0						0	
Lanes	1	2	0			0	2		0	
Configuration	L	T	<u> </u>				Т		TR	
Upstream Signal		0					0			
Minor Street		Northbound					Southbou	ınd		
Movement	7	8	9			10	11		12	
	L	Т	R			L	Т		R	
Volume (veh/h)		4.00	1 00			0			30	
Peak-Hour Factor, PHF	1.00	1.00	1.00	'		0.60	1.00	_	0.60	
Hourly Flow Rate, HFR (veh/h)	0	0	0			0	0		49	
Percent Heavy Vehicles	0	0	0			5	0		5	
Percent Grade (%)		0					0	•		
Flared Approach		N					N			
Storage		0					0			
RT Channelized	1		0						0	
Lanes	0	0	0			0	0		0	
Configuration			Ī .				LR			
Delay, Queue Length, a	and Level of Se	ervice	*		-					
Approach	Eastbound	Westbound	Northbo		ound		S	outhbour	bound	
Movement	1	4	7	8		9	10	11	12	
Lane Configuration	L							LR		
v (veh/h)	11					ĺ		49		
C (m) (veh/h)	906							698		
v/c	0.01							0.07		
95% queue length	0.04						†	0.23	1	
Control Delay (s/veh)	9.0							10.5		
LOS	A							В		
Approach Delay (s/veh)						<u> </u>		10.5	ı	
Approach LOS								B		
Copyright © 2010 University of F				C:S+ TM	\/:	5.0	Genor		/2011 3:33 PM	

HCS+TM Version 5.6

General Information	n		Site Infe	ormation					
			[F A4:1- A4:	5 A 11 A 12 A 12 B 1					
Analyst Agency/Co.	R Marvin Marvin As	annointan	Intersecti		MDT	5 Mile Align & Coulson I			
Date Performed 10/8/201				Jurisdiction Analysis Year		2035			
Analysis Time Period Design F			Analysis	Allalysis Teal		2000			
Project Description Bil		04/ 1/1/1							
East/West Street: Five			North/Sou	uth Street: Cou	Ilson Road				
ntersection Orientation:				riod (hrs): 0.25					
Vehicle Volumes ar		nte	10.0.0)	()					
Major Street		Eastbound		1	Westhou	Westbound			
Movement	1	2	3	4	5	1	6		
TIO VOITION	i	Ť	R	L L	Ť	_	R		
/olume (veh/h)	<u>-</u> 55	780	1		520	 	5		
Peak-Hour Factor, PHF	0.90	0.90	1.00	1.00	0.90		0.90		
Hourly Flow Rate, HFR veh/h)	61	866	0	0	577		5		
Percent Heavy Vehicles	4			0					
Median Type	Undivided								
RT Channelized			0				0		
Lanes	1	2	0	0 0			0		
Configuration	L	T			T	· 7			
Jpstream Signal		0	1		0				
Minor Street		Northbound			Southboo	ınd			
Movement	7	8	9	10	11		12		
	L	Т	R	L	Т		R		
/olume (veh/h)			1	5			80		
Peak-Hour Factor, PHF	1.00	1.00	1.00	0.70	1.00		0.70		
Hourly Flow Rate, HFR (veh/h)	0	0	0	7	0	114			
Percent Heavy Vehicles	0	0	0 5		0		5		
Percent Grade (%)		0		0					
Flared Approach		N							
Storage		0			0				
RT Channelized			0	0		1			
Lanes	0	0	0	·		0			
Configuration	1		İ		LR	<u> </u>			
Delay, Queue Length, a	and Level of Se	ervice	-	*		*			
Approach	Eastbound	Westbound	No	rthbound	l s	Southbound			
Movement	1	4	7	8 9	10	11	12		
_ane Configuration	L		-	- 	- 	LR	<u> </u>		
/ (veh/h)	61			- 	- 	121	\vdash		
C (m) (veh/h)	975		-	- 	-	624	\vdash		
							\vdash		
//C	0.06					0.19	-		
95% queue length	0.20					0.71			
Control Delay (s/veh)	8.9					12.2			
_OS	Α					В			
Approach Delay (s/veh)						12.2			
Approach LOS	roach LOS					В			

LANE SUMMARY

Site: Five Mile Road Alignment Mary Street Intersection

Five Mile Road Alignment Mary Street Intersection Year 2035 PM Design Hour Roundabout

Lane Use	and Pe	rforma	ance													
	. [Deman	d Flows		HV	Can	Deg.	Lane	Average	Level of	95% Back		Lane	SL	Cap. I	
	L veh/h	veh/h	R veh/h	Total veh/h	пv %	Cap.	Satn v/c	Util. %	Delay sec	Service	Vehicles veh	Distance ft	Length ft	Туре	Adj. I %	Block. %
South East:				VG11/11	/0	VGII/II	V/C	/0	366		VEII		- 1		/0	/0
Lane 1	543	0	0	543	4.0	1600	0.340	100	12.5	LOS B	2.4	61.6	1600	_	0.0	0.0
Lane 2	0	304	0	304	3.0	1320	0.231	68 ⁵	4.5	LOS A	1.4	36.0	1600	_	0.0	0.0
Approach	543	304	0	848	3.6		0.340		9.7	LOS A	2.4	61.6				
North West:	Five Mil	le Aligr	SEB													
Lane 1	0	109	0	109	2.0	853	0.128	100	7.5	LOS A	0.7	17.8	1600	_	0.0	0.0
Lane 2	0	98	33	130	1.7	1018	0.128	100	7.3	LOS A	0.7	18.7	1600	_	0.0	0.0
Approach	0	207	33	239	1.9		0.128		7.4	LOS A	0.7	18.7				
South West	: Mary S	treet N	IEB													
Lane 1	33	0	0	33	1.0	638	0.051	100	14.0	LOS B	0.2	5.1	200	_	0.0	0.0
Lane 2	0	0	359	359	3.0	1087	0.330	100	6.8	LOS A	1.8	46.1	200		0.0	0.0
Approach	33	0	359	391	2.8		0.330		7.4	LOS A	1.8	46.1				
Intersection				1478	3.1		0.340		8.7	LOS A	2.4	61.6				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

5 Lane underutilisation determined by program

Processed: Monday, December 19, 2011 3:01:47 PM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Traffic Study\Capacity\Calculations\Mary Street\Five Mile\Five Mile Align Mary Int PM 2035.sip 8001325, MARVIN & ASSOCIATES, SINGLE



	TW	O-WAY STOP	CONTR	OL SU	JMN	MARY				
General Information	n		Site II	nform	atio	on				
Analyst	R Marvin		Interse	ection			Dover & 8	5 Mile 5	5 Mile	Align
Agency/Co.	Marvin As	ssociates	Jurisdi				MDT			<u> </u>
Date Performed	10/3/201	1	Analys	is Year	ſ		2035			
Analysis Time Period	Design H	our PM								
Project Description Bil	llings Bypass									
East/West Street: Dove						t: Five Mi	le Road			
Intersection Orientation:	North-South		Study F	Period ((hrs)	: 0.25				
Vehicle Volumes ar	nd Adjustme									
Major Street		Northbound					Southbou	ınd		
Movement	1	2	3			4	5			6
\(\frac{1}{2} \cdot \cdo	L	T	R			<u>L</u>	T 100			R
Volume (veh/h)	30	240	50			5	160			5
Peak-Hour Factor, PHF Hourly Flow Rate, HFR	0.90	0.90	0.90	' 		0.90	0.90		U	.90
(veh/h)	33	266	55			5	177			5
Percent Heavy Vehicles	3					3				
Median Type			1		livided					
RT Channelized			0							0
Lanes	0	1	0			0	1			0
Configuration	LTR					LTR				
Upstream Signal		0					0			
Minor Street		Eastbound					Westbou	nd		
Movement	7	8	9		10		11			12
	L	Т	R			L	Т			R
Volume (veh/h)	10	85	20		30		65			10
Peak-Hour Factor, PHF	0.80	0.80	0.80		0.80		0.80		0	.80
Hourly Flow Rate, HFR (veh/h)	12	106	24		37		81			12
Percent Heavy Vehicles	0	3	0			0	3			0
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0							0
Lanes	0	1	0			0	1			0
Configuration		LTR					LTR			
Delay, Queue Length, a	nd Level of Se	rvice								
Approach	Northbound	Southbound	,	Westbo	ound		l l	Eastbo	und	
Movement	1	4	7	8		9	10	11	r	12
Lane Configuration	LTR	LTR		LTR	?			LTF		
v (veh/h)	33	5		130)			142	2	
C (m) (veh/h)	1387	1233		398				444	4	
v/c	0.02	0.00		0.33				0.3	2	
95% queue length	0.07	0.01		1.40			1	1.3		
Control Delay (s/veh)	7.7	7.9		18.4			<u> </u>	16.		
LOS	A	A		C			†	C		
Approach Delay (s/veh)				18.4	1	I.	 	16.9		
Approach LOS					•		 	C		
Copyright © 2010 University of FI		Pasanyad		C HCS+ TM Vers		5.0	Generated: 12/19/2011		11 2:57 DI	

Copyright © 2010 University of Florida, All Rights Reserved

HCS+TM Version 5.6

Generated: 12/19/2011 2:57 PM

Five Mile Align 2035 Secondary Imp

R Mary Imp

R Mary Street/Bitteroot

12/19/2011

Analysis Duration: 15 mins.

Pm Design Hour

Case: FIVEMICA

Pm	Design I	lour		Case: FIVEMI~1 Geometry: Movements Service													
	Lanes					Geom	etry: Mo	vemen	ıts Se	rviced b	y Lane ar	nd Lane V	Vidths (1	feet)			
	Approach	Outbound	La	ne 1		Lan	e 2		Lane	3	La	ne 4	La	ane 5		Lan	e 6
EB	2	1	L	12.)	TR	12.0										
WB	2	1	L	12.)	TR	12.0										
NB	1	1	LTR	12.)												
SB	1	1	LTR	12.	0												
				Eas	t			Wes	st			North			Sc	outh	
	Data		L	Т		R	L	Т		R	L	Т	R	L		Т	R
Move	ment Volur	ne (vph)	20	31)	50	80	390	0	60	50	100	80	40		60	10
PHF			0.92	0.9	2 ().92	0.92	0.92	2	0.92	0.92	0.92	0.92	0.92	0.	.92	0.92
% He	% Heavy Vehicles		0	4		0	0	4		0	0	1	0	0		1	0
Lane	Groups		L	TR			L	TR				LTR			L	TR	
Arriv	al Type		3	3			3	3				3				3	
RTO	R Vol (vph)			10				10)			30				5	
Peds/	Hour			5			5				5				5		
% Gr	ade			0				0			0			0			
Buses	/Hour			0				0			0					0	
Parke	rs/Hour (Le	ft Right)							-						-		
Signa	1 Settings: A	Actuated		Oper	ational	Analys	is	Cy	cle L	ength:	60.0 Sec	С	Lost Tin	ne Per Cy	cle: 10	0.0 Se	ec
Phase	:	1		2		3	4			5	6		7	8		Ped	d Only
EB		LTP															
WB		LTP															
NB				LTP													
SB				LTP													
Green 33.0 17.0		_			1				ļ , , , , , , , , , , , , , , , , , , ,						0		
Yello	w All Red	3.5	1.5 3.:	5 1.5	5												

	Capacity Analysis Results Approach: Lane Cap v/s g/C Lane v/c Delay Delay													
App EB	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS				
ED	L	437	0.028	0.550	L	0.050	6.5	A	8.7	A				
	TR	997	0.210	0.550	TR	0.381	8.8	A						
WB														
	L	521	0.092	0.550	L	0.167	7.4	A	9.5	A				
	* TR	997	0.264	0.550	TR	0.479	9.9	A						
NB														
	* LTR	465	0.132	0.283	LTR	0.467	18.0	В	18.0	В				
SB														
				·	·									
	LTR	442	0.072	0.283	LTR	0.256	16.7	В	16.7	В				

Intersection: Delay = 11.3 sec/veh SIG/Cinema v3.08

Int. LOS=B $X_c = 0.48$

* Critical Lane Group

 \sum (v/s)Crit= 0.40

Page 1

Five Mile Align 2035 Secondary Imp R Marvin Pm Design Hour Mary Street/Bitteroot 12/19/2011 Case: FIVEMI~1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	60
EB	L	0 / 1	24.7	0.0	↓ ' ↓
	TR	4 / 5	16.7	0.0	1
	All		17.0	0.0	80 _
WB	L	1 / 2	17.8	0.0	
	TR	5 / 6	17.2	0.0	<u>→</u>
					$310 \longrightarrow $
	All		17.2	0.0	50 —
NB	LTR	2/3	14.3	0.0	
					50 80
	All		14.3	0.0	
					1 2
SB	LTR	2 / 2	12.2	0.0	== 2 2=
					32 4 2 16 4 2
	All		12.2	0.0	
	Inte	rsect.	16.0		

SIG/Cinema v3.08 Page 2

	TW	O-WAY STOP	CONTR	OL SU	MMAR	Υ				
General Information	n		Site I	nforma	ation					
Analyst	R Marvin		Interse	ection			5 Mile AL		iry	
Agency/Co.	Marvin &		\dashv				Hawthorn			
Date Performed	9/28/201		- Jurisdi				City Billin	gs		
Analysis Time Period	Peak PM		Analys	is Year			2035			
Project Description Bil	llings Bypass Fi	'S								
East/West Street: Mary			North/S	South St	reet: H	awtho	rne			
Intersection Orientation:					hrs): <i>0.2</i>					
Vehicle Volumes ar	nd Adjustme	ents								
Major Street		Eastbound					Westbou	nd		
Movement	1	2	3		4		5			6
	L	Т	R		L		Т			R
Volume (veh/h)		380	35		30		450			
Peak-Hour Factor, PHF	1.00	0.90	0.90		0.90		0.90			1.00
Hourly Flow Rate, HFR (veh/h)	0	422	38		33		500			0
Percent Heavy Vehicles	0				0					
Median Type			Two Way Le		t Turn La	ne				
RT Channelized			0							0
Lanes	0	1	0		1		1			0
Configuration			TR		L		Т			
Upstream Signal		0					0			
Minor Street		Northbound					Southbou	ınd		
Movement	7	8	9		10		11			12
	L	Т	R		L		Т			R
Volume (veh/h)	20		20							
Peak-Hour Factor, PHF	0.80	1.00	0.80)	1.00	00 1.00				1.00
Hourly Flow Rate, HFR (veh/h)	24	0	24		0		0			0
Percent Heavy Vehicles	0	0	0		0		0			0
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0							0
Lanes	0	0	0		0		0			0
Configuration		LR								
Delay, Queue Length, a	ind Level of Se	rvice								
Approach	Eastbound	Westbound	ı	Northbo	und		S	Southbo	ound	
Movement	1	4	7	8		9	10	11		12
Lane Configuration		L		LR						
v (veh/h)		33		48						
C (m) (veh/h)		1112		481	T T					
v/c		0.03		0.10			Ì	i –		
95% queue length		0.09		0.33	_					
Control Delay (s/veh)		8.3		13.3	_		†			
LOS		A		В						<u> </u>
Approach Delay (s/veh)			13.3							<u> </u>
					 					
Approach LOS Copyright © 2010 University of Fl		HCS+ TM Version 5.6 Generated: 12/19/201)11 2:59				

LANE SUMMARY

Site: Five Mile Align US87/312/ Main/Bench/Mary

Five Mile Align US87/312/Main/Bench/Mary Secondary Improvements Roundabout

Lane Use	Lane Use and Performance Demand Flows Deg. Lane Average Level of 95% Back of Queue Lane SL Cap. Prob.															
	ا	Deman			1.15.7	0	Deg.	Lane	Average	Level of			Lane	SL		
	L l- //-	T	R	Total	HV	Cap.	Satn	Util.	Delay	Service	Vehicles	Distance	Length	Type		Block.
South: Bend		veh/h	ven/n	veh/h	%	veh/h	v/c	%	sec		veh	ft	ft		%	%
Lane 1	11	120	168	299	0.0	394	0.759	100	20.6	LOS C	5.5	138.3	1600	_	0.0	0.0
Approach	11	120	168	299	0.0		0.759		20.6	LOS C	5.5	138.3				
South East:	•	treet N	WB													
Lane 1	391	0	0	391	1.3	543	0.721	100	24.5	LOS C	6.1	153.6	1600	_	0.0	0.0
Lane 2	0	239	11	250	4.0	400	0.625	87 ⁵	16.3	LOS B	4.1	105.0	1600	_	0.0	0.0
Approach	391	239	11	641	2.4		0.721		21.3	LOS C	6.1	153.6				
North East:	HWY 3	12 SWE	3													
Lane 1	71	164	0	234	1.7	472	0.496	100	15.6	LOS B	3.3	84.1	1600	_	0.0	0.0
Lane 2	0	271	11	282	2.0	568	0.496	100	12.6	LOS B	3.6	91.2	1600	_	0.0	0.0
Approach	71	435	11	516	1.9		0.496		13.9	LOS B	3.6	91.2				
North West:	US 87	SEB														
Lane 1	11	109	103	223	2.1	570	0.391	100	8.8	LOS A	2.1	54.1	1600	_	0.0	0.0
Approach	11	109	103	223	2.1		0.391		8.8	LOS A	2.1	54.1				
South West:	Main S	Street N	E Boun	d												
Lane 1	457	160	0	617	1.0	1002	0.615	100	14.6	LOS B	6.0	152.2	1600	_	0.0	0.0
Lane 2	0	514	239	753	1.3	1223	0.615	100	7.3	LOS A	6.2	155.4	1600	_	0.0	0.0
Approach	457	674	239	1370	1.2		0.615		10.6	LOS B	6.2	155.4				
Intersection				3049	1.5		0.759		14.3	LOS B	6.2	155.4				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

5 Lane underutilisation determined by program

Processed: Monday, December 19, 2011 3:03:48 PM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Traffic Study\Capacity\Calculations\Mary Street\Five Mile\Mary Align Five Mile US87 312 Main Bench Sec Imp PM 2035.sip

8001325, MARVIN & ASSOCIATES, SINGLE



APPENDIX H

Johnson Lane Interchange

Design Options

Figures & Capacity Calculations

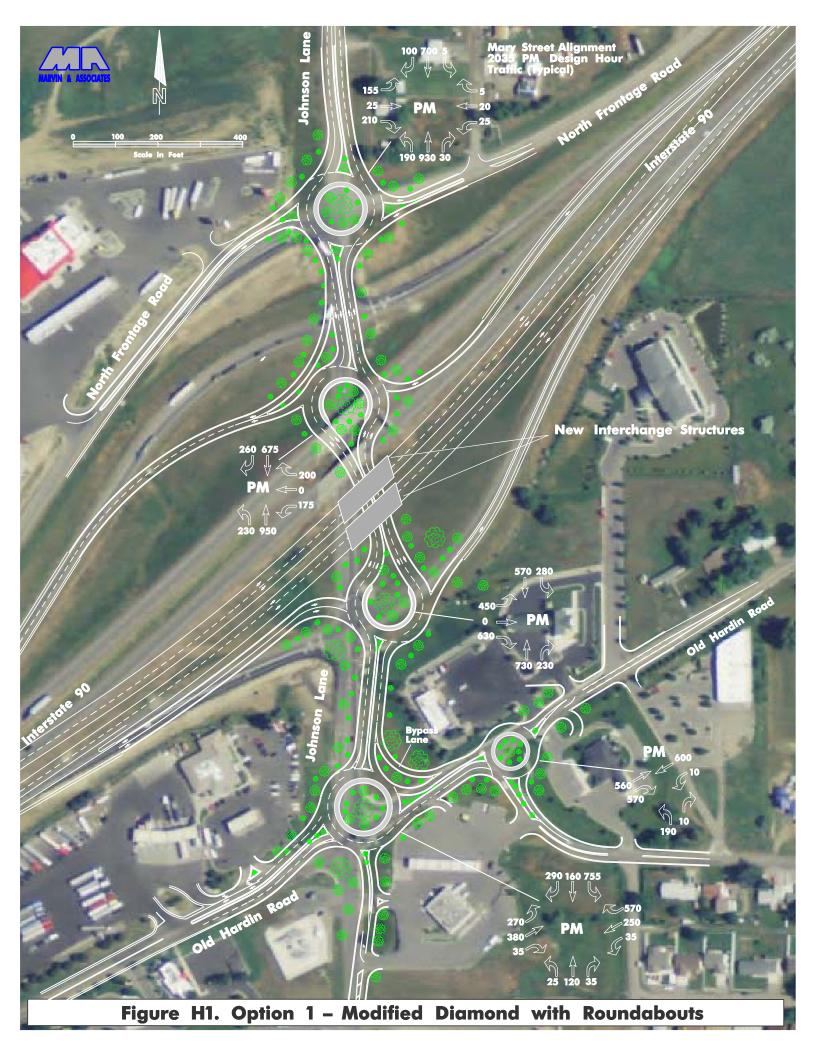
er.			

APPENDIX H

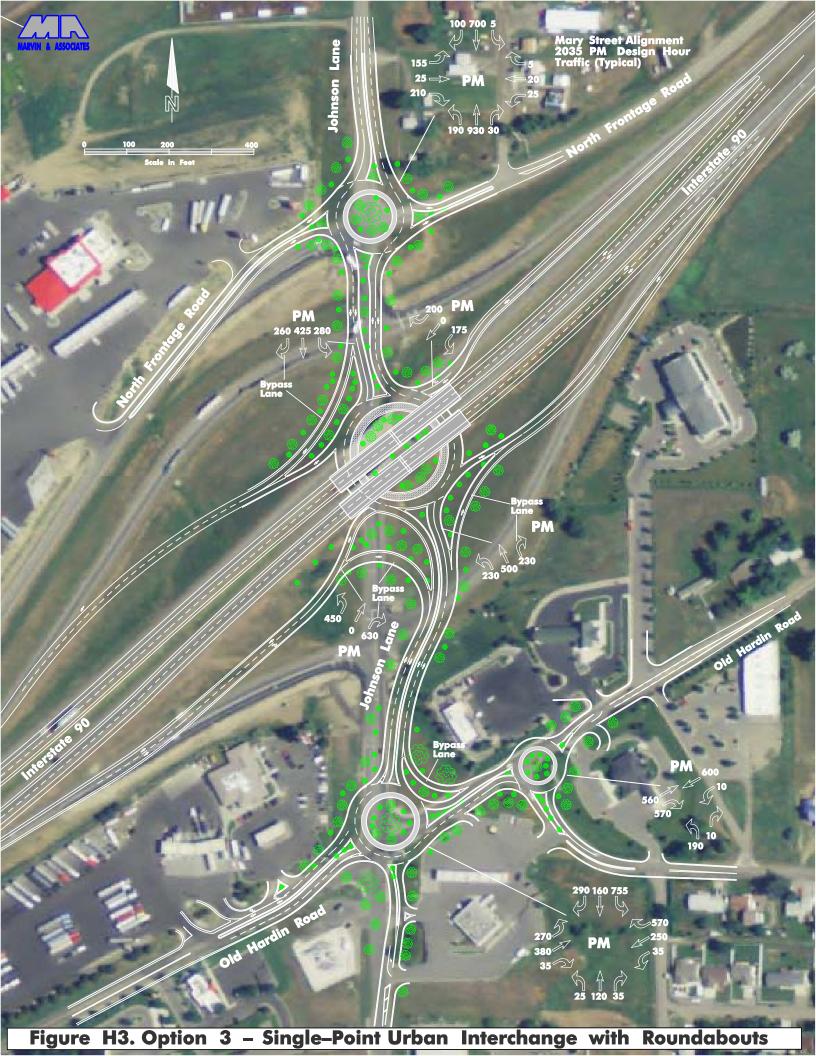
Johnson Lane Interchange

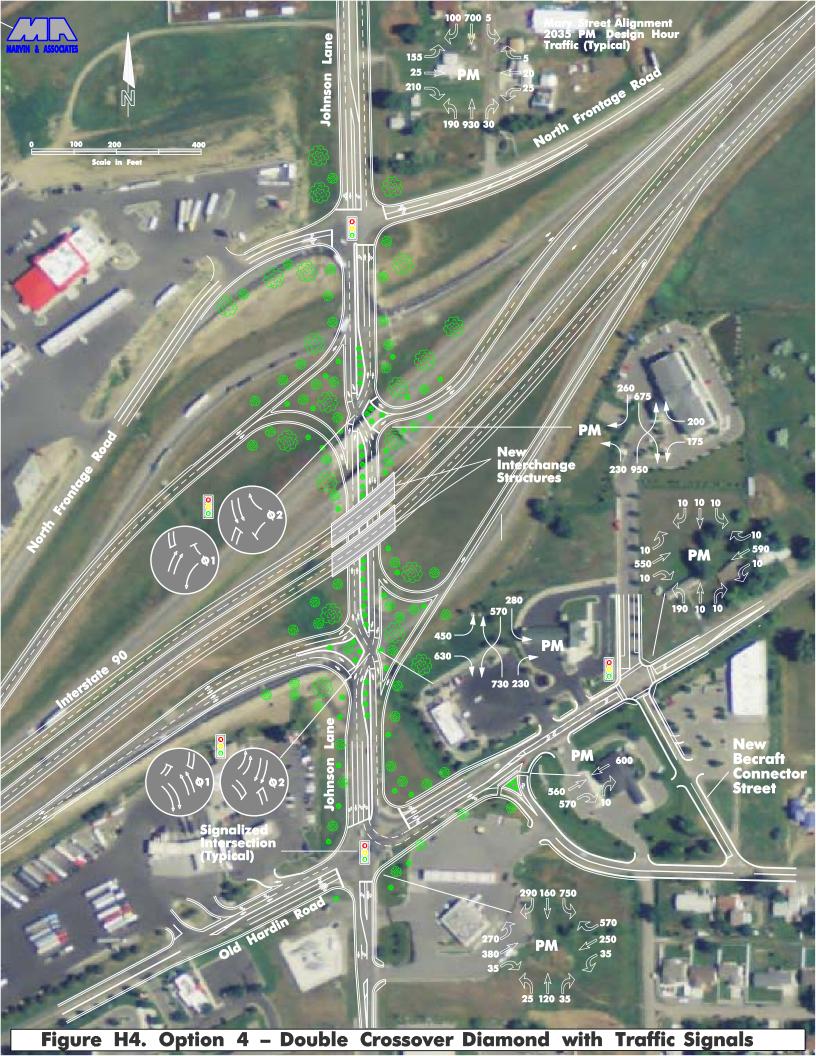
Design Option Figures

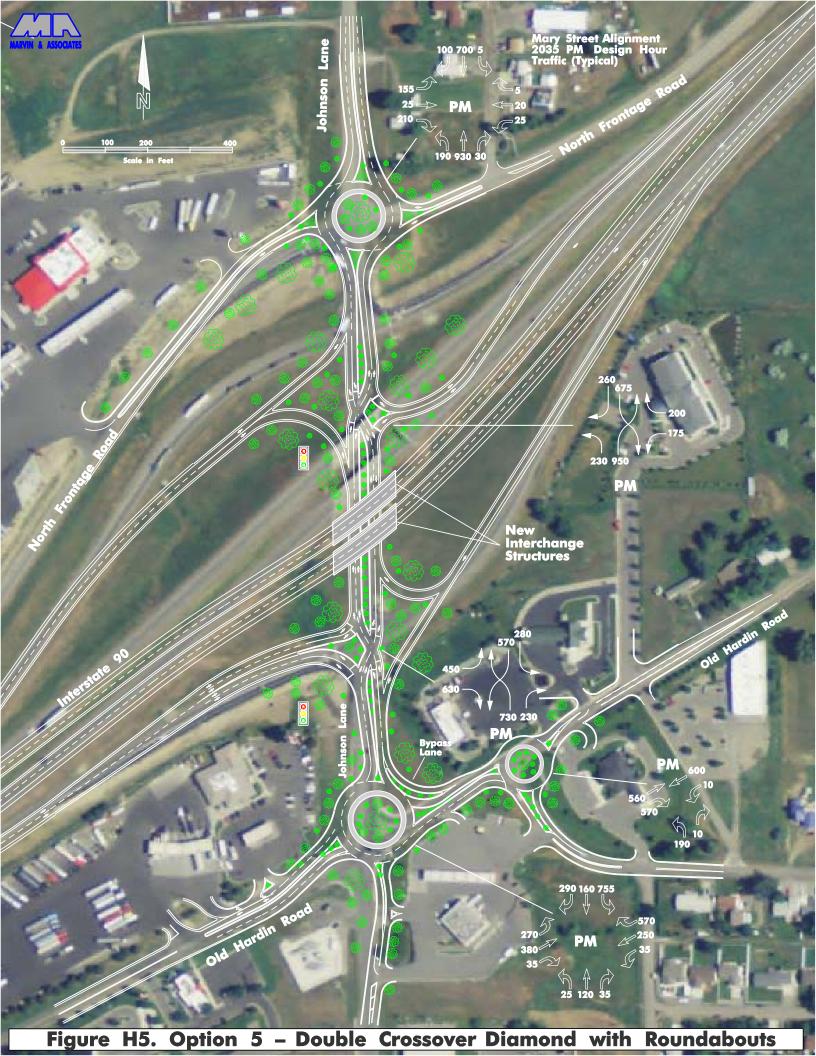
er.			











er.			

APPENDIX H

Johnson Lane Interchange

Design Options

Capacity Calculations

er.			

Year 2035 Mary Op1 Alternate

Old Hardin Road/Johnson Lane

Area Type: Non CBD

R Marvin

Peak PM Hour

Old Hardin Road/Johnson Lane

Analysis Duration: 15 mins.

Case: Old Hardin Johnson 2035 PM 102011

Pea	ık PM Ho	ur			Case	: Old	l Ha	rdin Jo	hnson 2	2035 PM	I 10201	1				
	Lanes					Geom	etry: Mo	vemer	nts Se	erviced b	y Lane ar	nd Lane W	idths (1	feet)		
	Approach	Outbound	La	ne 1		Lane	2		Lane	3	Laı	ne 4	La	ane 5	I	ane 6
EB	3	2	L	12.0) '	Т	12.0	TR	١	12.0						
WB	4	2	L	12.0) /	Т	12.0	Т		12.0	R	12.0				
NB	2	2	L	12.0	T (R	12.0									
SB	4	1	L	12.0)]	L	12.0	Т		12.0	R	12.0				
				Eas	t			We	st			North			South	ı
	Data		L	Т]	R	L	Т		R	L	T	R	L	Т	R
Move	ement Volun	nt Volume (vph) 270 380 35		35	35	25	0	570	25	120	35	750	160	290		
PHF	IF 0.95 0.9		0.93	5 0.	.95	0.95	0.9	5	0.95	0.95	0.95	0.95	0.95	0.95	0.95	
% He	eavy Vehicles 10 1 (0	0	1	L	1	1	1	0	0	1	10			
Lane	Groups		L	TR			L	Т		R	L	TR		L	Т	R
Arriv	al Type		3	3			3	3		3	3	3		3	3	3
RTO	R Vol (vph)			5)			5			60	
Peds/	Hour			5			0					0			5	
% Gr	ade			0				0)			0			0	
Buses	s/Hour			0				0				0			0	
Parke	rs/Hour (Le	ft Right)														
Signa	l Settings: A	Actuated		Opera	ational A	Analys	is	Cy	ycle I	Length:	80.0 Sec	:	Lost Tin	ne Per Cy	cle: 18.0	Sec
Phase	:	1		2		3	4			5	6		7	8		Ped Only
EB		L		LTP												
WB		L		LTR		R										
NB							LT	P								
SB		R				TP										
Green	1	13.0		14.0		3.0	12	.0								0
Yello	w All Red	3.0	0.0 3.	5 1.5	3.5	1.5	3.5	1.5								

			Conor	city Analysis R	aculte				Approa	oh:
	_	_	•							CII.
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay	1.00	Delay	1.00
App	Group	(vph)	Ratio		Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB	Lper	172	0.024	0.237					28.5	C
	* Lpro	267	0.163	0.162	L	0.647	20.3	С		
	* TR	618	0.122	0.175	TR	0.699	34.0	C		
WB	Lper	112	0.000	0.237					19.3	В
	Lpro	293	0.020	0.162	L	0.091	15.3	В		
	Т	625	0.074	0.175	T	0.421	29.6	С		
	R	839	0.323	0.525	R	0.615	14.3	В		
NB										
	L	268	0.015	0.150	L	0.097	29.4	C	33.0	C
	* TR	274	0.087	0.150	TR	0.577	33.6	С		
SB										
	* L	1007	0.225	0.287	L	0.784	30.0	С	25.4	С
	T	541	0.089	0.287	Т	0.311	22.4	C		
	R	714	0.165	0.488	R	0.339	12.7	В		

Intersection: Delay = 24.9 sec/veh SIG/Cinema v3.08

Int. LOS=C

* Critical Lane Group

 \geq (v/s)Crit= 0.60

Year 2035 Mary Op1 Alternate R Marvin Peak PM Hour

Old Hardin Road/Johnson Lane

10/20/11

Case: Old Hardin Johnson 2035 PM 102011

App EB	Lane Group L TR	Queues Per Lane Avg/Max (veh) 6 / 10 4 / 6	Average Speed (mph) 8.6 10.5	Spillback in Worst Lane (% of Peak Period) 0.0 0.0	160 290 750
	All		9.8	0.0	←
WB	L	1 / 2	7.4	0.0	
	Т	2 / 4	13.2	0.0	
	R	2/3	21.2	0.0	270 -
	All		15.7	0.0	380 →
NB	L	1 / 3	8.0	0.0	35 —
	TR	2 / 4	10.7	0.0	
					$\begin{array}{ c c c c c c c c c c c c c c c c c c c$
	All		10.2	0.0	
SB	L	6/9	9.9	0.0	$egin{array}{c ccccccccccccccccccccccccccccccccccc$
	T	3 / 5	10.0	0.0	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
	R	2/3	22.0	0.0	13 3 0 13 4 2 22 4 2 11
	All		11.5	0.0	
	Inte	rsect.	11.8		

Old Hardin Road & Johnson Lane Year 2035 PM Hour Roundabout

Lane Use	and Pe	erform	ance													
		Deman	d Flows		HV	Сар.	Deg.	Lane	Average	Level of	95% Back		Lane	SL	Сар.	
	L veh/h	veh/h	R veh/h	Total veh/h	%	veh/h	Satn v/c	Util. %	Delay sec	Service	Vehicles veh	Distance ft	Length ft	Type	Adj. %	Block. %
South: John			VCII/II	VC11/11	/0	VCII/II	V/C	/0	300		VCII	- 10	- 10		/0	70
Lane 1	27	130	38	196	8.0	285	0.687	100	31.5	LOS C	5.1	128.1	1600	_	0.0	0.0
Approach	27	130	38	196	8.0		0.687		31.5	LOS C	5.1	128.1				
East: Old H	ardin W	B														
Lane 1	38	272	0	310	0.0	788	0.393	100	6.0	LOS A	2.6	65.7	1600	_	0.0	0.0
Lane 2	0	0	620	620	0.0	1610	0.385	100	2.4	Х	X	Х	1600		0.0	X
Approach	38	272	620	929	0.0		0.393		3.6	LOS A	2.6	65.7				
North: John	son SB															
Lane 1	821	0	0	821	0.0	1150	0.714	100	12.6	LOS B	9.0	224.4	1600	_	0.0	0.0
Lane 2	0	174	315	489	4.2	882	0.555	100	6.3	LOS A	4.7	121.8	1600	_	0.0	0.0
Approach	821	174	315	1310	1.6		0.714		10.2	LOS B	9.0	224.4				
West: Old F	lardin E	В														
Lane 1	293	47	0	341	5.2	474	0.719	100	20.3	LOS C	5.8	152.0	1600	-	0.0	0.0
Lane 2	0	366	38	404	0.1	562	0.719	100	13.0	LOS B	6.3	157.9	1600	_	0.0	0.0
Approach	293	413	38	745	2.4		0.719		16.3	LOS B	6.3	157.9				
Intersection				3179	1.3		0.719		11.0	LOS B	9.0	224.4				

X: Not applicable for Continuous lane.

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Monday, October 31, 2011 3:01:47 PM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Johnson & Mary Add Concepts July 2011\Johnson Lane\Capacity 102011\Old Hardin Johnson Mary Op1 PM 2035.sip

8001325, MARVIN & ASSOCIATES, SINGLE



Becraft Connection & Old Hardin

R Marvin
Year 2035 PM

Old Hardin Road/Becraft ConnectArea Type: Non CBD

10/21/2011
Analysis Duration: 15 mins.
Case: Becraft Connection Old Hardin 2035 PM

	ar 2035 P	M					e: Becra	ft Conn	ection C	old Hard	in 2035	PM	11. 131	111115.
	Lanes				Geo	metry: Mo	ovements	Serviced b	y Lane ar	nd Lane W	idths (fe	eet)		
	Approach	Outbound	La	ine 1	La	ne 2	La	ne 3	Laı	ne 4	La	ne 5	La	ne 6
EB	2	1	L	12.0	TR	12.0								
WB	2	1	L	12.0	TR	12.0								
NB	1	1	LTR	12.0										
SB	1	1	LTR	12.0										
				East			West			North			South	
	Data		L	Т	R	L	Т	R	L	Т	R	L	Т	R
Move	ment Volur	ne (vph)	10	550	10	10	590	10	190	10	10	10	10	10
PHF			0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
% He	avy Vehicle	es	0	0	0	0	0	0	0	0	0	0	0	0
Lane	Groups		L	TR		L	TR			LTR			LTR	
Arriva	al Type		3	3		3	3			3			3	
RTOI	R Vol (vph)			0			0			0			0	
Peds/	Hour			5			5			5			5	
% Gra	ade			0			0			0			0	
Buses	/Hour			0			0			0			0	
Parke	rs/Hour (Le	eft Right)												
Signa	1 Settings: A	Actuated		Operati	onal Analy	ysis	Cycle	e Length:	80.0 Sec	2	Lost Tim	e Per Cyc	le: 10.0 S	ec
Phase	:	1		2	3	4		5	6		7	8	Pe	d Only
EB		LTP												
WB		LTP												
NB				LTP										
SB				LTP										
Green	1	50.0		20.0										0
Yello	w All Red	3.5	1.5 3.	5 1.5										

			Approa	ch:						
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
EB										
	L	376	0.018	0.625	L	0.029	5.9	A	9.8	A
	TR	1184	0.321	0.625	TR	0.514	9.9	A		
WB										
	L	408	0.017	0.625	L	0.027	5.8	A	10.3	В
	* TR	1184	0.344	0.625	TR	0.551	10.4	В		
NB										
	* LTR	338	0.169	0.250	LTR	0.678	31.5	С	31.5	С
SB										
	LTR	402	0.021	0.250	LTR	0.082	23.0	C	23.0	С

Intersection: Delay = $13.5 \,\text{sec/veh}$ Int. LOS=B $X_c = 0.59$ * Critical Lane Group $\Sigma (\text{v/s})$ Crit = $0.51 \,\text{SIG/Cinema v3.08}$ Marvin & Associates Page 1

Becraft Connection & Old Hardin R Marvin Year 2035 PM Old Hardin Road/Becraft Connect

10/21/2011

Case: Becraft Connection Old Hardin 2035 PM

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	10 10 10 •
EB	L	0 / 1	9.4	0.0	←
	TR	6 / 7	17.2	0.0	10 ← 10
					590
	All		17.1	0.0	
WB	L	0 / 1	9.8	0.0	
	TR	6 / 7	17.5	0.0	10 -
					$ \begin{array}{ccc} 10 & \longrightarrow \\ 550 & \longrightarrow \\ \end{array} $
	All		17.3	0.0	10 —
NB	LTR	3 / 4	10.2	0.0	
					190 10
	All		10.2	0.0	
					1 2 11
SB	LTR	1 / 1	11.0	0.0	
					49 4 2 19 1 4 2
	All		11.0	0.0	
	Inte	rsect.	15.5		

Becraft & Old Hardin Road Year 2035 PM Roundabout

Lane Use	and Pe	rform	ance													
	[Deman	d Flows		1.157	0	Deg.	Lane	Average	Level of	95% Back	of Queue	Lane	SL	Cap. F	
	L veh/h	T veh/h	R veh/h	Total veh/h	HV %	Cap.	Satn v/c	Util. %	Delay sec	Service	Vehicles veh	Distance ft	Length ft	Type	Adj. E %	Block. %
South: Bec					, ,										,,	
Lane 1	207	0	11	217	0.0	699	0.311	100	13.0	LOS B	1.8	44.8	1600		0.0	0.0
Approach	207	0	11	217	0.0		0.311		13.0	LOS B	1.8	44.8				
East: Old H	lardin WE	3														
Lane 1	11	652	0	663	0.0	1032	0.643	100	4.4	LOS A	6.3	158.7	1600	_	0.0	0.0
Approach	11	652	0	663	0.0		0.643		4.4	LOS A	6.3	158.7				
West: Old H	Hardin El	3														
Lane 1	0	609	0	609	0.0	1504	0.405	100	1.9	LOS A	3.4	84.9	1600	-	0.0	0.0
Lane 2	0	0	620	620	0.0	1405	0.441	100	2.8	LOS A	3.9	97.0	250	-	0.0	0.0
Approach	0	609	620	1228	0.0		0.441		2.3	LOS A	3.9	97.0				
Intersection	1			2109	0.0		0.643		4.1	LOS A	6.3	158.7				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Monday, October 31, 2011 2:54:40 PM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Johnson & Mary Add Concepts July 2011\Johnson Lane\Capacity 102011\Becraft Old Hardin 2035 PM.sip

8001325, MARVIN & ASSOCIATES, SINGLE



LANE SUMMARY

Site: Johnson Lane & WB Ramps Year 2035 PM

Johnson Lane & Westbound Ramps Year 2035 PM Roundabout

Lane Use	and Pe	erform	ance													
		Deman	d Flows		1.15.7		Deg.	Lane	Average	Level of	95% Back	of Queue	Lane	SL	Cap.	Prob.
	L	Τ	R	Total	HV	Cap.	Satn	Util.	Delay	Service	Vehicles	Distance	Length	Type		Block.
	veh/h		veh/h	veh/h	%	veh/h	v/c	%	sec		veh	ft	ft		%	%
South: John	nson NE	3														
Lane 1	250	351	0	601	4.0	1453	0.414	100	3.7	LOS A	0.0	0.0	1600	_	0.0	0.0
Lane 2	0	681	0	681	4.0	1647	0.414	100	0.7	LOS A	0.0	0.0	1600	_	0.0	0.0
Approach	250	1033	0	1283	4.0		0.414		2.1	LOS A	0.0	0.0				
East: WB C	off Ramp)														
Lane 1	190	1	217	409	4.5	538	0.759	100	19.1	LOS B	5.5	143.4	1600	_	0.0	0.0
Approach	190	1	217	409	4.5		0.759		19.1	LOS B	5.5	143.4				
North: John	son SB															
Lane 1	0	337	0	337	4.0	901	0.374	100	3.8	LOS A	2.4	63.0	1600	_	0.0	0.0
Lane 2	0	397	1	398	4.0	1064	0.374	100	3.3	LOS A	2.6	66.2	1600	_	0.0	0.0
Approach	0	734	1	735	4.0		0.374		3.5	LOS A	2.6	66.2				
Intersection	n			2426	4.1		0.759		5.4	LOS A	5.5	143.4				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Tuesday, December 20, 2011 2:15:30 PM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Traffic Study\Capacity\Calculations\Johnson Int Design Cap\WB Ramps Johnson Mary Opt1PM 2035.sip 8001325, MARVIN & ASSOCIATES, SINGLE



Johnson Lane & Eaastbound Ramps Year 2035 PM Roundabout

Lane Use	and Pe	rform	ance													
	L	Т	d Flows R veh/h	Total veh/h	HV %	Cap.	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back Vehicles veh	of Queue Distance ft	Lane Length ft	SL Type	Cap. Adj. %	Prob. Block. %
South: John	son NB															
Lane 1	0	462	0	462	4.0	594	0.779	100	20.7	LOS C	10.5	270.9	1600	_	0.0	0.0
Lane 2	0	331	250	581	4.4	746	0.779	100	18.6	LOS B	11.9	307.2	600		0.0	0.0
Approach	0	793	250	1043	4.2		0.779		19.5	LOS B	11.9	307.2				
North: SB J	ohnson															
Lane 1	304	117	0	422	4.7	1498	0.281	100	5.9	LOS A	0.0	0.0	1600	_	0.0	0.0
Lane 2	0	502	0	502	4.0	1785	0.281	100	0.8	LOS A	0.0	0.0	1600	_	0.0	0.0
Approach	304	620	0	924	4.3		0.281		3.1	LOS A	0.0	0.0				
West: I90 E	B Off Ra	amp														
Lane 1	489	5	0	495	4.0	814	0.607	100	13.9	LOS B	3.8	98.9	1600	_	0.0	0.0
Lane 2	0	0	5	5	4.0	432	0.013	100	8.0	LOS A	0.0	1.0	1600	_	0.0	0.0
Approach	489	5	5	500	4.0		0.607		13.8	LOS B	3.8	98.9				
Intersection				2467	4.2		0.779		12.2	LOS B	11.9	307.2				

Level of Service (LOS) Method: Delay (HCM 2000).

 $\label{lem:condition} \mbox{Roundabout LOS Method: Same as Signalised Intersections.}$

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Monday, October 31, 2011 3:05:50 PM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Johnson & Mary Add Concepts July 2011\Johnson Lane\Capacity 102011\EB Ramps Johnson Mary Opt1PM 2035.sip

8001325, MARVIN & ASSOCIATES, SINGLE



LANE SUMMARY

Site: North Frontage Road & Johnson Lane Year 2035 PM

N Frontage Johnson Lane Year 2035 PM Roundabout

Lane Use	and Pe	rform	ance													
		Deman	d Flows		HV	Can	Deg.	Lane	Average	Level of	95% Back		Lane	SL	Cap. F	
	L veh/h	veh/h	R veh/h	Total veh/h	пv %	Cap.	Satn v/c	Util. %	Delay sec	Service	Vehicles veh	Distance ft	Length ft	Type	Adj. E %	Block. %
South: John		V 011/11	VO11//11	V 011/11	70	V 011/11	•,, 0	70	000		7011				70	70
Lane 1	207	385	0	591	4.3	1075	0.550	100	6.0	LOS A	4.8	124.2	1600	_	0.0	0.0
Lane 2	0	626	33	659	4.0	1198	0.550	100	3.6	LOS A	4.9	127.4	1600	_	0.0	0.0
Approach	207	1011	33	1250	4.1		0.550		4.7	LOS A	4.9	127.4				
East: N From	ntage W	B														
Lane 1	27	22	5	54	1.0	369	0.147	100	11.9	LOS B	0.6	15.5	1600		0.0	0.0
Approach	27	22	5	54	1.0		0.147		11.9	LOS B	0.6	15.5				
North: John	son SB															
Lane 1	5	411	0	417	4.0	1033	0.404	100	3.9	LOS A	2.8	72.3	1600	_	0.0	0.0
Lane 2	0	350	109	458	4.0	1135	0.404	100	3.9	LOS A	2.9	73.9	1600	_	0.0	0.0
Approach	5	761	109	875	4.0		0.404		3.9	LOS A	2.9	73.9				
West: N Fro	ntage E	В														
Lane 1	168	33	228	429	4.3	532	0.807	100	18.0	LOS B	7.0	180.6	1600	_	0.0	0.0
Approach	168	33	228	429	4.3		0.807		18.0	LOS B	7.0	180.6				
Intersection				2609	4.0		0.807		6.8	LOS A	7.0	180.6				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Monday, October 31, 2011 3:14:30 PM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Johnson & Mary Add Concepts July 2011\Johnson Lane\Capacity 102011\N Frtg Johnson 2035 PM.sip 8001325, MARVIN & ASSOCIATES, SINGLE



Year 2035 Mary Op1 Alt

N Frontage Rd/Johnson Lane

Area Type: Non CBD

R Marvin

10/20/11

Analysis Duration: 15 mins.

Peak PM

Case: N Ertg Johnson Mary Op1 2035 PM

Pea	ık PM							Case	e: N F	rtg	Johnso	n Mary	Op1 20	35 PM	Dura	om	. 151	
	Lanes						Geom	etry: Mo	ovemen	ts Se	erviced b	y Lane ar	nd Lane W	idths (f	eet)			
	Approach	Outbound	I	ane	: 1		Lan	e 2]	Lane	e 3	Laı	ne 4	La	ne 5		Lar	ne 6
EB	2	1	L		12.0	Т	R	12.0										
WB	2	1	L		12.0	Т	R	12.0										
NB	3	2	L		12.0	-	Γ	12.0	TR		12.0							
SB	3	2	L		12.0	-	Γ	12.0	TR		12.0							
					East				Wes	t			North				South	
	Data		L		Т	I	3	L	Т		R	L	T	R	L		Т	R
Move	ement Volur	ne (vph)	155		25	2	10	25	20)	5	190	930	30	5	5	700	100
PHF			0.92		0.92	0.	92	0.92	0.92	2	0.92	0.92	0.92	0.92	0.92	2	0.92	0.92
% Не	avy Vehicle	es	4		2		8	2	2		2	8	4	2	2	2	4	2
Lane	Groups		L		TR			L	TR			L	TR		L		TR	
Arriv	al Type		3		3			3	3			3	3		3		3	
RTO	R Vol (vph)				40				0				5				30	
Peds/	Hour				0				5				5				0	
% Gr	ade				0				0				0				0	
Buse	s/Hour				0				0				0				0	
Parke	rs/Hour (Le	eft Right)																
Signa	l Settings: A	Actuated		(Operat	ional A	Analys	is	Су	cle I	Length:	80.0 Sec	2	Lost Tin	ne Per C	Cycle:	8.0 S	ec
Phase) :	1		2	,	3	3	4			5	6		7	8		Pe	d Only
EB		LTP																
WB		LTP																
NB				LT	'n	L	ГР											
SB						L	ГР											
Green	1	24.0		12	0.0	30	5.0											0
Yello	w All Red	0.0	0.0 3	3.0	0.0	3.5	1.5											

					. 1.				_	,
			Capac	city Analysis R	lesults		T		Approa	ch:
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay	
App	Group	(vpĥ)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB										
	L	389	0.130	0.300	L	0.432	22.8	C	22.9	C
	* TR	463	0.137	0.300	TR	0.458	23.0	C		
WB										
	L	241	0.034	0.300	L	0.112	20.4	С	20.1	C
	TR	543	0.015	0.300	TR	0.050	19.9	В		
NB	Lper	198	0.000	0.512					8.6	A
	* Lpro	251	0.124	0.150	L	0.461	10.5	В		
	TR	2204	0.300	0.637	TR	0.471	8.2	A		
SB										
	L	231	0.010	0.450	L	0.022	12.4	В	17.4	В
	* TR	1541	0.244	0.450	TR	0.543	17.4	В		

Intersection: Delay = 13.9 sec/veh SIG/Cinema v3.08

Int. LOS=B X

* Critical Lane Group

 \sum (v/s)Crit= 0.51

Marvin & Associates

Page 1

Year 2035 Mary Op1 Alt R Marvin Peak PM N Frontage Rd/Johnson Lane 10/20/11 Case: N Frtg Johnson Mary Op1 2035 PM

App EB	Lane Group L TR	Queues Per Lane Avg/Max (veh) 4 / 6 2 / 4	Average Speed (mph) 6.3 20.8	Spillback in Worst Lane (% of Peak Period) 0.0	700 100 5 - 5
	All		13.2	0.0	$\begin{array}{c c} & & & & & & & & & & & & & & & & & & &$
WB	L	0 / 1	6.9	0.0	<u> </u>
	TR	1 / 1	15.1	0.0	
					$\begin{array}{c c} 155 & \longrightarrow \\ 25 & \longrightarrow \\ \end{array}$
	All		12.2	0.0	
NB	L	3 / 5	9.0	0.0	
	TR	5 / 7	17.4	0.0	
					190 30 930
	All		15.6	0.0	
SB	L	0 / 1	19.7	0.0	
	TR	5 / 7	14.2	0.0	
					24 0 0 12 3 0 35 4 2
	All		14.3	0.0	
	Inte	rsect.	14.6		

Johnson SPUI Mary Op1 2035 EB Off Ramp/Johnson Lane Area Type: Non CBD

R Marvin 10/20/11 Analysis Duration: 15 mins.

PM Case: Johnson SPUI Mary Op1 2035 PM

PM	arvin [:0/11 e: Johns	on SPU	I Mary (Op1 203	maiysis 5 PM	Duratio	n: 151	mins.
	Lanes						Geon	netry: Mo	vements	Serviced b	y Lane ar	nd Lane W	/idths (fe	eet)		
	Approach	Outbour	ıd	Lan	e 1		Lan	e 2	La	ine 3	La	ne 4	La	ne 5	La	ne 6
EB	1	1		L	12.0											
WB	1	1		L	12.0											
NB	3	2		L	12.0	-	Г	12.0	Т	12.0						
SB	3	2		L	12.0	-	Г	12.0	Т	12.0						
					East	•			West			North			South	
	Data			L	Т]	R	L	Т	R	L	Т	R	L	Т	R
Move	ment Volui	me (vph)) 4	450	0		0	175	0	0	230	500	0	280	395	0
PHF			0	0.92	0.90	0.	90	0.92	0.90	0.90	0.92	0.92	0.90	0.92	0.92	0.90
% He	% Heavy Vehicles			4	2		2	4	2	2	2	2	2	4	2	2
Lane	Lane Groups			L				L			L	Т		L	Т	
Arriv	al Type			3				3			3	3		3	3	
RTO	R Vol (vph)	l		0				0			0			0		
Peds/	Hour				0				0			0		0		
% Gr	ade				0				0			0			0	
Buses	s/Hour				0				0			0			0	
Parke	rs/Hour (Le	eft Right)													
Signa	l Settings: A	Actuated			Operat	ional A	Analys	sis	Cycl	e Length:	80.0 Sec	2	Lost Tim	e Per Cyc	le: 13.0 S	ec
Phase	:	1		2	2		3	4		5	6		7	8	Pe	d Only
EB		L														
WB		L														
NB				L		L										
SB				L		L										
Green		30			9.0	3.5	8.0									0
Yello	w All Red	3.5	1.5				1.5									

			Capac	ity Analysis R	lesults				Approa	ch:
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
EB					_					
	* L	651	0.282	0.375	L	0.751	26.1	C	26.1	C
WB										
	L	651	0.109	0.375	L	0.292	17.6	В	17.6	В
NB	Lper	165	0.000	0.287					26.9	C
	Lpro	420	0.141	0.237	L	0.427	13.5	В		
	* T	796	0.153	0.225	T	0.682	33.1	С		
SB	Lper	116	0.000	0.287					24.5	С
	* Lpro	412	0.175	0.237	L	0.576	16.8	В		
	T	796	0.121	0.225	T	0.539	30.0	С		

Intersection: Delay = 25.1 sec/veh SIG/Cinema v3.08

Int. LOS=C

 $X_c = 0.73$ * Critical Lane Group

 $\sum (v/s)$ Crit= 0.61

Marvin & Associates

Johnson SPUI Mary Op1 2035 R Marvin PM EB Off Ramp/Johnson Lane

10/20/11

Case: Johnson SPUI Mary Op1 2035 PM

App EB	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	395
	All		10.7	0.0	175
WB	L	3 / 3	12.5	0.0	
					450 -
	All		12.5	0.0	
NB	L	3 / 7	9.5	0.0	
	Т	5 / 8	11.2	0.0	
					230 500
	All		10.8	0.0	
SB	L	4 / 7	8.7	0.0	1 2 3 1
	T	4 / 7	12.5	0.0	
					29 4 2 19 3 0 17 4 2
	All		11.5	0.0	
	Inte	rsect.	11.1		

Johnson Lane SPUI Roundabout 2035 PM Roundabout

Lane Use	Lane Use and Performance															
		Deman	d Flows				Deg.	Lane	Average	Level of	95% Back	of Queue	Lane	SL	Cap. F	Prob.
	L	Т	R	Total	HV	Cap.	Satn	Util.	Delay	Service	Vehicles	Distance	Length	Type	Adj. E	Block.
	veh/h	veh/h	veh/h	veh/h	%	veh/h	v/c	%	sec		veh	ft	ft		%	%
South: John	son NB	3														
Lane 1	250	86	0	336	4.7	608	0.553	100	14.6	LOS B	5.1	133.2	600	_	0.0	0.0
Lane 2	0	457	5	463	4.0	837	0.553	100	7.6	LOS A	5.8	150.7	600	_	0.0	0.0
Approach	250	543	5	799	4.3		0.553		10.5	LOS B	5.8	150.7				
North East:	WB Off	Ramp														
Lane 1	191	0	0	191	5.0	427	0.449	100	15.8	LOS B	2.8	71.6	600	-	0.0	0.0
Lane 2	0	0	217	217	5.0	538	0.404	100	9.3	LOS A	2.6	67.9	600	_	0.0	0.0
Approach	191	0	217	409	5.0		0.449		12.3	LOS B	2.8	71.6				
North: John	son SB															
Lane 1	304	0	0	304	5.0	918	0.331	100	8.9	LOS A	2.2	57.0	600	_	0.0	0.0
Lane 2	0	462	5	467	4.0	1198	0.390	100	2.3	LOS A	2.9	75.8	600	_	0.0	0.0
Approach	304	462	5	772	4.4		0.390		4.9	LOS A	2.9	75.8				
South West	: EB Off	f Ramp														
Lane 1	490	0	12	502	4.9	562	0.893	100	25.5	LOS C	10.7	278.2	600	_	0.0	0.0
Approach	490	0	12	502	4.9		0.893		25.5	LOS C	10.7	278.2				
Intersection				2482	4.6		0.893		12.1	LOS B	10.7	278.2				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Tuesday, November 01, 2011 12:22:25 PM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Johnson & Mary Add Concepts July 2011\Johnson Lane\Capacity 102011\Johnson RA SPUI 2035

8001325, MARVIN & ASSOCIATES, SINGLE



			FREEWA	Y WEAV	ING WOR	KSHEE	T		
Genera	l Informat	tion			Site Info	rmation			
Analyst Agency/Coi Date Perfor Analysis Tir	med	R Ma Marvi 8/4/20 PM	n & Associates	6	Freeway/Dir of Weaving Seg Jurisdiction Analysis Yea	Location	Southbound EB Off Ramp to Old Hardin Ro Billings 2035		
Inputs					•				
Weaving nu Weaving se Terrain	ee-flow speed, umber of lanes, eg length, L (ft)	, N	35 4 500 Lev	el	Weaving type Volume ratio, Weaving ratio	VR		A 2.0 3.0	
Conver	sions to p	oc/h Unde	T	ondition			_		•
(pc/h)	V	PHF	Truck %	RV %	E _T	E _R	f_{HV}	fp	V
V _{o1}	360	0.92	1	1	1.5	1.2	0.993	1.00	394
V_{o2}	237	0.92	5	1	1.5	1.2	0.974	1.00	264
V_{w1}	388	0.92	1	0	1.5	1.2	0.995	1.00	423
V_{w2}	220	0.92	1	0	1.5	1.2	0.995	1.00	240
V _w		•	•	663	V_{nw}		•	•	658
V						l			1321
Weavin	g and No	n-Weavir	g Speeds	5					
			Unconstr					trained	
- /E. I. II. II. O	4.7	Weaving	j (i = w)	Non-Wea	ving (i = nw)		ng (i = w)	1	ving (= nw)
a (Exhibit 2 b (Exhibit 2		 		-			35 20		020 00
c (Exhibit 2				<u> </u>			97	<u> </u>	30
d (Exhibit 2							80	\	75
Weaving intens						1.	65	0.	18
Weaving and n speeds, Si (mi/	on-weaving h)					24	.44	36	.17
Maximum n	lanes required number of lanes If Nw < Nw	s, Nw (max)	·		1.94 1.40	if Nw > N	v (max) const	rained operati	on
					f Service,	and Cap	acity		
	egment speed,			29.15					
	egment density	, D (pc/mi/ln)		11.33					
Level of ser				В					
	base condition	~		5440					
	s a 15-minute fl	-		5402					
Capacity as	s a full-hour vol	ume, c _h (veh/l	h)	4970					
Notes									

a. Weaving segments longer than 2500 ft. are treated as isolated merge and diverge areas using the procedures of Chapter 25, "Ramps and Ramp

Copyright © 2008 University of Florida, All Rights Reserved

HCS+TM Version 5.4

Generated: 8/4/2011 11:24 AM

b. Capacity constrained by basic freeway capacity.

c. Capacity occurs under constrained operating conditions.
d. Three-lane Type A segments do not operate well at volume ratios greater than 0.45. Poor operations and some local queuing are expected in

e. Four-lane Type A segments do not operate well at volume ratios greater than 0.35. Poor operations and some local queuing are expected in

f. Capacity constrained by maximum allowable weaving flow rate: 2,800 pc/h (Type A), 4,000 (Type B), 3,500 (Type C). g. Five-lane Type A segments do not operate well at volume ratios greater than 0.20. Poor operations and some local queuing are expected in such

h. Type B weaving segments do not operate well at volume ratios greater than 0.80. Poor operations and some local queuing are expected in such

i. Type C weaving segments do not operate well at volume ratios greater than 0.50. Poor operations and some local queuing are expected in such

Double Cross Johnson Mary Op1

R Marvin

PM Hour YR 2035

EB Ramp Right/Johnson

Area Type: Non CBD

09/08/2011

Analysis Duration: 15 mins.

Case: Double Cross EB Ramp Johnson Mary Op1 2035 PM

PM	Hour YF	R 2035					Case: Double Cross EB Ramp Johnson Mary Op1 2035 PM										
	Lanes						Geom	etry: Mo	vement	ts Ser	viced b	y Lane ar	nd Lane V	Vidths (f	eet)		
	Approach (Outbound	I	ane	: 1		Lan	e 2	I	Lane	3	Laı	ne 4	La	ne 5	L	ane 6
EB	2	0	R		12.0	F	2	12.0									
WB	2	0	R		12.0	F	۲	12.0									
NB	2	2	Т		12.0	7	Γ	12.0									
SB	2	2	Т		12.0	7	Г	12.0									
					East				West	t			North			South	
	Data		L		Т	F	۲ .	L	Т		R	L	Т	R	L	Т	R
Move	ement Volun	ne (vph)	0		0	6.	30	0	0		450	0	730	0	0	230	0
PHF			0.90		0.90	0.9	92	0.90	0.90		0.92	0.90	0.92	0.90	0.90	0.92	0.90
% He	% Heavy Vehicles				2		5	2	2		5	2	4	2	2	4	2
Lane Groups						F	۲ ا				R		Т			Т	
Arriv	al Type					3	3				3		4			4	
RTO	R Vol (vph)				100				80				0			0	
Peds/	Hour			0						0			5			5	
% Gr	ade				0				0				0			0	
Buses	s/Hour				0				0	0			0			0	
Parke	ers/Hour (Le	ft Right)															
Signa	al Settings: A	Actuated		(Operati	onal A	nalys	sis	Сус	cle L	ength:	80.0 Sec	2	Lost Tin	ne Per Cy	cle: 10.0	Sec
Phase	e:	1		2	2	3	3	4			5	6		7	8	F	Ped Only
EB		P															
WB	VB P																
NB	NB T																
SB				T													
Greei		37.0		33				ļ.,			T						0
Yellow All Red 3.5 1.5			3.5	1.5													

			Comme	: A1:- D	14 .				A	-1
		I	Capac	city Analysis R	esuits				Approa	CII:
	Lane	Cap (vph)	v/s	g/C Ratio	Lane	v/c	Delay (sec/veh)		Delay (sec/veh)	
App	Group	(vph)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB										
	R	1252	0.213	0.463	R	0.460	15.9	В	15.9	В
WB										
	* R	1117	0.149	0.412	R	0.360	17.1	В	17.1	В
NB										
	* T	1605	0.228	0.463	T	0.494	13.4	В	13.4	В
SB										
	T	1432	0.072	0.412	T	0.175	13.4	В	13.4	В

Intersection: Delay = 14.8 sec/veh SIG/Cinema v3.08

Int. LOS=B

= 0.43 * Critical Lane Group

 \sum (v/s)Crit= 0.38

Marvin & Associates

Page 1

Double Cross Johnson Mary Op1 R Marvin PM Hour YR 2035 EB Ramp Right/Johnson 09/08/2011

Case: Double Cross EB Ramp Johnson Mary Op1 2035 PM

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	230
					1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
EB	R	3 / 4	19.2	0.0	
	All		19.2	0.0	_
					- -
WB	R	3 / 5	15.3	0.0	
	All		15.3	0.0	630 —
NB	Т	2/3	17.6	0.0	
					730
	All		17.6	0.0	/30
					$egin{array}{c ccccccccccccccccccccccccccccccccccc$
SB	Т	0 / 0	25.9	0.0	1 2 1 1
	_				36 4 2 32 4 2
	All		25.9	0.0	
	Inte	rsect.	18.1		

Double Cross Johnson Mary Op1 WB Ramp Left/Johnson Area Type: Non CBD R Marvin 09/08/2011 Analysis Duration: 15 mins. PM Hour YR 2035 Case: Double Cross WB Ramp Johnson Mary Op1 2035 PM

	Hour YF	R 2035					Case	e: Doub	le Cross	WB Ra			lary Op1		
	Lanes					Geo	metry: Mo	vements	Serviced b	y Lane ar	nd Lane W	idths (f	feet)		
	Approach (Outbour	ıd	Lane	e 1	La	me 2	La	ine 3	La	ne 4	La	ane 5	La	ne 6
EB	2	0		R	12.0	R	12.0								
WB	2	0		R	12.0	R	12.0								
NB	2	2		Т	12.0	Т	12.0								
SB	2	2		Т	12.0	Т	12.0								
					East			West			North			South	
	Data			L	T	R	L	Т	R	L	Т	R	L	Т	R
Move	ement Volun	ne (vph))	0	0	175	0	0	200	0	950	0	0	675	0
PHF			0	0.90	0.90	0.92	0.90	0.90	0.92	0.90	0.92	0.90	0.90	0.92	0.90
% He	% Heavy Vehicles			2	2	5	2	2	5	2	4	2	2	4	2
Lane	Lane Groups					R			R		Т			Т	
Arriv	al Type					3			3		4			4	
RTO	R Vol (vph)				30			25			0			0	
Peds/	Hour				0			0			5			5	
% Gr	ade				0			0			0			0	
Buses	s/Hour				0			0			0			0	
Parke	ers/Hour (Le	ft Right)												
Signa	d Settings: A	Actuated			Operati	ional Anal	ysis	Cycl	e Length:	80.0 Sec	2	Lost Tin	ne Per Cyc	le: 10.0 S	ec
Phase	:	1		2	2	3	4	-	5	6		7	8	Pe	d Only
EB		I	•												
WB	В														
NB	В Т														
SB				7	Γ										
Greei	n	37	.0		3.0										0
Yello	w All Red	3.5	1.5 3.5 1.5												

			Conor	city Analysis R	oculte				Approa	oh:
										CII.
	Lane	Cap (vph)	v/s	g/C Ratio	Lane	v/c	Delay (sec/veh)		Delay (sec/veh)	
App	Group	(vph)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB										
	R	1252	0.058	0.463	R	0.126	12.5	В	12.5	В
WB										
	R	1117	0.070	0.412	R	0.170	15.2	В	15.2	В
NB										
	* T	1605	0.298	0.463	Т	0.644	15.5	В	15.5	В
SB			-			-				
	* T	1432	0.211	0.412	T	0.513	16.7	В	16.7	В

Intersection: Delay = 15.7 sec/veh SIG/Cinema v3.08

Int. LOS=B

= 0.58 * Critical Lane Group

 \geq (v/s)Crit= 0.51

Marvin & Associates

Page 1

Double Cross Johnson Mary Op1 R Marvin PM Hour YR 2035 WB Ramp Left/Johnson 09/08/2011

Case: Double Cross WB Ramp Johnson Mary Op1 2 35 PM

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	675
					1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
EB	R	1 / 2	17.4	0.0	
	All		17.4	0.0	_
					-
					- -
WB	R	1 / 2	15.4	0.0	
	All		15.4	0.0	
NB	Т	5 / 7	13.3	0.0	
					950
	All		13.3	0.0	
					$egin{array}{c ccccccccccccccccccccccccccccccccccc$
SB	Т	2 / 4	17.3	0.0	, 4
					36 4 2 32 4 2
	All		17.3	0.0	
	Inte	rsect.	14.9		

HCM Analysis Summary

Double Cross Adjacent RA Mary OP1

R Marvin
PM Hour YR 2035

EB Ramp Right/Johnson
O9/08/2011
Analysis Duration: 15 mins.
Case: Double Cross EB Ramp Johns Adjacent RA 2035 PM

	Hour YF	R 2035						e: Doub	le Cross	EB Ran			ent RA		
	Lanes					Geor	netry: Mo	vements	Serviced b	y Lane ar	nd Lane W	/idths (fe	eet)		
	Approach (Outbound	I	ane	1		ne 2		ne 3	Ĭ	ne 4		ne 5	Lai	ne 6
EB	2	0	R		12.0	R	12.0								
WB	2	0	R		12.0	R	12.0								
NB	2	2	T		12.0	Т	12.0								
SB	2	2	Т		12.0	Т	12.0								
		East West North					South								
	Data		L		T	R	L	Т	R	L	Т	R	L	Т	R
Move	ment Volun	ne (vph)	0		0	630	0	0	450	0	730	0	0	230	0
PHF			0.90		0.90	0.92	0.90	0.90	0.92	0.90	0.92	0.90	0.90	0.92	0.90
% He	% Heavy Vehicles		2		2	5	2	2	5	2	4	2	2	4	2
Lane	Groups					R			R		T			T	
Arriv	al Type					3			3		3			3	
RTOI	R Vol (vph)				100			100			0			0	
Peds/	Hour				0			0			5			5	
% Gr	ade				0			0			0			0	
Buses	s/Hour				0			0			0			0	
Parke	rs/Hour (Le	ft Right)		-											
Signa	l Settings: A	Actuated		О	peratio	nal Analy	sis	Cycle	e Length:	50.0 Sec	2	Lost Tim	e Per Cyc	le: 10.0 S	ec
Phase	:	1		2		3	4		5	6		7	8	Pe	d Only
EB		P													
WB				P											
NB		Т													
SB				T											
Green	1	22.0		18.0	0										0
Yello	w All Red	3.5	1.5 3	.5	1.5										

			Capacity Analysis Results Approach:											
			Capac		esuits					cn:				
	Lane	Cap (vph)	v/s	g/C Ratio	Lane	v/c	Delay (sec/veh)		Delay (sec/veh)					
App	Group	(vph)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS				
EB														
	R	1191	0.213	0.440	R	0.484	11.4	В	11.4	В				
WB														
*	R	975	0.140	0.360	R	0.390	13.1	В	13.1	В				
NB														
*	T	1527	0.228	0.440	T	0.519	10.3	В	10.3	В				
SB														
	T	1250	0.072	0.360	T	0.200	11.1	В	11.1	В				

Intersection: Delay = 11.2 sec/veh SIG/Cinema v3.08

Int. LOS=B

* Critical Lane Group

 \geq (v/s)Crit= 0.37

Marvin & Associates

Page 1

Double Cross Adjacent RA Mary OP1 R Marvin PM Hour YR 2035 EB Ramp Right/Johnson 09/08/2011

Case: Double Cross EB Ramp Johns Adjacent RA 2035 PM

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	230
					1
EB	R	2/3	19.9	0.0	
	All		19.9	0.0	<u> </u>
					<u> </u>
]
WB	R	2/3	17.9	0.0	
	All		17.9	0.0	630 —
NB	Т	4 / 5	16.5	0.0	
					730
	All		16.5	0.0	
					$\frac{1}{1}$
SB	Т	1 / 2	18.5	0.0	, • • • • • • • • • • • • • • • • • •
					21 4 2 17 4 2
	All		18.5	0.0	
	Inte	rsect.	18.0		

HCM Analysis Summary

Double Cross WB Ramps Adjacent RA

R Marvin
PM Hour YR 2035

WB Ramp Left/Johnson
O9/08/2011
Analysis Duration: 15 mins.
Case: Double Cross WB Ramp Adjacent RA 2035 PM

	Marvin I Hour YF	R 2035						e: Doub	ole Cross	WB Ra	ımp Adj	acent F	RA 2035	PM	IIIIIS.
	Lanes					Geo	metry: Mo	vements	Serviced b	y Lane ar	nd Lane W	Vidths (1	feet)		
	Approach (Outboun	d	Lane	e 1	La	ne 2	L	ane 3	La	ne 4	La	ane 5	La	ne 6
EB	2	0		R	12.0	R	12.0								
WB	2	0		R	12.0	R	12.0								
NB	2	2		Т	12.0	T	12.0								
SB	2	2		Т	12.0	Т	12.0								
					East			West	·		North	•		South	
	Data			L	Т	R	L	Т	R	L	Т	R	L	T	R
Move	ement Volun	ne (vph)		0	0	175	0	0	200	0	950	0	0	675	0
PHF			0.	.90	0.90	0.92	0.90	0.90	0.92	0.90	0.92	0.90	0.90	0.92	0.90
% He	avy Vehicle	s		2	2	5	2	2	5	2	4	2	2	4	2
Lane	Groups					R			R		Т			T	
Arriv	al Type					3			3		3			3	
RTO	R Vol (vph)				30			25			0			0	
Peds/	Hour				0			0			5			5	
% Gr	ade				0			0			0			0	
Buses	s/Hour				0			0			0			0	
Parke	ers/Hour (Le	ft Right)													
Signa	l Settings: A	ctuated			Operati	onal Analy	ysis	Cyc	le Length:	50.0 Sec	с	Lost Tin	ne Per Cyc	le: 10.0 S	lec
Phase	:	1		2	2	3	4		5	6		7	8	Pe	ed Only
EB		P													
WB					P										
NB		Т													
SB		_		7											
Green		22.			3.0										0
Yello	w All Red	3.5	1.5	3.5	1.5										

			Capac	ity Analysis R	esults				Approa	ich:	
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS	
EB											
	R	1191	0.058	0.440	R	0.133	8.6	A	8.6	A	
WB											
	R	975	0.070	0.360	R	0.195	11.5	В	11.5	В	
NB											
	* T	1527	0.298	0.440	Т	0.676	12.2	В	12.2	В	
SB											
	* T	1250	0.211	0.360	T	0.587	13.5	В	13.5	В	

Intersection: Delay = 12.3 sec/veh SIG/Cinema v3.08

Int. LOS=B

 $X_c = 0.64$ * Critical Lane Group

 $\sum (v/s)$ Crit= 0.51

Marvin & Associates

Page 1

Double Cross WB Ramps Adjacent RA R Marvin PM Hour YR 2035 WB Ramp Left/Johnson 09/08/2011

Case: Double Cross WB Ramp Adjacent RA 2035 Pl

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	675
					1
EB	R	1 / 2	18.0	0.0	
	All		18.0	0.0	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \
					J
WB	R	1 / 2	18.6	0.0]
	All		18.6	0.0	
NB	T	5 / 6	15.3	0.0]
					950
	All		15.3	0.0	
					1 2
SB	Т	3 / 5	16.0	0.0	1 1 1 1 1 1
					21 4 2 17 4 2
	All		16.0	0.0	
	Inte	rsect.	16.1		

er.			

Appendix I

US 87/Old Hwy 312 Intersection

Design Options

Figures & Capacity Calculations

er.			

Appendix I

US 87/Old Hwy 312 Intersection

Design Option Figures

er.			

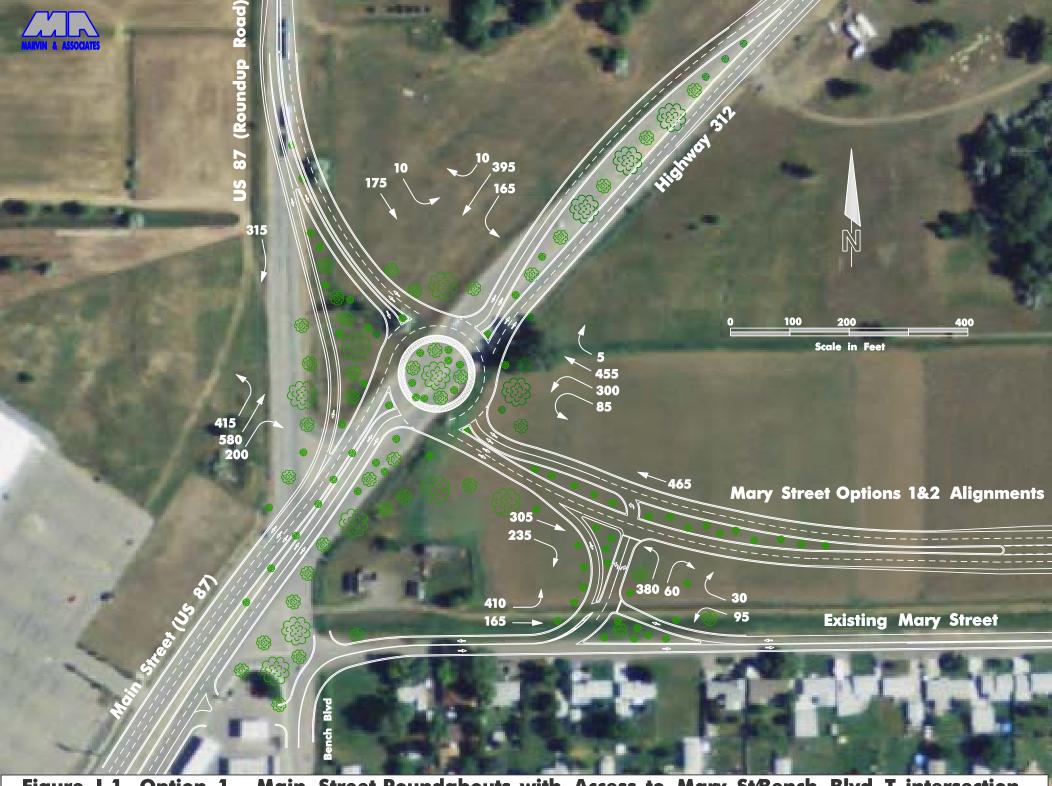


Figure I–1. Option 1 – Main Street Roundabouts with Access to Mary St/Bench Blvd. T–intersection



Figure I-2. Option 2 - Primary & Secondary Roundabouts



er.			

Appendix I

US 87/Old Hwy 312 Intersection

Design Options

Capacity Calculations



er.			

Site: Rou 4-way 2-Lane & 1-Lane **Exits US**

Mary Street Alignment US87/312/Bench/Mary Design Option 1 Roundabout

Lane Use	Lane Use and Performance															
	. [Deman	d Flows		111/	Can	Deg.	Lane	Average	Level of	95% Back		Lane	SL		Prob.
	L veh/h	T veh/h	R veh/h	Total veh/h	HV %	Cap. veh/h	Satn v/c	Util. %	Delay sec	Service	Vehicles veh	Distance ft	Length ft	Type	Adj. I %	Block. %
South East:					/0	VC11/11	V/C	/0	300		VOII	- '	- 10		/0	/0
Lane 1	418	21	0	439	2.4	518	0.847	100	26.4	LOS C	7.8	197.8	1600	_	0.0	0.0
Lane 2	0	474	5	479	4.0	566	0.847	100	17.5	LOS B	8.1	207.9	1600	_	0.0	0.0
Approach	418	495	5	918	3.2		0.847		21.8	LOS C	8.1	207.9				
North East:	North East: Highway 312 SW Bound															
Lane 1	179	107	0	287	2.4	392	0.731	100	26.7	LOS C	5.6	143.6	1600	_	0.0	0.0
Lane 2	0	322	11	333	3.0	455	0.731	100	20.0	LOS C	6.1	155.3	1600	_	0.0	0.0
Approach	179	429	11	620	2.7		0.731		23.1	LOS C	6.1	155.3				
North West:	US 87	SE Bo	und													
Lane 1	11	190	5	207	3.8	451	0.458	100	13.0	LOS B	2.6	66.6	700	_	0.0	0.0
Approach	11	190	5	207	3.8		0.458		13.0	LOS B	2.6	66.6				
South West	: Main S	Street N	IE Boun	d												
Lane 1	451	145	0	596	1.8	897	0.664	100	17.2	LOS B	7.2	182.7	1600	_	0.0	0.0
Lane 2	0	486	217	703	1.6	1058	0.664	100	10.4	LOS B	7.5	189.2	1600	_	0.0	0.0
Approach	451	630	217	1299	1.7		0.664		13.5	LOS B	7.5	189.2				
Intersection				3043	2.5		0.847		17.9	LOS B	8.1	207.9				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Wednesday, November 23, 2011 5:16:14 PM Copyright © 2000-2011 Akcelik and Associates Pty Ltd SIDRA INTERSECTION 5.1.8.2059

Project: Not Saved

8001325, MARVIN & ASSOCIATES, SINGLE

www.sidrasolutions.com



	TW	O-WAY STO	P CONTR	OL SUN	IMARY			
General Information	n		Site I	nformat	ion			
Analyst	R Marvir	າ	Interse	ection		Mary Alig	nment &	Bench
Agency/Co.		<i>Issociates</i>	Jurisdi	iction		MDT		
Date Performed	12/21/20		Analys	sis Year		2035 Opt	tion 1	
Analysis Time Period	PM Desi	ign Hour						
Project Description Bil								
East/West Street: Mary		ent			et: Bench	Blvd		
ntersection Orientation:	East-West		Study I	Period (hr	s): <i>0.25</i>			
Vehicle Volumes ar	nd Adjustm	ents						
Major Street		Eastbound				Westbou	ınd	
Movement	1	2	3		4	5		6
	L	Т	R		L	Т		R
/olume (veh/h)	4.00	305	4.00		4.00	465		1.00
Peak-Hour Factor, PHF	1.00	0.92	1.00	<u>' </u>	1.00	0.92		1.00
Hourly Flow Rate, HFR veh/h)	0	331	0		0	505		0
Percent Heavy Vehicles	0				0			
Median Type				Raised c	urb			
RT Channelized			0					0
anes	0	2	0		0	2		0
Configuration		T				T		
Jpstream Signal		0				0		
Minor Street		Northbound				Southbou	ınd	
Movement	7	8	9		10	11		12
	L	Т	R		L	Т		R
/olume (veh/h)	380		60					
Peak-Hour Factor, PHF	0.92	1.00			1.00	1.00		1.00
Hourly Flow Rate, HFR veh/h)	413	0	60		0	0		0
Percent Heavy Vehicles	0	0	0		0	0		0
Percent Grade (%)	Ti Ti	0				0		
Flared Approach	1	N	Î			N		
Storage	1	0				0		
RT Channelized	1		0					0
_anes	1	0	1		0	0		0
Configuration	L	i	R					
Delay, Queue Length, a	nd Level of S	ervice	,					
Approach	Eastbound	Westbound		Northbour	nd	S	Southbour	nd
Movement	1	4	7	8	9	10	11	12
ane Configuration		i	L		R		1	1
v (veh/h)		İ	413		60		Ì	1
C (m) (veh/h)		1	540		884		1	1
ı/c		1	0.76		0.07			1
95% queue length		1	6.82	<u> </u>	0.22			+
Control Delay (s/veh)		†	30.1	 	9.4	 	 	+
OS		+	D D	 	+		 	+
		+		07.5	A		<u> </u>	
Approach Delay (s/veh)			+	27.5				
Approach LOS				D				

Copyright © 2010 University of Florida, All Rights Reserved

HCS+TM Version 5.6

Generated: 12/21/2011 3:08 PM

	TW	O-WAY STO	P CONTR	OL SU	MMARY			
General Information	n		Site I	nforma	ition			
Analyst	R Marvir	າ	Inters	ection		Mary & E	Bench	
Agency/Co.	Marvin A	Ssociates	Jurisd	iction		MDT		
Date Performed	12/21/20)11	Analy	sis Year		2035 Opi	tion 1	
Analysis Time Period	Pm Desi	ign Hour						
Project Description Bil	llings Bypass		•					
East/West Street: Mary	Street (exist)		North/	South Sti	reet: <i>Bench</i>	n Blvd		
Intersection Orientation:	North-South		Study	Period (h	rs): <i>0.25</i>			
Vehicle Volumes ar	nd Adjustm	ents						
Major Street		Northboun				Southboo	und	
Movement	1	2	3		4	5		6
	L	Т	R		L	Т		R
Volume (veh/h)		440						
Peak-Hour Factor, PHF	1.00		1.00)	1.00	1.00		1.00
Hourly Flow Rate, HFR (veh/h)	0	440	0		0	0		0
Percent Heavy Vehicles	0				0			
Median Type				Raised	curb			
RT Channelized			0					0
Lanes	0	2	0		0	0		0
Configuration		T						
Upstream Signal		0				0		
Minor Street		Eastbound	d			Westbou	ınd	
Movement	7	8	9		10	11		12
	L	Т	R		L	Т		R
Volume (veh/h)					95			30
Peak-Hour Factor, PHF	1.00	1.00	1.00)	0.92	1.00		0.92
Hourly Flow Rate, HFR (veh/h)	0	0	0		103	0		32
Percent Heavy Vehicles	0	0	0		0	0		0
Percent Grade (%)		0	-			0	•	
Flared Approach		N				N		
Storage		0				0		
RT Channelized	Ti Ti		0	ĺ				0
Lanes	0	0	0		0	0		0
Configuration						LR		
Delay, Queue Length, a	nd Level of S	ervice	-			Į.		
Approach	Northbound	Southbound		Westbou	ınd		Eastboun	d
Movement	1	4	7	8	9	10	11	12
Lane Configuration		1		LR		1		1
v (veh/h)		1	1	135		1		\top
C (m) (veh/h)		1	1	629	1	1	1	1
v/c		1	+	0.21	+	1		
95% queue length		+	_	0.21	_	+	1	+
<u> </u>		 	+	12.3	+	+	1	+
Control Delay (s/veh)		 	+		+	+		_
LOS				В		 		
Approach Delay (s/veh)				12.3				
Approach LOS				В				

Copyright © 2010 University of Florida, All Rights Reserved

HCS+TM Version 5.6

Site: Mary Alignment US87/312/ Main/Bench/Mary Design Opt 2

US87/312/Main/Bench Mary Street Alignment Design Option 2 Roundabout

Lane Use	and Pe	rform	ance													
		Deman	d Flows		1.15.7	_	Deg.	Lane	Average	Level of	95% Back		Lane	SL	Сар.	
	L veh/h	T veh/h	R vob/b	Total veh/h	HV %	Cap.	Satn v/c	Util. %	Delay	Service	Vehicles	Distance	Length	Type	Adj. %	Block. %
South: Bend		ven/n	ven/n	ven/n	70	veh/h	V/C	70	sec	_	veh	ft	ft	_	7 0	70
Lane 1	22	125	0	147	0.0	408	0.359	100	16.2	LOS B	1.8	45.7	600	_	0.0	0.0
Lane 2	0	0	332	332	0.0	576	0.576	100	9.1	LOS A	4.0	99.7	200	_	0.0	0.0
Approach	22	125	332	478	0.0		0.576		11.3	LOS B	4.0	99.7				
South East:	South East: Mary Street Alignment NWB															
Lane 1	397	0	0	397	1.5	601	0.660	100	21.2	LOS C	4.9	123.8	1600	_	0.0	0.0
Lane 2	0	228	5	234	4.0	428	0.546	83 ⁵	13.6	LOS B	3.1	80.6	1600		0.0	0.0
Approach	397	228	5	630	2.4		0.660		18.4	LOS B	4.9	123.8				
North East:	HWY 3	12 SWE	3													
Lane 1	179	103	0	282	1.2	487	0.580	100	19.3	LOS B	4.4	109.8	1600	-	0.0	0.0
Lane 2	0	326	11	337	3.0	581	0.580	100	14.8	LOS B	4.7	121.2	1600	_	0.0	0.0
Approach	179	429	11	620	2.2		0.580		16.8	LOS B	4.7	121.2				
North West:	US 87	SEB														
Lane 1	11	109	87	207	2.3	528	0.391	100	9.4	LOS A	2.2	55.0	1600	_	0.0	0.0
Approach	11	109	87	207	2.3		0.391		9.4	LOS A	2.2	55.0				
South West	: Main S	Street N	IE Boun	d												
Lane 1	451	139	0	590	1.0	979	0.603	100	15.3	LOS B	5.8	146.3	1600	_	0.0	0.0
Lane 2	0	492	245	736	1.3	1222	0.603	100	7.6	LOS A	6.0	150.9	1600		0.0	0.0
Approach	451	630	245	1326	1.1		0.603		11.0	LOS B	6.0	150.9				
Intersection				3261	1.5		0.660		13.5	LOS B	6.0	150.9				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

5 Lane underutilisation determined by program

Processed: Monday, November 28, 2011 3:57:26 PM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Traffic Study\Capacity\Calculations\Mary Street\Mary Align US87 312 Main bench Design Opt 2 PM 2035.sip

8001325, MARVIN & ASSOCIATES, SINGLE



Site: Rou 4-way 1-Lane US

Mary Street Alignment Single Lane Roundabout Bench and Mary Street South of Main Street US87 Option 2 Design Roundabout

Lane Use	and Pe	erforma	ince													
	L veh/h		R veh/h	Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back Vehicles veh	of Queue Distance ft	Lane Length ft	SL Type	Cap. I Adj. I %	Prob. Block. %
South East:	Mary S	Street WE	3													
Lane 1	103	0	33	136	0.0	732	0.186	100	10.6	LOS B	1.0	24.7	1600	_	0.0	0.0
Approach	103	0	33	136	0.0		0.186		10.6	LOS B	1.0	24.7				
North: Main	North: Main US 87 Connect SB															
Lane 1	33	0	342	375	0.0	1109	0.338	100	3.2	LOS A	2.3	58.0	600	_	0.0	0.0
Approach	33	0	342	375	0.0		0.338		3.2	LOS A	2.3	58.0				
South West:	: Bench	Blvd EE	3													
Lane 1	446	0	152	598	0.0	1106	0.541	100	7.1	LOS A	5.0	124.9	1600	_	0.0	0.0
Approach	446	0	152	598	0.0		0.541		7.1	LOS A	5.0	124.9				
Intersection				1109	0.0		0.541		6.2	LOS A	5.0	124.9				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections. Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Friday, November 25, 2011 5:48:39 PM SIDRA INTERSECTION 5.1.8.2059 Project: Not Saved 8001325, MARVIN & ASSOCIATES, SINGLE Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com



Site: Mary Street Alignment US87/312/Bench Design Option 3

Mary Street Alignment US87/312/Bench Design Option 3 Roundabout

Lane Use	and Pe	rform	ance													
		Deman	d Flows				Deg.	Lane	Average	Level of	95% Back		Lane	SL		Prob.
	L	Τ.	R	Total	HV	Cap.	Satn	Util.	Delay	Service	Vehicles	Distance	Length	Type		Block.
Operation Experts			veh/h	veh/h	%	veh/h	v/c	%	sec		veh	ft	ft		%	%
South East:																
Lane 1	326	120	0	446	1.5	543	0.822	100	20.9	LOS C	7.3	183.8	600	_	0.0	0.0
Lane 2	0	233	272	505	1.9	614	0.822	100	14.3	LOS B	7.6	194.1	600		0.0	0.0
Approach	326	353	272	951	1.7		0.822		17.4	LOS B	7.6	194.1				
North East:	North East: Highway 312 SW Bound															
Lane 1	179	105	0	284	2.0	484	0.588	100	20.3	LOS C	4.2	107.4	1600	_	0.0	0.0
Lane 2	0	313	11	324	2.0	552	0.588	100	14.0	LOS B	4.5	113.8	1600	_	0.0	0.0
Approach	179	418	11	609	2.0		0.588		17.0	LOS B	4.5	113.8				
North West:	US 87	SE Bo	und													
Lane 1	11	190	5	207	3.8	508	0.406	100	10.7	LOS B	2.2	55.6	700	_	0.0	0.0
Approach	11	190	5	207	3.8		0.406		10.7	LOS B	2.2	55.6				
South West	: Main S	Street N	IE Bound	d												
Lane 1	451	156	0	607	1.7	983	0.618	100	14.7	LOS B	6.0	152.8	1600	_	0.0	0.0
Lane 2	0	474	245	719	1.3	1164	0.618	100	8.1	LOS A	6.1	154.4	1600	_	0.0	0.0
Approach	451	630	245	1326	1.5		0.618		11.1	LOS B	6.1	154.4	-			
Intersection				3092	1.8		0.822		14.2	LOS B	7.6	194.1				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Wednesday, November 30, 2011 3:30:09 PM Copyright © 2000-2011 Akcelik and Associates Pty Ltd SIDRA INTERSECTION 5.1.8.2059 Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Traffic Study\Capacity\Calculations\Mary Street\Mary Align US87 312 Main Bench Design Opt 3 PM 2035 sin

8001325, MARVIN & ASSOCIATES, SINGLE



Site: Mary Street Alignment Bench/ Mary Intersection Design Option 3

Mary Street Alignment Bench/Mary Intersection Design Option 3 Roundabout

Lane Use	Lane Use and Performance															
		Deman	d Flows		HV	Cap.	Deg.	Lane	Average	Level of	95% Back		Lane	SL	Cap. I	
	veh/h	veh/h	R veh/h	Total veh/h	пv %	veh/h	Satn v/c	Util. %	Delay sec	Service	Vehicles veh	Distance ft	Length ft	Туре	Adj. E %	Block. %
South: Mary			7311/11	V 011/11	70	V 011/11	• • • • • • • • • • • • • • • • • • • •	,,	000		7011				,,	70
Lane 1	103	33	5	141	0.0	612	0.231	100	12.0	LOS B	1.5	36.3	1600	_	0.0	0.0
Approach	103	33	5	141	0.0		0.231		12.0	LOS B	1.5	36.3				
East: Mary S	East: Mary Street Alignment WB															
Lane 1	5	92	0	98	0.0	787	0.124	100	7.8	LOS A	0.7	17.9	1600	_	0.0	0.0
Lane 2	0	0	538	538	3.0	1577	0.341	100	5.3	Χ	Х	Х	1600	_	0.0	Х
Approach	5	92	538	636	2.5		0.341		5.7	LOS A	0.7	17.9				
North: Benc	h Conn	ect SB														
Lane 1	326	11	0	337	3.9	1135	0.297	100	9.1	LOS A	1.9	48.0	600	_	0.0	0.0
Lane 2	0	0	370	370	0.0	1318	0.280	95 ⁵	3.5	LOS A	1.8	44.5	600		0.0	0.0
Approach	326	11	370	707	1.8		0.297		6.2	LOS A	1.9	48.0				
West: Bench	n Blvd E	ЕΒ														
Lane 1	380	65	152	598	0.0	928	0.644	100	10.8	LOS B	6.6	164.5	1600		0.0	0.0
Approach	380	65	152	598	0.0		0.644		10.8	LOS B	6.6	164.5				
Intersection				2082	1.4		0.644		7.7	LOS A	6.6	164.5				

X: Not applicable for Continuous lane.

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

5 Lane underutilisation determined by program

Processed: Wednesday, November 30, 2011 3:34:27 PM Copyright © 2000-2011 Akcelik and Associates Pty Ltd SIDRA INTERSECTION 5.1.8.2059 www.sidrasolutions.com

Project: C:\Documents\and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Traffic Study\Capacity\Calculations\Mary Street\Mary Align Bench_Mary Design Opt 3 PM 2035.sip 8001325, MARVIN & ASSOCIATES, SINGLE



er.			

APPENDIX J

Five Mile Road/Old Hwy 312

Design Options

Figures & Capacity Calculations

er.			

APPENDIX J

Five Mile Road/Old Hwy 312

Design Option Figures

er.			

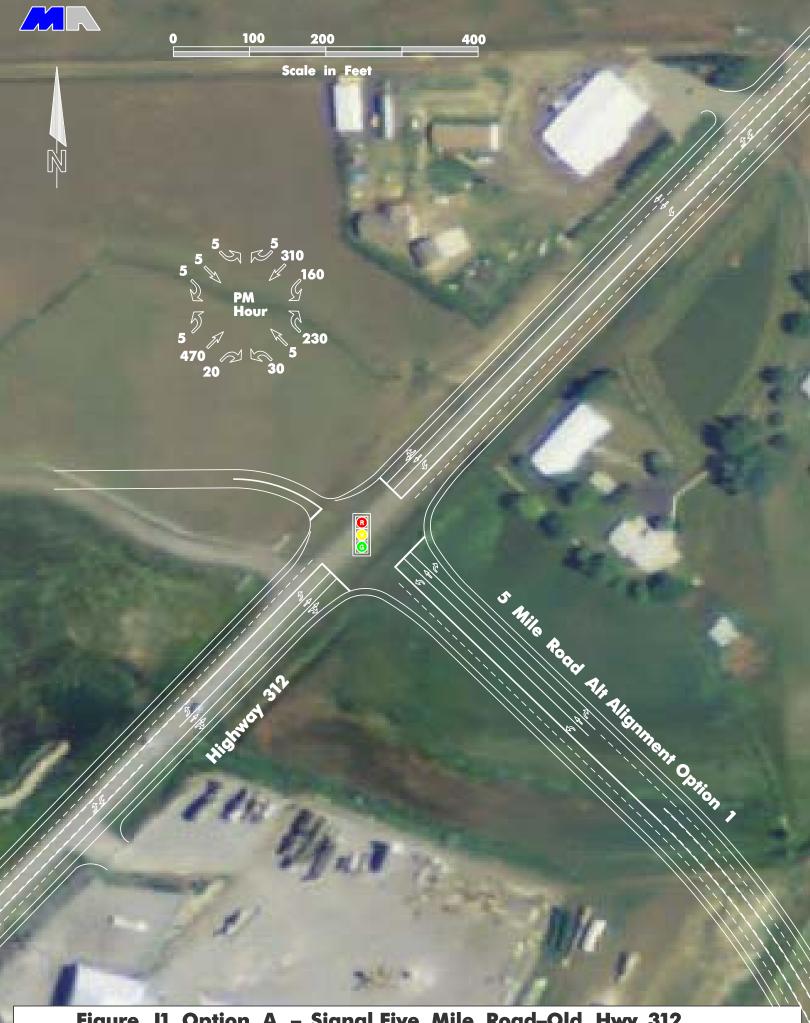
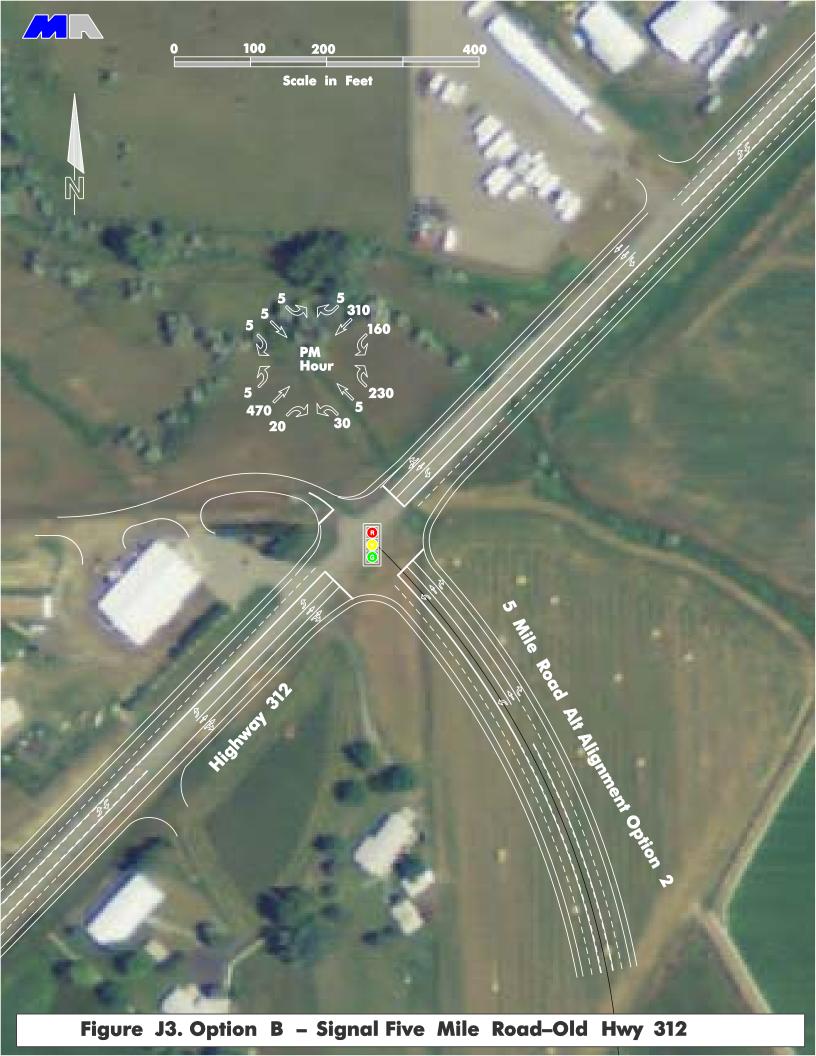
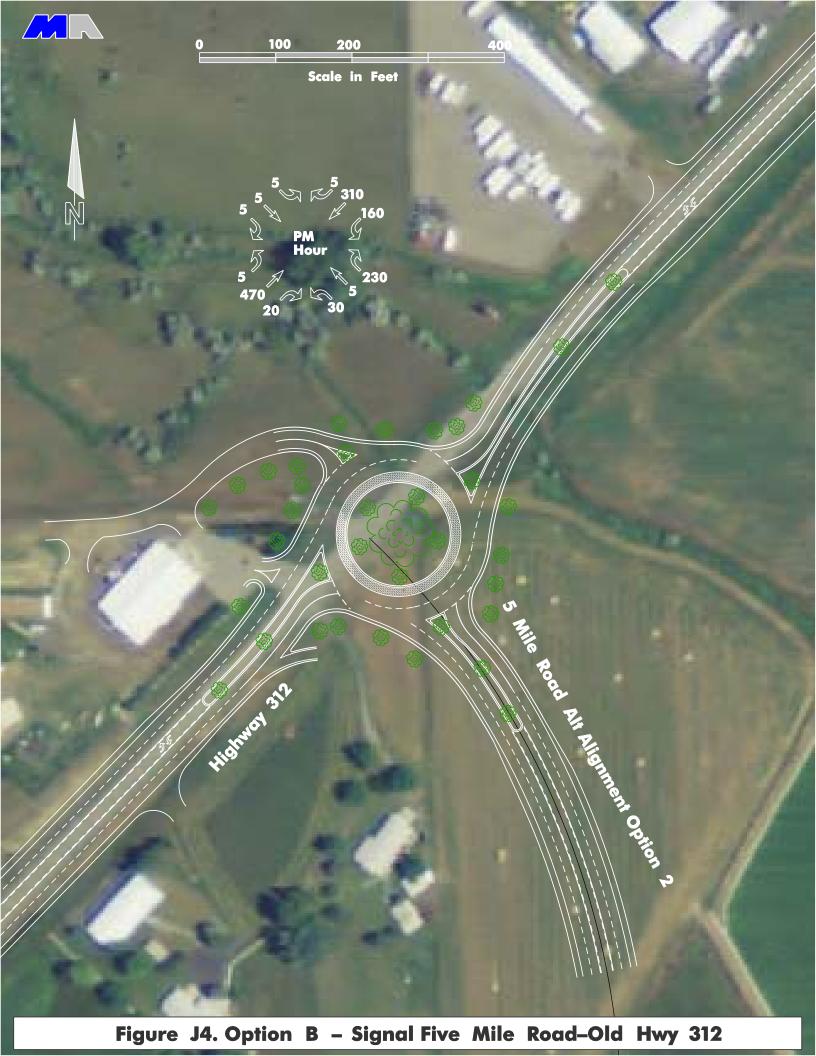


Figure J1. Option A - Signal Five Mile Road-Old Hwy 312







APPENDIX J

Five Mile Road/Old Hwy 312

Design Options

Capacity Calculations

er.			

HCM Analysis Summary

Five Mile Align HWY 312 Highway 312/Five Mile Align Area Type: Non CBD R Marvin 12/01/2011 Analysis Duration: 15 mins. PM design Hour Case: Five Mile Align 312 PM 2035

PM	I design H	Iour	Case: Five Mile Align 312 PM 2035 Geometry: Movements Serviced by Lane and Lane Widths (feet)												
	Lanes					Geo	metry: Mo	vements	Serviced b	y Lane ar	nd Lane W	idths (f	eet)		
	Approach (Outbound	i	Lane	e 1	La	ne 2	La	ne 3	Laı	ne 4	La	ne 5	La	ne 6
EB	3	2		L	12.0	Т	12.0	TR	12.0						
WB	3	2		L	12.0	T	12.0	TR	12.0						
NB	3	1		L	12.0	Т	12.0	R	12.0						
SB	1	1	L	TR	12.0										
					East			West			North			South	
	Data			L	Т	R	L	Т	R	L	T	R	L	Т	R
Move	ement Volun	ne (vph)		5	470	20	160	310	5	30	5	230	5	5	5
PHF			0.	.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
% Не	% Heavy Vehicles			1	3	1	2	3	1	3	1	3	1	1	1
Lane	Lane Groups			L	TR		L	TR		L	T	R		LTR	
Arriv	al Type			3	3		3	3		3	3	3		3	
RTO	R Vol (vph)				0			0			100			0	
Peds/	Hour				0			0			0			0	
% Gr	ade				0			0			0			0	
Buse	s/Hour				0			0			0			0	
Parke	ers/Hour (Le	ft Right)													
Signa	al Settings: A	Actuated			Operati	onal Analy	/sis	Cycle	e Length:	60.0 Sec	2	Lost Tin	ne Per Cyc	le: 11.0 S	ec
Phase	:	1		2	2	3	4		5	6		7	8	Pe	d Only
EB		LTP	,												
WB		LTP	,												
NB	LTP														
SB		LTP													
	Green 35.0				1.0					,					0
Yello	w All Red	4.0	2.0	3.5	1.5										

Capacity Analysis Results									Approach:	
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
EB	L	595	0.006	0.583	L	0.010	5.3	A	6.5	A
	TR	2032	0.156	0.583	TR	0.268	6.5	A	0.5	71
WB										
	* L	488	0.213	0.583	L	0.365	8.7	A	6.9	A
	TR	2039	0.100	0.583	TR	0.172	6.0	A		
NB										
	L	321	0.024	0.233	L	0.103	18.1	В	19.3	В
	T	439	0.003	0.233	T	0.014	17.7	В		
	* R	366	0.092	0.233	R	0.393	19.7	В		
SB										
	LTR	393	0.011	0.233	LTR	0.046	17.8	В	17.8	В

Intersection: Delay = $8.7\,\mathrm{sec/veh}$ Int. LOS=A $X_c = 0.37$ * Critical Lane Group $\Sigma(v/s)$ Crit= 0.30 SIG/Cinema v3.08 Marvin & Associates Page 1

Five Mile Align HWY 312 R Marvin PM design Hour Highway 312/Five Mile Align 12/01/2011

Case: Five Mile Align 312 PM 2035

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	5 5 5
EB	L	0 / 0	31.5	0.0	
	TR	2/3	19.6	0.0	
					↓ 160
	All		19.6	0.0	<u></u>
WB	L	1 / 2	17.3	0.0	
	TR	2/3	19.7	0.0	
					5 -
	All		19.0	0.0	470 →
NB	L	0 / 1	8.1	0.0	20 ¬
	T	0 / 1	24.6	0.0	
	R	1 / 3	16.2	0.0	30 230
	All		18.2	0.0	
					1 2 11
SB	LTR	0 / 1	11.8	0.0	
					35 4 2 13
	All		11.8	0.0	
Intersect.		19.0			

LANE SUMMARY

Site: Five Mile Road Alignment HWY 312 Intersection

Five Mile Road Alignment Highway 312 Intersection Year 2035 PM Design Hour Roundabout

Lane Use	and Pe	erform	ance													
		Deman	d Flows				Deg.	Lane	Average	Level of	95% Back		Lane	SL	Cap.	
	L	Τ.	R	Total	HV	Cap.	Satn	Util.	Delay	Service	Vehicles	Distance	Length	Type		Block.
Cauth Fast		veh/h		veh/h	%	veh/h	v/c	%	sec		veh	ft	ft		%	%
South East:	-					400		2.25					4000			
Lane 1	33	5	0	38	3.6	480	0.079	28 ⁵	15.4	LOS B	0.3	7.3	1600	_	0.0	0.0
Lane 2	0	0	250	250	3.0	891	0.281	100	7.9	LOS A	1.2	31.8	1600		0.0	0.0
Approach	33	5	250	288	3.1		0.281		8.9	LOS A	1.2	31.8				
North East:	HWY 3	12 SW	3													
Lane 1	174	74	0	248	3.0	1335	0.186	100	10.2	LOS B	1.1	28.1	1600	_	0.0	0.0
Lane 2	0	263	5	268	3.0	1445	0.186	100	4.5	LOS A	1.1	28.4	1600	_	0.0	0.0
Approach	174	337	5	516	3.0		0.186		7.3	LOS A	1.1	28.4				
North West:	Access	Road	SEB													
Lane 1	5	5	5	16	1.0	753	0.022	100	8.1	LOS A	0.1	1.9	1600	_	0.0	0.0
Approach	5	5	5	16	1.0		0.022		8.1	LOS A	0.1	1.9				
South West	: HWY	312 NE	В													
Lane 1	5	249	0	254	3.0	1172	0.217	100	5.5	LOS A	1.2	31.0	1600	_	0.0	0.0
Lane 2	0	262	22	284	3.0	1310	0.217	100	5.3	LOS A	1.2	31.5	200	_	0.0	0.0
Approach	5	511	22	538	3.0		0.217		5.4	LOS A	1.2	31.5				
Intersection				1359	3.0		0.281		6.9	LOS A	1.2	31.8				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

5 Lane underutilisation determined by program

Processed: Thursday, December 01, 2011 1:02:56 PM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Traffic Study\Capacity\Calculations\Mary Street\Five Mile Align HWY 312 Int PM 2035.sip

8001325, MARVIN & ASSOCIATES, SINGLE



5 Mile & HWY 312 Secondary Imps Highway 312/Five Mile Align Area Type: Non CBD R Marvin 12/01/2011 Analysis Duration: 15 mins. PM Design Hour Case: MARYAL~1

	I Design I	Hour		Case: MARYAL~1								111113.			
	Lanes					Geo	metry: Mo	vements	Serviced b	y Lane ar	nd Lane W	/idths (1	reet)		
	Approach (Outboun	d	Lane	e 1	La	ne 2	La	ine 3	La	ne 4	La	ane 5	La	ne 6
EB	3	2		L	12.0	Т	12.0	TR	12.0						
WB	3	2		L	12.0	Т	12.0	TR	12.0						
NB	2	1	I	LT	12.0	R	12.0								
SB	1	1	L	TR	12.0										
					East			West	Vest North				South		
	Data			L	Т	R	L	Т	R	L	T	R	L	T	R
Move	ement Volun	ne (vph)		5	470	20	150	300	5	30	5	210	5	5	5
PHF			0	.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
% He	avy Vehicle	s		1	3	1	2	3	1	3	1	3	1	1	1
Lane	Groups			L	TR		L	TR			LT	R		LTR	
Arriv	al Type			3	3		3	3			3	3		3	
RTO	R Vol (vph)				0			0			100			0	
Peds/	Hour				0			0			0			0	
% Gr	ade				0			0			0			0	
Buses	s/Hour				0			0			0			0	
Parke	ers/Hour (Le	ft Right)													
Signa	ıl Settings: A	Actuated			Operati	onal Anal	ysis	Cycl	e Length:	60.0 Sec	2	Lost Tin	ne Per Cyc	ele: 11.0 S	ec
Phase	:	1		2	2	3	4		5	6		7	8	Pe	d Only
EB		LTI	2												
WB		LT	2												
NB				LT	ГР										
SB				L											
Greei		35.			1.0										0
Yello	w All Red	4.0	2.0	3.5	1.5										

	Capacity Analysis Results Approach:										
		_				,					
	Lane	Cap (vph)	v/s	g/C Ratio	Lane	v/c	Delay (sec/veh)	T 00	Delay	LOG	
App	Group	(vpn)	Ratio	Ratio	Group	Ratio	(sec/ven)	LOS	(sec/veh)	LOS	
EB	_										
	L	601	0.006	0.583	L	0.010	5.3	A	6.5	Α	
	TR	2032	0.156	0.583	TR	0.268	6.5	A			
WB											
	* L	488	0.200	0.583	L	0.342	8.4	A	6.8	Α	
	TR	2039	0.097	0.583	TR	0.166	5.9	A			
NB											
	LT	344	0.026	0.233	LT	0.113	18.2	В	19.0	В	
	* R	366	0.078	0.233	R	0.333	19.3	В			
SB											
	LTR	391	0.011	0.233	LTR	0.046	17.8	В	17.8	В	

Intersection: Delay = 8.4 sec/veh SIG/Cinema v3.08

Int. LOS=A $X_c = 0.34$

* Critical Lane Group

 \sum (v/s)Crit= 0.28

5 Mile & HWY 312 Secondary Imps R Marvin PM Design Hour Highway 312/Five Mile Align 12/01/2011 Case: MARYAL~1

App EB	Lane Group L	Queues Per Lane Avg/Max (veh) 0 / 0	Average Speed (mph) 31.5	Spillback in Worst Lane (% of Peak Period) 0.0	5 5 5 1 1 1 5
	IK	2/4	19.4	0.0	→ 300 → 150
	All		19.4	0.0	
WB	L	1 / 3	17.0	0.0	
	TR	2 / 2	20.4	0.0	
					5 -
	All		19.3	0.0	470
NB	LT	0 / 1	21.3	0.0	
	R	1 / 3	16.3	0.0	30 210
	All		18.7	0.0	
					1 2 !!!
SB	LTR	0 / 1	11.8	0.0	===
					35 4 2 13 4 2
	All		11.8	0.0	
	Inte	rsect.	19.1		

SIG/Cinema v3.08 Page 2

er.			

APPENDIX K

Mary Street Alignment/Bitteroot Drive

Design Options

Figures & Capacity Calculations

er.			

APPENDIX K

Mary Street Alignment/Bitteroot Drive



er.			











Figure K5. Mary Street Alignments Design Option E





Figure K7. Mary Street Alignments Design Option G

er.			

APPENDIX K

Mary Street Alignment/Bitteroot Drive

Design Options

Capacity Calculations

er.			

Mary Alignment Bitteroot Alt A

Mary Alignment/Bitteroot

R Marvin

Design Hour PM

Mary Alignment/Bitteroot

Area Type: Non CBD

11/29/2011

Analysis Duration: 15 mins.

Case: Mary Align & Bitteroot Alt A 2035 PM

	viarvin sign Hour	· PM			Case: Mary Align & Bitteroot Alt A 2035 PM										
	Lanes					Geor	metry: Mo	vements !	Serviced b	y Lane ar	nd Lane W	idths (fe	eet)		
	Approach	Outbound		Lane	e 1	La	ne 2	Laı	ne 3	Laı	ne 4	La	ne 5	Laı	ne 6
EB	3	2	I		12.0	Т	12.0	TR	12.0						
WB	3	2	I		12.0	Т	12.0	TR	12.0						
NB	2	1	I		12.0	TR	12.0								
SB	2	1	I		12.0	TR	12.0								
		East			West			North			South				
	Data L T		T	R	L	Т	R	L	T	R	L	Т	R		
Move	ement Volur	ne (vph)	1	10	360	10	110	520	50	20	110	95	40	50	30
PHF			0.9	90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
% He	avy Vehicle	es		1	4	0	0	4	1	0	1	0	0	1	0
Lane	Groups		L	-	TR		L	TR		L	TR		L	TR	
Arriv	al Type		3	3	3		3	3		3	3		3	3	
RTOI	R Vol (vph)				0			10			25			5	
Peds/	Hour				5			5			5			5	
% Gr	ade				0			0			0			0	
Buses	s/Hour				0			0			0			0	
Parke	rs/Hour (Le	ft Right)													
Signa	l Settings: A	Actuated			Operation	onal Analy	/sis	Cycle	e Length:	60.0 Sec	2	Lost Tim	e Per Cyc	le: 10.0 S	ec
Phase	:	1		2	2	3	4		5	6		7	8	Pe	d Only
EB		LTP													
WB		LTP													
NB				LT	ГР										
SB				LT	ГР										
Greer	1	32.0			3.0										0
Yello	w All Red	3.5	1.5	3.5	1.5										

			Como	aitre Amalessia D	aau16a				A	ale.
	Lane	Cap (vph)	v/s	g/C Ratio	Lane	v/c	Delay (sec/veh)	1.00	Approa Delay	
App EB	Group	(vpn)	Ratio	Ratio	Group	Ratio	(sec/ven)	LOS	(sec/veh)	LOS
	L	401	0.015	0.533	L	0.027	6.8	A	7.7	A
	TR	1844	0.119	0.533	TR	0.223	7.7	Α		
WB										
	L	516	0.126	0.533	L	0.236	8.6	A	8.5	A
	* TR	1831	0.181	0.533	TR	0.340	8.5	A		
NB										
	L	399	0.017	0.300	L	0.055	15.0	В	16.6	В
	* TR	530	0.113	0.300	TR	0.377	16.7	В		
SB										
	L	354	0.037	0.300	L	0.124	15.3	В	15.4	В
	TR	535	0.047	0.300	TR	0.157	15.5	В		

Intersection: Delay = 10.0 sec/veh SIG/Cinema v3.08

Int. LOS=B

* Critical Lane Group

 \geq (v/s)Crit= 0.29

 $X_c = 0.35$ * Constant * Constant * Associates

Mary Alignment Bitteroot Alt A R Marvin Design Hour PM Mary Alignment/Bitteroot 11/29/2011

Case: Mary Align & Bitteroot Alt A 2035 PM

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	50 30 40
EB	L	0 / 0	28.9	0.0	
	TR	2 / 3	18.1	0.0	50 ← 520
					↓ 110
	All		18.2	0.0	
WB	L	1 / 2	14.4	0.0	
	TR	3 / 4	17.6	0.0	
					10 -
	All		17.4	0.0	360 →
NB	L	0 / 1	12.5	0.0	
	TR	2/3	17.7	0.0	
					20 95
	All		17.1	0.0	
SB	L	1 / 2	12.5	0.0	1 2 11
	TR	1 / 2	17.3	0.0	
					31 4 2 17 1 4 2
	All		15.1	0.0	
	Inte	rsect.	17.3		

Mary Street Alignment Bitteroot Alternative B Roundabout

Lane Use	Lane Use and Performance															
	C	eman	d Flows		LI\	Con	Deg.	Lane	Average	Level of	95% Back		Lane	SL	Cap. F	
	L veh/h	T veh/h	R veh/h	Total veh/h	HV %	Cap.	Satn v/c	Util. %	Delay sec	Service	Vehicles veh	Distance ft	Length ft	Type	Adj. E %	Block. %
South: Bitter		V 011/11	VO11/11	V 011/11	70	V 011/11	•,, 0	70	000		7011				70	,,
Lane 1	22	120	103	245	0.0	778	0.314	100	4.7	LOS A	1.4	35.5	200		0.0	0.0
Approach	22	120	103	245	0.0		0.314		4.7	LOS A	1.4	35.5				
East: Mary A	Alignmer	nt WB														
Lane 1	120	234	0	353	2.6	1201	0.294	100	7.9	LOS A	1.9	48.5	1600	_	0.0	0.0
Lane 2	0	331	54	386	3.4	1311	0.294	100	5.3	LOS A	1.9	49.6	1600	_	0.0	0.0
Approach	120	565	54	739	3.1		0.294		6.6	LOS A	1.9	49.6				
North: Bitter	oot SB															
Lane 1	43	54	33	130	0.3	661	0.197	100	6.9	LOS A	0.8	19.8	1600	_	0.0	0.0
Approach	43	54	33	130	0.3		0.197		6.9	LOS A	8.0	19.8				
West: Mary	Alignme	nt EB														
Lane 1	11	184	0	195	3.8	1125	0.174	100	5.9	LOS A	0.9	24.5	1600	_	0.0	0.0
Lane 2	0	207	11	218	3.8	1255	0.174	100	5.4	LOS A	1.0	24.9	1600	_	0.0	0.0
Approach	11	391	11	413	3.8		0.174		5.7	LOS A	1.0	24.9				
Intersection				1527	2.5		0.314		6.0	LOS A	1.9	49.6				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Thursday, December 22, 2011 11:04:34 AM SIDRA INTERSECTION 5.1.8.2059 Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Traffic Study\Capacity\Calculations\Mary Street\Mary Bitteroot Design Opts\Mary Align Bitteroot Alt B 2035 PM.sip

8001325, MARVIN & ASSOCIATES, SINGLE



Mary Alignment Bitteroot Alt C

R Mary In Special Hour PM

Mary Alignment/Bitteroot Alt C 2035 PM

Case: Mary Align & Bitteroot Alt C 2035 PM

	narvın sign Hour	· PM		Case: Mary Align & Bitteroot Alt C 2035 PM Geometry: Movements Serviced by Lane and Lane Widths (feet)									nins.		
	Lanes					Geo	metry: Mo	vements	Serviced b	y Lane ar	d Lane W	idths (fe	eet)		
	Approach	Outbound	1	Lane	e 1	La	ne 2	La	ne 3	Laı	ne 4	La	ne 5	Laı	ne 6
EB	3	2		L	12.0	Т	12.0	TR	12.0						
WB	3	2		L	12.0	Т	12.0	TR	12.0						
NB	1	1	L	TR	12.0										
SB	1	1	L	TR	12.0										
					East			West			North			South	
	Data			L	T	R	L	Т	R	L	Т	R	L	Т	R
Move	ment Volur	ne (vph)		10	360	10	110	520	50	20	110	95	40	50	30
PHF			0	.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
% He	% Heavy Vehicles			1	4	0	0	4	1	0	1	0	0	1	0
Lane	Lane Groups			L	TR		L	TR			LTR			LTR	
Arriv	al Type			3	3		3	3			3			3	
RTOI	R Vol (vph)				0			10			25			5	
Peds/	Hour			5			5			5				5	
% Gr	ade				0			0		0				0	
Buses	/Hour				0			0			0			0	
Parke	rs/Hour (Le	ft Right)													
Signa	1 Settings: A	Actuated			Operation	onal Analy	/sis	Cycle	Length:	60.0 Sec	:	Lost Tim	e Per Cycl	le: 10.0 S	ec
Phase	:	1		2	2	3	4		5	6		7	8	Pe	d Only
EB		LTF	•												
WB	B LTP														
NB				L											
SB				L											
Greer		32.0			3.0										0
Yello	w All Red	3.5	1.5	3.5	1.5										

			~		4.					Capacity Analysis Results Approach:												
		Г	Capac		esults		1		Approa	ch:												
App EB	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS												
ED	L	401	0.015	0.533	L	0.027	6.8	A	7.7	A												
	TR	1844	0.119	0.533	TR	0.223	7.7	A														
WB																						
	L	A	8.5	Α																		
	* TR	1831	0.181	0.533	TR	0.340	8.5	A														
NB																						
	* LTR	523	0.127	0.300	LTR	0.424	17.0	В	17.0	В												
SB																						
	LTR	466	0.082	0.300	LTR	0.275	16.1	В	16.1	В												
	LIK	400	0.082	0.300	LIK	0.273	10.1	В	10.1	В												

Intersection: Delay = 10.2 sec/veh SIG/Cinema v3.08

Int. LOS=B $X_c = 0.37$

* Critical Lane Group

 \sum (v/s)Crit= 0.31

Marvin & Associates

Mary Alignment Bitteroot Alt C R Marvin Design Hour PM Mary Alignment/Bitteroot 11/29/2011

Case: Mary Align & Bitteroot Alt C 2035 PM

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	50 30 40 V
EB	L	0 / 0	28.9	0.0	4 4
	TR	2/3	18.2	0.0	
					<u>↓</u> 110
	All		18.2	0.0	↓
WB	L	1 / 2	14.5	0.0	
	TR	3 / 4	17.7	0.0	
					10 -
	All		17.4	0.0	360 →
NB	LTR	2/3	16.5	0.0	
					20 95
	All		16.5	0.0	
SB	LTR	2 / 2	14.6	0.0	
					31 4 2 17 1 4 2
	All		14.6	0.0	
	Inte	rsect.	17.2		

	TW	O-WAY STOP	CONTRO	OL SUM	MARY				
General Information	<u> </u>		Site Ir	nformat	ion				
Analyst	R Marvin		Interse	ction		Mary & B	itteroot Al	l Options	
Agency/Co.	Marvin A	ssociates	Jurisdi	ction		MDT		•	
Date Performed	10/8/201	1	Analys	is Year		Year 203	5		
Analysis Time Period	Design H	our PM							
Project Description Bil	lings Bypass								
East/West Street: Mary	Street		North/S	South Stre	eet: <i>Bittero</i>	ot			
Intersection Orientation:	North-South		Study F	Period (hr	s): 0.25				
Vehicle Volumes ar	nd Adjustme	nts							
Major Street		Northbound				Southbou	ınd		
Movement	1	2	3		4	5		6	
	L	T	R		L	T		R	
Volume (veh/h)	30	180	35		5	120		50	
Peak-Hour Factor, PHF	0.80	0.80	0.80		0.75	0.75		0.75	
Hourly Flow Rate, HFR (veh/h)	37	224	43		6	160		66	
Percent Heavy Vehicles	0				0				
Median Type				Undivid	ed				
RT Channelized			0					0	
Lanes	0	1	0		0	1		0	
Configuration	LTR				LTR				
Upstream Signal		0				0			
Minor Street		Eastbound				Westbou	nd		
Movement	7	8	9		10	11		12	
	L	Т	R		L	Т		R	
Volume (veh/h)	40	30	40		10	15		5	
Peak-Hour Factor, PHF	0.70	0.70	0.70		0.60	0.60		0.60	
Hourly Flow Rate, HFR (veh/h)	57	42	57		16	24		8	
Percent Heavy Vehicles	0	0	0		0	0		0	
Percent Grade (%)		0				0			
Flared Approach		N				N			
Storage		0				0			
RT Channelized			0					0	
Lanes	0	1	0		0	1		0	
Configuration		LTR				LTR			
Delay, Queue Length, a	nd Level of Se	rvice	·				· · · · · · · · · · · · · · · · · · ·		
Approach	Northbound	Southbound	\	Westbour	nd		Eastbound	d	
Movement	1	4	7	8	9	10	11	12	
Lane Configuration	LTR	LTR		LTR		†	LTR	1	
v (veh/h)	37	6		48		Ť T	156	1	
C (m) (veh/h)	1354	1308		434		1	520	1	
v/c	0.03	0.00		0.11		1	0.30	1	
95% queue length	0.08	0.01		0.37	+	†	1.25	†	
Control Delay (s/veh)	7.7	7.8		14.3	+	 	14.9	+	
LOS	A	A A		В	+	†	В	+	
Approach Delay (s/veh)			14.3		 	14.9	1		
Approach LOS		<u></u>	B B						
Copyright © 2010 University of Flo			<u> </u>	CS.TM Vor		Generated: 12/22/2011 2:4			

HCS+TM Version 5.6

Generated: 12/22/2011 2:47 PM

Mary Alignment Bitterroot Alt D

R Marvin
Design Hour PM

Mary Alignment/Bitteroot
Area Type: Non CBD

4/6/12
Analysis Duration: 15 mins.
Case: MARY ALIGN & BITTEROOT ALT D 2035 PM

	sign Hour	PM				Case: MARY ALIGN & BITTEROOT ALT D 2035 PM								111113.		
	Lanes					Geor	metry: Mo	vements	Serviced l	y Lane ar	nd Lane W	idths (f	eet)			
	Approach	Outbound	1	Lane	e 1	La	ne 2	La	ane 3	La	ne 4	La	ane 5	La	ne 6	
EB	3	2	1	L	12.0	Т	12.0	TR	12.0							
WB	3	2	I	L	12.0	Т	12.0	TR	12.0							
NB	2	1]	L	12.0	TR	12.0									
SB	2	1	J	L	12.0	TR	12.0									
					East			West			North			South		
	Data		I	L	T	R	L	Т	R	L	Т	R	L	Т	R	
Move	ment Volun	ne (vph)		10	410	10	120	535	50	20	100	75	45	50	30	
PHF			0.	.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
% He	% Heavy Vehicles			1	4	0	0	4	1	0	1	0	0	1	0	
Lane	Lane Groups			L	TR		L	TR		L	TR		L	TR		
Arriv	al Type			3	3		3	3		3	3		3	3		
RTO	R Vol (vph)				0			10			25			5		
Peds/	Hour				5			5			5			5		
% Gr	ade				0			0			0		0		0	
Buses	s/Hour				0			0			0			0		
Parke	rs/Hour (Le	ft Right)														
Signa	l Settings: A	Actuated		(Operati	onal Analy	/sis	Cycl	le Length:	60.0 Sec	2	Lost Tin	ne Per Cyc	le: 10.0 S	ec	
Phase	:	1		2	2	3	4		5	6		7	8	Pe	d Only	
EB		LTP														
WB	WB LTP															
NB				LT	ГР											
SB				LT												
Greei		32.0			3.0								1		0	
Yello	w All Red	3.5	1.5	3.5	1.5											

			Conor	city Analysis R	aculta				Annua	oh.
	T								Approa	CII.
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay (sec/veh)		Delay	
App	Group	(vph)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB										
	L	392	0.015	0.533	L	0.028	6.8	Α	7.9	Α
	TR	1845	0.135	0.533	TR	0.253	7.9	Α		
WB										
	L	489	0.145	0.533	L	0.272	9.0	A	8.6	Α
	* TR	1831	0.186	0.533	TR	0.348	8.5	A		
NB										
	L	399	0.017	0.300	L	0.055	15.0	В	16.2	В
	* TR	535	0.094	0.300	TR	0.312	16.3	В		
SB										
	L	370	0.041	0.300	L	0.135	15.4	В	15.4	В
	TR	535	0.047	0.300	TR	0.157	15.5	В		

Intersection: Delay = 9.9 sec/veh SIG/Cinema v3.08

Int. LOS=A

34 * Critical Lane Group

 \geq (v/s)Crit= 0.28

Marvin & Associates

Mary Alignment Bitterroot Alt D R Marvin Design Hour PM Mary Alignment/Bitteroot 4/6/12

Case: MARY ALIGN & BITTEROOT ALT D 2035

	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	50 30 45
EB	L	0 / 0	27.4	0.0	- 50
	TR	2 / 4	18.7	0.0	- 535
	All		18.8	0.0	
WB	L	2/3	8.4	0.0	
	TR	3 / 6	18.6	0.0	
	All		17.2	0.0	410 →
NB	L	0 / 1	14.8	0.0	
	TR	2/3	15.9	0.0	
					$\begin{vmatrix} & & & 20 & 75 \\ & & 100 \end{vmatrix}$
	All		15.8	0.0	
SB	L	0 / 2	14.4	0.0	1 2 11
	TR	1 / 2	14.9	0.0	
					31 4 2 17
	All		14.7	0.0	
	Inte	rsect.	17.2		

Mary Alignment Bitterroot Alt E Mary Alignment/Bitteroot Area Type: Non CBD 4/6/12 Analysis Duration: 15 mins. R Marvin

Des	sign Hour	PM		Case: MARY ALIGN & BITTEROOT ALT E Cap Geometry: Movements Serviced by Lane and Lane Widths (feet)											
	Lanes					Geo	metry: Mo	ovement	s Serviced	by Lane ar	nd Lane V	Vidths (1	feet)		
	Approach (Outboun	d	Lane	e 1	La	ine 2	L	ane 3	La	ne 4	L	ane 5	La	ne 6
EB	3	2		L	12.0	Т	12.0	TR	12.0						
WB	3	2		L	12.0	Т	12.0	TR	12.0						
NB	2	1		L	12.0	TR	12.0								
SB	2	1		L	12.0	TR	12.0								
					East			West			North			South	
	Data			L	T	R	L	Т	R	L	Т	R	L	T	R
Move	ement Volun	ne (vph)		25	375	50	90	550	65	50	80	105	45	25	50
PHF			0	.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
% He	% Heavy Vehicles			1	4	0	0	4	1	0	1	0	0	1	0
Lane	Lane Groups			L	TR		L	TR		L	TR		L	TR	
Arriv	al Type			3	3		3	3		3	3		3	3	
RTO	R Vol (vph)				0			15			35			10	
Peds/	Hour				5			5			5			5	
% Gr	ade				0			0			0			0	
Buses	s/Hour				0			0			0			0	
Parke	rs/Hour (Le	ft Right))												
Signa	l Settings: A	ctuated			Operati	onal Anal	ysis	Сус	le Length:	60.0 Sec	c	Lost Tir	ne Per Cyc	le: 10.0 S	ec
Phase	»:	1		2	2	3	4	ļ.	5	6		7	8	Pe	ed Only
EB		LT	P												
WB		LT	P												
NB				LT	ГР										
SB				LT	ГР										
Green	1	32.	0	18	3.0										0
Yello	w All Red	3.5	1.5	3.5	1.5										

	Capacity Analysis Results Approach: Long Cop V/G Long V/G Delay Delay Delay													
	_	~				,	·			CII.				
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay	1.00	Delay	LOG				
App	Group	(vph)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS				
EB	_				_									
	L	377	0.040	0.533	L	0.074	7.2	A	7.9	Α				
	TR	1818	0.139	0.533	TR	0.260	7.9	A						
WB														
	L	486	0.110	0.533	L	0.206	8.3	A	8.6	A				
	* TR	1827	0.195	0.533	TR	0.365	8.7	A						
			0.1270			0.000								
NB														
	L	403	0.042	0.300	L	0.139	15.4	В	16.1	В				
	* TR	529	0.095	0.300	TR	0.316	16.4	В						
SB														
	L	370	0.041	0.300	L	0.135	15.4	В	15.4	В				
	TR	516	0.042	0.300	TR	0.140	15.4	В						

Intersection: Delay = 9.9 sec/veh SIG/Cinema v3.08

Int. LOS=A

 $X_c = 0.35$ * C Marvin & Associates * Critical Lane Group

 \sum (v/s)Crit= 0.29

Mary Alignment Bitterroot Alt E R Marvin Design Hour PM Mary Alignment/Bitteroot 4/6/12 Case: MARY ALIGN & BITTEROOT ALT E Cap

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	25 50 45
EB	L	0 / 1	11.6	0.0	←
	TR	3/3	18.4	0.0	
					- 90
	All		18.1	0.0	
WB	L	1 / 2	8.9	0.0	
	TR	3 / 4	18.4	0.0	
					25 -
	All		17.6	0.0	375 →
NB	L	1 / 2	12.7	0.0	50 —
	TR	2/3	15.9	0.0	
					50 105
	All		15.1	0.0	
SB	L	0 / 2	16.0	0.0	$egin{array}{ c c c c c c c c c c c c c c c c c c c$
	TR	1 / 1	20.4	0.0	
					31 4 2 17
	All		18.3	0.0	
	Inte	rsect.	17.3		

Mary Alignment Bitterroot Alt F Mary Alignment/Bitteroot Area Type: Non CBD 4/6/12 Analysis Duration: 15 mins. R Marvin

Des	sign Hour	PM		Case: MARY ALIGN & BITTEROOT ALT F Cap Geometry: Movements Serviced by Lane and Lane Widths (feet)											
	Lanes					Geo	metry: Mo	ovements	Serviced l	y Lane ar	nd Lane W	/idths (1	feet)		
	Approach (Outbour	ıd	Lane	e 1	La	ine 2	L	ane 3	Laı	ne 4	L	ane 5	La	ne 6
EB	3	2		L	12.0	Т	12.0	TR	12.0						
WB	3	2		L	12.0	T	12.0	TR	12.0						
NB	2	1		L	12.0	TR	12.0								
SB	2	1		L	12.0	TR	12.0								
					East			West			North			South	
	Data			L	T	R	L	Т	R	L	T	R	L	T	R
Move	ment Volun	ne (vph))	10	360	10	110	520	110	20	110	95	40	50	30
PHF			0	.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
% He	% Heavy Vehicles			1	4	0	0	4	1	0	1	0	0	1	0
Lane	Lane Groups			L	TR		L	TR		L	TR		L	TR	
Arriv	al Type			3	3		3	3		3	3		3	3	
RTOI	R Vol (vph)				0			15			35			10	
Peds/	Hour				5			5			5			5	
% Gr	ade				0			0			0			0	
Buses	/Hour				0			0			0			0	
Parke	rs/Hour (Le	ft Right])												
Signa	1 Settings: A	ctuated			Operati	onal Anal	ysis	Cyc	le Length:	60.0 Sec	:	Lost Tir	ne Per Cyc	le: 10.0 S	ec
Phase	:	1		2	2	3	4		5	6		7	8	Pe	ed Only
EB		LT	P												
WB		LT	P												
NB				LT	ГР										
SB				LT											
Greer	1	32.	.0	18	3.0										0
Yello	w All Red	3.5	1.5	3.5	1.5										

	Capacity Analysis Results												
	T								Approa	CII.			
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay				
App	Group	(vph)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS			
EB													
	L	367	0.016	0.533	L	0.030	6.8	Α	7.7	Α			
	TR	1844	0.119	0.533	TR	0.223	7.7	A					
WB													
	L	516	0.126	0.533	L	0.236	8.6	A	8.7	Α			
	* TR	1825	0.200	0.533	TR	0.375	8.8	A					
NB													
	L	401	0.016	0.300	L	0.055	15.0	В	16.4	В			
	* TR	533	0.106	0.300	TR	0.355	16.6	В					
SB													
	L	363	0.036	0.300	L	0.121	15.3	В	15.4	В			
	TR	540	0.043	0.300	TR	0.144	15.4	В					

Intersection: Delay = 10.0 sec/veh SIG/Cinema v3.08

Int. LOS=A

 $X_c = 0.37$ * C Marvin & Associates * Critical Lane Group

 $\sum (v/s)$ Crit= 0.31

Mary Alignment Bitterroot Alt F R Marvin Design Hour PM Mary Alignment/Bitteroot 4/6/12 Case: MARY ALIGN & BITTEROOT ALT F Cap

App EB	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	50 30 40
ЕБ	TR	2/3	18.0	0.0	110
	IK	2/3	16.0	0.0	→ 520 → 110
	All		18.1	0.0	↓
WB	L	1 / 2	15.3	0.0	
	TR	4 / 5	17.5	0.0	
	All		17.4	0.0	360 →
NB	L	0 / 1	6.4	0.0	
	TR	2 / 4	16.9	0.0	
					20 95
	All		16.1	0.0	
SB	L	1 / 2	9.6	0.0	
	TR	1 / 2	18.8	0.0	
					31 4 2 17 4 2
	All		15.5	0.0	
	Inte	rsect.	17.2		

Mary Alignment Bitterroot Alt G Mary Alignment/Bitteroot Area Type: Non CBD

R Marvin 4/6/12 Analysis Duration: 15 mins.

Design Hour PM Case: MARY ALIGN & BITTEROOT ALT G Cap

Des	sign Hour	PM						Case	: MA	RY	ALIG	N & F	311.1.	ERO	OT AI	LT G	Cap		
	Lanes					G	Geome	try: Mo	vemen	ıts Ser	viced b	y Lane	and L	ane W	idths (feet)			
	Approach	Outbour	ıd	Lane	e 1		Lane	2		Lane	3	I	ane 4		L	ane 5		Laı	ne 6
EB	3	2		L	12.0	Т		12.0	TR		12.0								
WB	3	2		L	12.0	Т		12.0	TR		12.0								
NB	2	1		L	12.0	TR	٤	12.0											
SB	2	1		L	12.0	TR	١	12.0											
					East				Wes	st			N	orth			South		
	Data			L	T	R		L	Т		R	L		T	R	I	_	Т	R
Move	ment Volun	ne (vph))	10	360	10	О	135	520)	65	20		105	150		15	50	30
PHF			0	.90	0.90	0.90	0	0.90	0.90	О	0.90	0.90	C	.90	0.90	0.9	90	0.90	0.90
% He	avy Vehicle	es		1	4	0)	0	4		1	0		1	0		0	1	0
Lane	Groups			L	TR			L	TR			L	,	ΓR		I		TR	
Arriva	al Type			3	3			3	3			3		3		3	3	3	
RTOF	R Vol (vph)				0				15	5				50				10	
Peds/l	Hour				5				5					5				5	
% Gra	ade				0				0					0				0	
Buses	/Hour				0				0					0				0	
Parke	rs/Hour (Le	ft Right)										-						
Signa	l Settings: A	Actuated			Operati	onal Ar	nalysis	s	Cy	cle L	ength:	60.0 S	lec]	Lost Tir	ne Per	Cycle	: 10.0 S	ec
Phase	:	1		2	2	3		4			5	6			7	8	3	Pe	d Only
EB		LT	P																
WB		LT	P																
NB				L	ГР														
SB				L	ГР														
Green	ı	32	.0	18	3.0							<u> </u>							0
Yello	w All Red	3.5	1.5	3.5	1.5														

	Capacity Analysis Results												
	T								Approa	CII.			
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay				
App	Group	(vph)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS			
EB													
	L	394	0.015	0.533	L	0.028	6.8	Α	7.7	Α			
	TR	1844	0.119	0.533	TR	0.223	7.7	A					
WB													
	L	516	0.155	0.533	L	0.291	9.2	A	8.7	Α			
	* TR	1826	0.185	0.533	TR	0.347	8.5	A					
NB													
	L	401	0.016	0.300	L	0.055	15.0	В	16.9	В			
	* TR	527	0.130	0.300	TR	0.433	17.1	В					
SB													
	L	329	0.046	0.300	L	0.152	15.5	В	15.4	В			
	TR	540	0.043	0.300	TR	0.144	15.4	В					

Intersection: Delay = 10.2 sec/veh SIG/Cinema v3.08

Int. LOS=B

= 0.38 * Critical Lane Group

 \geq (v/s)Crit= 0.31

Marvin & Associates

Mary Alignment Bitterroot Alt G R Marvin Design Hour PM Mary Alignment/Bitteroot 4/6/12

Case: MARY ALIGN & BITTEROOT ALT G Cap

App EB	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	50 30 45 , ,
	TR	2/3	18.1	0.0	<u>← 65</u>
					→ 520 → 135
	All		18.1	0.0	<u></u>
WB	L	1 / 2	10.3	0.0	
	TR	3 / 4	18.9	0.0	
					10 -
	All		17.8	0.0	360 →
NB	L	0 / 1	9.6	0.0	
	TR	2 / 4	16.2	0.0	
					20 150 105
	All		15.7	0.0	
SB	L	0 / 2	11.9	0.0	1 2 !!!
	TR	1 / 2	16.7	0.0	===
					31 4 2 17 4 2
	All		15.5	0.0	
	Inte	rsect.	17.2		

	TW	O-WAY STOP	CONTR	OL SI	JMN	//ARY					
General Information	<u> </u>		Site I	nform	atic	on .					
Analyst	R Marvin		Interse	ection			Mary Stre	et & E	Bitterr	oot Opt	
Agency/Co.	MArvin A		⊣ I∟——	Thurst aliation				D			
Date Performed	4/6/2012		Jurisdiction				MDT				
Analysis Time Period	PM Desig	gn	Analysis Year				2035				
Drainet Description Di	llings Dungs						<u> </u>				
Project Description <i>Bil</i> East/West Street: <i>Mary</i>	lings Bypass Street		North/S	South S	troot	t: Bitterro	ot Drive				
Intersection Orientation:						: 0.25	JI DIIVE				
Vehicle Volumes ar		nte	jotady i	onou ((1110)	. 0.20					
Major Street	Aujustine	Northbound					Southbou	ınd			
Movement	1	2	3	+		4	5	T		6	
MOVEMENT	 	T	R	- 		L	T	o		R	
Volume (veh/h)	 	180	25				130			50	
Peak-Hour Factor, PHF	1.00	0.90	0.90	,		1.00	0.90		(0.90	
Hourly Flow Rate, HFR (veh/h)	0	200	27			0	144			55	
Percent Heavy Vehicles	0					0					
Median Type			•	Raised	d cur	b	•				
RT Channelized			0							0	
Lanes	0	1	0	ĺ		0	1			0	
Configuration			TR							TR	
Upstream Signal		0					0				
Minor Street		Eastbound		ĺ			Westbou	nd			
Movement	7	8	9			10	11			12	
	L	Т	R			L	Т			R	
Volume (veh/h)			40							15	
Peak-Hour Factor, PHF	1.00	1.00	0.90	'		1.00	1.00		(0.90	
Hourly Flow Rate, HFR (veh/h)	0	0	44			0	0			16	
Percent Heavy Vehicles	0	0	0			0	0			0	
Percent Grade (%)		0					0				
Flared Approach		N					N				
Storage		0					0				
RT Channelized			0							0	
Lanes	0	0	1			0	0			1	
Configuration			R							R	
Delay, Queue Length, a	nd Level of Se		_								
Approach	Northbound	Southbound	'	Westbo	ound		E	Eastbo	und		
Movement	1	4	7	8	\Box	9	10	1	1	12	
Lane Configuration						R				R	
v (veh/h)						16				44	
C (m) (veh/h)		i				831				877	
v/c					\neg	0.02	Ì			0.05	
95% queue length					\neg	0.06				0.16	
Control Delay (s/veh)		<u> </u>		<u> </u>	\dashv	9.4				9.3	
LOS				 	\dashv	A A	 	\vdash		A.	
Approach Delay (s/veh)				9. <i>4</i>		А	 	9.3)		
Approach LOS		 					-	9.3 A	'		
Approach LOS Copyright © 2010 University of Fl		<u></u>	<u> </u>	A HCS+ TM			<u> </u>		:	12 4:09 P	

HCS+TM Version 5.6

	TW	O-WAY STOP	CONTR	OL SI	UMN	MARY				
General Information	n		Site I	nform	natio	on				
Analyst	R Marvin		Interse	ection			Mary Stre	et & Bitte	rroot Opt	
Agency/Co.	Marvin A	ssociates	luriodi	otion			G MDT			
Date Performed	4/6/2012			Jurisdiction Analysis Year						
Analysis Time Period	PM Desig	n	Analys	is rea	.1		2035			
Project Description Bil	llings Bypass		Į. L				•			
East/West Street: Mary	Street		North/S	South S	Stree	t: Bitterro	ot Drive			
Intersection Orientation:	North-South		Study F	Period	(hrs)	: 0.25				
Vehicle Volumes ar	nd Adjustme	nts								
Major Street		Northbound					Southbou	ınd		
Movement	1	2	3			4	5		6	
	L	Т	R			L	Т		R	
Volume (veh/h)	30	205					130		65	
Peak-Hour Factor, PHF	0.90	0.90	1.00			1.00	0.90		0.90	
Hourly Flow Rate, HFR (veh/h)	33	227	0			0	144		72	
Percent Heavy Vehicles	0					0				
Median Type				Undi	vided	1				
RT Channelized			0						0	
Lanes	1	1	0			0	1		0	
Configuration	L	T							TR	
Upstream Signal		0					0			
Minor Street		Eastbound					Westbou	nd		
Movement	7	8	9			10	11		12	
	L	Т	R			L	Т		R	
Volume (veh/h)	40		70							
Peak-Hour Factor, PHF	1.00	1.00	1.00			1.00	1.00		1.00	
Hourly Flow Rate, HFR (veh/h)	40	0	70			0	0		0	
Percent Heavy Vehicles	0	0	0			0	0		0	
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0						0	
Lanes	0	0	0			0	0		0	
Configuration		LR								
Delay, Queue Length, a		rvice								
Approach	Northbound	Southbound	,	Westbo	ound		E	Eastbound	t	
Movement	1	4	7	8		9	10	11	12	
Lane Configuration	L							LR		
v (veh/h)	33							110		
C (m) (veh/h)	1366							711		
v/c	0.02							0.15		
95% queue length	0.07							0.55		
Control Delay (s/veh)	7.7							11.0		
LOS	A			\vdash				В	1	
Approach Delay (s/veh)						I		11.0		
Approach LOS								B		
Copyright © 2010 University of FI		ļ		HCS+TM	4				2012 4:11 P	

	TW	O-WAY STOP	CONTR	OL SU	MM	ARY					
General Information	n		Site I	nforma	ation	n					
Analyst	R Marvin		Interse	ection			Mary Alig		r		
Agency/Co.	Marvin A							Connection			
Date Performed	4/9/2012			Jurisdiction Analysis Year			MDT				
Analysis Time Period	Pm Desig	gn Hour	Analys	sis year			2035				
Project Description Bil	llings Bypass		<u> </u>								
East/West Street: Mary		nts	North/S	North/South Street: Minor Connection Road							
Intersection Orientation:			Study F	Period (I	nrs):	0.25					
Vehicle Volumes ar	nd Adjustme	nts									
Major Street		Eastbound					Westbou	nd			
Movement	1	2	3			4	5		6		
	L	Т	R			L	Т		R		
Volume (veh/h)	1	495	60			5	695		2		
Peak-Hour Factor, PHF	0.90	0.90	0.90)	C	0.90	0.90		0.90		
Hourly Flow Rate, HFR (veh/h)	1	550	66			5	772		2		
Percent Heavy Vehicles	0					0					
Median Type				Undivi	ided						
RT Channelized			0						0		
Lanes	1	2	0			1	2		0		
Configuration	L	T	TR			L	Т		TR		
Upstream Signal		0					0				
Minor Street		Northbound					Southbou	ınd			
Movement	7	8	9			10	11		12		
	L	Т	R			L	Т		R		
Volume (veh/h)	25	0	10			0	0		1		
Peak-Hour Factor, PHF	0.90	0.90	0.90)	С	0.90	0.90		0.90		
Hourly Flow Rate, HFR (veh/h)	27	0	11			0 0			1		
Percent Heavy Vehicles	0	0	0			0	0		0		
Percent Grade (%)		0					0	•			
Flared Approach		N					N				
Storage		0					0				
RT Channelized			0						0		
Lanes	0	1	0			0	1		0		
Configuration		LTR					LTR				
Delay, Queue Length, a		7									
Approach	Eastbound	Westbound		Northbo	und			outhbour	_		
Movement	1	4	7	8	\dashv	9	10	11	12		
Lane Configuration	L	L		LTR	\dashv			LTR			
v (veh/h)	1	5		38	_			1	-		
C (m) (veh/h)	851	974		260			665				
v/c	0.00	0.01		0.15	_			0.00			
95% queue length	0.00	0.02		0.50	_			0.00			
Control Delay (s/veh)	9.2	8.7		21.2				10.4			
LOS	Α	Α		С				В			
Approach Delay (s/veh)				21.2				10.4			
Approach LOS				С				В			
Copyright © 2010 University of Fl	orida. All Rights Res	erved		HCS+TM	Version	on 5.6	Gen	erated: 4/9/	2012 4:53 P		

HCS+TM Version 5.6



BILLINGS BYPASS EIS NCPD 56(55)CN 4199

SECTION 2: Geometric Design Report

Billings Bypass April, 2012







BILLINGS BYPASS EIS NCPD 56(55)CN 4199

Intentionally Blank Page.

GEOMETRIC DESIGN

DOWL HKM completed research on applicable design standards, and developed geometric design criteria for roadways as a part of this project. Summaries of their efforts are contained within the following memorandums and typical section drawings.

There are two memorandums included herein. The first memorandum is dated February 11, 2012 and it addresses the design standards applicable to the proposed alternative alignments associated with this project. It includes all of the alignments that were evaluated in the Draft Environmental Impact Statement (EIS). Each alignment is discussed and specific details relative to alignment length, surrounding land use, boundary conditions, functional classification, and speed limits are presented. Design standards applicable to each roadway classification under various jurisdictional controls are also detailed.

The second memorandum is dated February 22, 2012 and it deals with design criteria relative to each of the alignment alternatives. Design criteria are categorized by both Urban or Rural NHS Principal Arterial standards and the design speed is noted for each alternative alignment. Specific design elements are discussed and typical section drawings are provided for the corridor alignments.

The addition of Secondary Improvements to either Mary Street or Five Mile Road required investigations into City and County standard typical sections that would be required. Therefore, one additional drawing was added to the end of this report section that illustrates the required typical sections that would be associated with Secondary Corridor Improvements.

MEMORANDUM

TO: Laura Meyer, David Evans & Associates

Debra Perkins-Smith, David Evans & Associates

FROM: Doug Enderson, PE, PTOE

DOWL HKM

DATE: February 11, 2011

RE: Design Standards Memorandum

COPIES: Todd Cormier, DOWL HKM

John Shoff, DOWL HKM

Bob Marvin, Marvin & Associates

The purpose of this memorandum is to evaluate the current alignments illustrated on the Design Analysis Map (January 2011) produced by David Evans & Associates and to determine if the MDT National Highway System (NHS) Rural Principal Arterial design criteria can be met. The MDT NHS Rural Principal Arterial design criteria has been chosen as the base design criteria for evaluation and any deviations necessary from that criteria are discussed in the following table.

The design speed for an MDT NHS Rural Principal Arterial for level terrain is 70 mph. Additional design criteria for an MDT NHS facility is detailed within the attached design criteria matrix. For comparison, the matrix also includes design criteria for local jurisdictions. Ultimately, design criteria will be established individually for each alignment. For example, the Johnson alignments connected to the Mary Street alignments would be designed with urban design criteria for the entire alignment instead of having a rural segment (M-1a or M-1b) between two urban segments.

Information detailed in this memorandum will serve as the foundation for the development of the Design Criteria Memorandum, as well as the continued design and refinement of the alternatives for Activity 102.



Alignment	ID#	Design Standards Discussion			
South of Yellows	stone Ri	ver			
Johnson Lane	J-1	The NHS Rural Principal Arterial design criteria for level terrain fit within this segment. However, the current and future commercial/industrial land use along this alignment warrants an Urban Principal Arterial design criteria to minimize right-of-way impacts and optimize access along the route. Also if the Urban Principal Arterial design criteria are considered, this alignment could be shifted to follow the existing Coulson Road alignment to further minimize right-of-way impacts and still provide access to local businesses.			
	J-2	The NHS Rural Principal Arterial design criteria for level terrain fit within this segment. However, the current and future commercial/industrial land use along this alignment warrants an Urban Principal Arterial design criteria to minimize right-of-way impacts and optimize access along the route.			
Pinehills Interchange	P-1	The NHS Rural Principal Arterial design criteria for level terrain can be accommodated for this alignment.			
Pinehills Split Interchange	PS-1	The NHS Rural Principal Arterial design criteria for level terrain can be accommodated for this alignment.			
Yellowstone Rive	er Cross	ing			
All Alignment Options		The bridge options can meet any NHS Principal Arterial design criteria. How the chosen alignment enters or departs the bridge location may dictate the exact design criteria for the bridge structure.			
North of Yellows	stone Ri	ver			
Mary Street	M-1a	The NHS Rural Principal Arterial design criteria for level terrain (70 mph) <i>cannot</i> be met for this alignment without major impacts to Five Mile Creek and existing residential homes. The design criteria for rolling terrain (60 mph) are more desirable in this section to minimize right-of way impacts and to avoid the Five Mile Creek floodplain.			
Titaly Succe	M-1b	The NHS Rural Principal Arterial design criteria for level terrain (70 mph) <i>cannot</i> be met for this alignment without major impacts to Five Mile Creek and existing residential homes. The design criteria for rolling terrain (60 mph) are more desirable in this section to minimize right-of way impacts and to avoid the Five Mile Creek floodplain.			



	M-2	The NHS Rural Principal Arterial design criteria for level terrain can be met in this section as the segment is generally straight. However, residential development currently exists south of the alignment and a subdivided residential development exists north of the alignment. Also along this segment, the current residents directly access Mary Street on the south side of the alignment. An Urban Principal Arterial design criteria is recommended for this segment because of the current and future land use and access requirements. A frontage road may be necessary for access control along this segment.
	M-3	The transition to connect to the existing Old Highway 312 is recommended as a NHS Urban Principal Arterial with a maximum design speed of 55 mph to minimize impacts (right-of-way), improve safety through controlled speed, and as the alignment will be ending at a controlled at-grade intersection at Old Highway 312.
	L-1	The NHS Rural Principal Arterial design criteria for level terrain (70 mph) <i>cannot</i> be met for this segment without major impacts to Five Mile Creek. The design criteria for rolling terrain (60 mph) are more desirable in this section to minimize right-of way impacts and to avoid the Five Mile Creek floodplain.
Legacy Lane	L-2	The NHS Rural Principal Arterial design criteria for level terrain can be accommodated for this segment.
	L-3	The transition to connect to the existing Old Highway 312 is recommended as a NHS Urban Principal Arterial with a maximum design speed of 55 mph to minimize impacts (right-of-way), improve safety through controlled speed, and as the alignment will be ending at a controlled at-grade intersection at Old Highway 312.
	O-1	These segments can be designed to the NHS Rural Principal Arterial design criteria for level terrain as the alignment is a relatively straight
Oxbow Park	O-2	from the Yellowstone River crossing to the Old Highway 312 connection. If any horizontal curves need to be introduced, NHS Rural Principal Arterial design criteria can be accommodated.
OADOW FAIK	O-3	The transition to connect to the existing Old Highway 312 is recommended as a NHS Urban Principal Arterial with a maximum design speed of 55 mph to minimize impacts (right-of-way), improve safety through controlled speed, and as the alignment will be ending at a controlled at-grade intersection at Old Highway 312.
Five Mile Road	F-1	The NHS Rural Principal Arterial design criteria for level terrain can be accommodated for this segment.

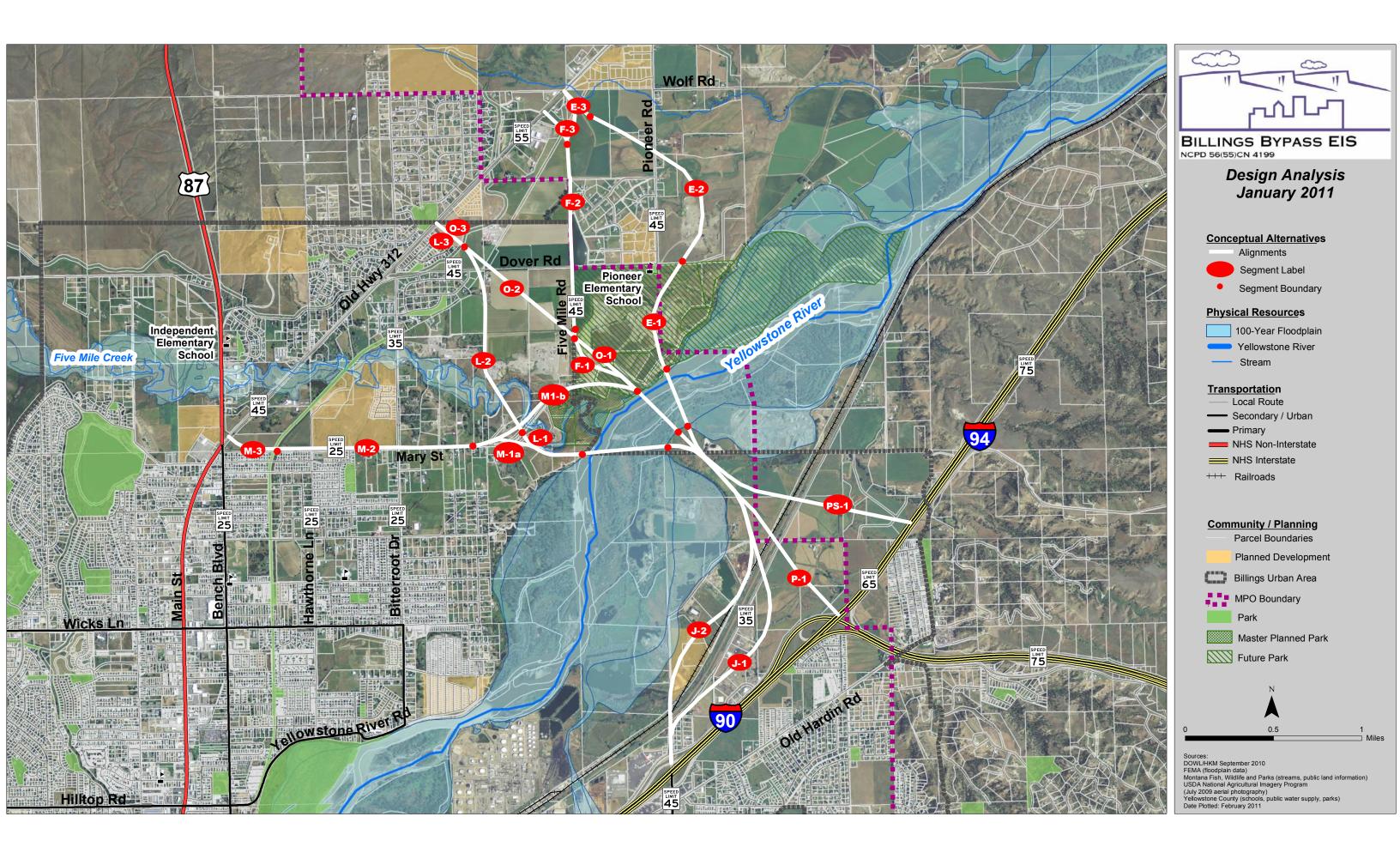


	F-2	The NHS Rural Principal Arterial design criteria for level terrain can be accommodated for this segment.				
	F-3	The transition to connect to the existing Old Highway 312 is recommended as a NHS Urban Principal Arterial with a maximum design speed of 55 mph to minimize impacts (right-of-way), improve safety through controlled speed, and as the alignment will be ending at a controlled at-grade intersection at Old Highway 312.				
	E-1	The NHS Rural Principal Arterial design criteria for level terrain can be accommodated for this segment.				
F1 F2	E-2	The NHS Rural Principal Arterial design criteria for level terrain carbe accommodated for this segment.				
E1-E3	E-3	The transition to connect to the existing Old Highway 312 is recommended as a NHS Urban Principal Arterial with a maximum design speed of 55 mph to minimize impacts (right-of-way), improve safety through controlled speed, and as the alignment will be ending at a controlled at-grade intersection at Old Highway 312.				

Attachments:

Design Analysis Map (January 2011) - Modified Design Analysis Matrix Design Criteria Matrix





Billings Bypass - Alternative Segment Data

	Segment Information				Character of Surrounding Area			Connecting Streets		
Alignment	ID Number	Description	Length (in miles)	Within MPO	Within Urban Area Boundary	Current Land Use (Based on 2009 Aerial Mapping)	Zoning	City/County Functional Classification	MDT Functional Classification	Speed Limits
outh of Yellowstone River										
Johnson Ln	J-1	Interstate to Yellowstone River floodplain (south option)	2.4	Yes	Yes	Agricultural / Industrial	Commercial/ Agricultural/ Industrial	Coulson Rd - Local Johnson Ln - Principal Arterial	Coulson Rd - Local Johnson Ln - Minor Arterial I-90 - Interstate Principal Arterial	Coulson Rd - 35 Johnson Ln - 45 I-90 - 65
Juliisul Eli	J-2	Interstate to Yellowstone River floodplain (north option)	2	Yes	Yes	Agricultural	Commercial/ Agricultural/ Industrial	Coulson Rd - Local Johnson Ln - Principal Arterial	Coulson Rd - Local Johnson Ln - Minor Arterial I-90 - Interstate Principal Arterial	Coulson Rd - 35 Johnson Ln - 45 I-90 - 65
Pinehills	P-1	Interstate to Yellowstone River floodplain	1.38	Yes	Yes	Agricultural	Agricultural	Coulson Rd - Local I-94 -Interstate	Coulson Rd - Local I-94 -Interstate Principal Arterial I-90 - Interstate Principal Arterial	Coulson Rd - 35 I-90 - 65 I-94 - 65
Pinehills Split	PS-1	Interstate to Yellowstone River floodplain	1.43	Yes	Yes	Agricultural	Agricultural	Coulson Rd - Local I-94 - Interstate I-90 - Interstate	Coulson Rd - Local I-94 - Interstate Principal Arterial I-90 - Interstate Principal Arterial	Coulson Rd - 35 I-90 - 65 I-94 - 65
Yellowstone River Crossing										
All Alignment Options	NA	Yellowstone River Floodplain	0.3 - 0.5	Yes	No	Floodplain	Agricultural	NA	NA	NA
North of Yellowstone River										
	M-1a	Yellowstone River floodplain to residential area (south option)	1.1	Yes	Yes	Agricultural / Low Density Residential	Agricultural	Mary St - Principal Arterial Five Mile Rd - Minor Arterial Flaming Creek - Local	Mary St - Urban Collector Five Mile Rd - Local Flaming Creek - Local	Mary St - 45 Five Mile Rd - 35 Flaming Creek - 25
	M1-b	Yellowstone River floodplain to residential area (north option)	1.5	Yes	Yes	Agricultural / Low Density Residential	Agricultural	Mary St - Principal Arterial Five Mile Rd - Minor Arterial	Mary St - Urban Collector Five Mile Rd - Local	Mary St - 45 Five Mile Rd - 35
Mary Street	M-2	Residential area to 312 transition	0.72	Yes	Yes	Residential / Agricultural	Residential / Agricultural	Mary St - Principal Arterial Bitterroot Dr - Principal Arterial Columbine Dr - Local Hawthorne Ln - Local	Mary St - Urban Collector Bitterroot Dr - Urban Collector (south) Bitterroot Dr - Local (north) Columbine Dr - Local Hawthorne Ln - Local	Mary St - 45 Bitterroot Dr - 25 Columbine Dr - 25 Hawthorne Ln - 25
	M-3	Transition to Old Hwy 312	0.25	Yes	Yes	Residential/ Agricultural	Agricultural/ Residential/ Commercial	Old Hwy 312 - US Hwy	Old Hwy 312 - Minor Arterial	Old Hwy 312 - 45
	L-1	Yellowstone River floodplain to Mary Street	0.37	Yes	Yes	Agricultural	Agricultural	Five Mile Rd - Minor Arterial	Five Mile Rd - Local	Five Mile Rd - 35
Legacy Lane	L-2	Mary Street to Old Hwy 312 transition	1.16	Yes	Yes	Agricultural / Low Density Residential	Agricultural/ Suburban Agricultural/ Residential	Five Mile Rd - Minor Arterial Dover Rd - Minor Arterial	Five Mile Rd - Local Dover Rd - Local	Five Mile Rd - 35 Dover Rd - 45
	L-3	Transition to Old Hwy 312	0.25	Yes	No	Residential	Residential	Old Hwy 312 - US Hwy	Old Hwy 312 - Minor Arterial	Old Hwy 312 - 55
	O-1	Yellowstone River floodplain to Five Mile Road	0.47	Yes	No	Mining (Future Park)	Agricultural	NA	NA	NA
Oxbow Park	0-2	Five Mile Road to 312 transition	0.78	Yes	Yes	Agricultural	Agricultural	Dover Rd - Minor Arterial Five Mile Rd - Minor Arterial	Dover Rd - Local Five Mile Rd - Local	Dover Rd - 45 Five Mile Rd - 45
	O-3	Transition to Old Hwy 312	0.25	Yes	Yes	Residential	Residential	Old Hwy 312 - US Hwy	Old Hwy 312 - Minor Arterial	Old Hwy 312 - 55
	F-1	Yellowstone River floodplain to Five Mile Road	0.54	Yes	No	Mining (Future Park)	Agricultural	Five Mile Rd - Minor Arterial	Five Mile Rd - Local	Five Mile Rd - 45
Five Mile Road	F-2	Five Mile Road to 312 transition	1.57	Partial	On border	Agricultural	Agricultural/ Beyond Zoning Limits	Dover Rd - Minor Arterial	Dover Rd - Local	Dover Rd - 45
	F-3	Transition to Old Hwy 312	0.25	No	No	Agricultural / Low Density Residential	Beyond Zoning Limits	Old Hwy 312 - US Hwy	Old Hwy 312 - Minor Arterial	Old Hwy 312 - 55
	E-1	Yellowstone River floodplain to Dover Road	0.65	Partial	No	Mining (Future Park)	Agricultural/ Beyond Zoning Limits	Dover Rd - Minor Arterial	Dover Rd - Local	Dover Rd - 45
E1-E3	E-2	Dover Road to 312 transition	1.2	No	No	Agricultural	Beyond Zoning Limits	Pioneer Rd - Minor Arterial Dover Rd - Minor Arterial	Pioneer Rd - Local Dover Rd - Local	Pioneer Rd - 45 Dover Rd - 45
	E-3	Transition to Old Hwy 312	0.25	No	No	Agricultural / Low Density Residential	Beyond Zoning Limits	Old Hwy 312 - US Hwy	Old Hwy 312 - Minor Arterial	Old Hwy 312 - 55

			V-IIt Ct		
Design Elements	Bypass Mainline - Rural	MDT Bypass Mainline - Urban	Bypass Mainline - Urban	City of Billings	Yellowstone County
Design Standards	NHS - Rural Principal Arterial (MDT Traffic Engr. Manual)	NHS - Urban Principal Arterial (MDT Traffic Engr. Manual)	Non-NHS Urban Principal Arterial ²	Subdivision Regulations, AASHTO	Subdivision Regulations, AASHTO
Lanes	2 - 4 lanes	4 lanes plus center turn lane	4 lanes plus center turn lane	4 lanes plus center turn lane	4 lanes plus center turn lane
Design Speed	Level = 70mph Rolling = 60 mph Mountainous = 50 mph	40 - 55 mph (Uncurbed, Multi-lane)	40 mph	-	-
Vertical Grade (max)	Level = 3% Rolling = 4% Mountainous = 7%	Level = 6% (40-50mph), 5% (55mph) Rolling = 7% (40-50mph), 6% (55mph) Mountainous = 9% (40-50mph), 8% (55mph)	7% max grade (desirable) 10% max grade (with approval)	Per AASHTO	Per AASHTO
Superelevation	e _{max} = 8%	40-45 mph: e _{max} = 4% 50-55 mph: e _{max} = 8%	e _{max} = 4%	Per AASHTO	Per AASHTO
Vertical Curve (Sag)	Level: K = 96 Rolling: K = 136 Mountainous: K = 181	40 mph: K = 64 45 mph: K = 79 50 mph: K = 96 55 mph: K = 115	K = 64 (desirable)	Per AASHTO	Per AASHTO
Vertical Curve (Crest)	Level: K = 84 Rolling: K = 151 Mountainous: K = 247	40 mph: K = 44 45 mph: K = 61 50 mph: K = 84 55 mph: K = 114	K = 44 (desirable)	Per AASHTO	Per AASHTO
Horizontal Curve (min)	Level = 1810 ft at e_{max} Rolling = 1200 ft at e_{max} Mountainous = 758 ft at e_{max}	40 mph = 533' 45 mph = 711' 50 mph = 760' 55 mph = 960'	533 ft. (40 mph @ e _{max})	Per AASHTO	Per AASHTO
Access Control	Limited Control of Access at discretion of MDT	Limited Control of Access at discretion of MDT	Limited Control of Access at discretion of MDT	-	-
Right of Way Requirements					
R/W Width	160 ft. (min.) ³ (80 ft. from C.L. each side)	160 ft. (min.) ³ (80 ft. from C.L. each side)	140 ft. (approx.) ³ (70 ft. from C.L. each side)	130 ft. Desired	120 ft. Desired
Typical Section Elements					
Driving Lane	12 ft.	4 at 12-ft; Turn Lane at 16 ft.	12' Outside, 11' Inside, 12' Turn Lane	14 ft. TWLTL; 11 ft. inside; 12 ft. outside	14 ft. TWLTL; 12 ft. inside; 14 ft. outside
Shoulder	8 ft.	8 ft.	6 ft.	Shoulder project specific 10 ft. boulevard	
Stormwater	Roadside ditches	Project Specific	Project Specific	Project Specific	Roadside ditches or project specific
Roadway Width	40 ft., Two Lane (min.) or project specific	80 ft.	70 ft.	64 - 86 ft.	92 ft.
Bicycles	Provided on shoulder (no striped bike lane)	Project Specific	4 ft. (minimum) 5 ft. (desirable)	Bike lanes (case-by-case) 1	Bike lanes (case-by-case) 1
Sidewalk	NA	5 - 10 ft.	5 ft.	5 ft. & 10 ft. (Min.) 10 ft. & 10 ft. (Desired)	5 ft.
Median	As Required 14 ft. (min); 50 ft. (desireable)	TWLTL or project specific	4 ft. (raised) (min.)	-	-
Cross Slope	2% Crown (typical)	2% Crown (typical)	1.5% (minimum) 2% (desirable)	2% Crown (typical)	2% Crown (typical)
Frontage Road	-	-	-	-	-

¹ Based on current update to Billings Area Bikeway and Trail Master Plan Draft Report (Jan 2011)

² From the Montana Department of Transportation Geometric Design Standards for Urban and Developed Areas

³ Final rightof-way width will contain all design elements plus 10 feet.

MEMORANDUM

TO: Laura Meyer, David Evans & Associates

Debra Perkins-Smith, David Evans & Associates

FROM: Doug Enderson, PE, PTOE

DOWL HKM

DATE: February 22, 2011

RE: Design Criteria Technical Memorandum

COPIES: Todd Cormier, DOWL HKM

John Shoff, DOWL HKM

Bob Marvin, Marvin & Associates

INTRODUCTION

The Billings North Bypass Feasibility Study, NCPD 56(42) CN 4199, was completed in 2001. Initially, the bypass route was planned to connect the I-90/94 interchange area east of Billings with N-53 (MT 3) northwest of Billings. This route would also serve local traffic by providing an alternative route for local traffic traversing eastern and northeastern portions of the city. This study concluded that a bypass was feasible from an economic and engineering perspective and should be advanced for environmental analysis and refinement. In 2010, the scope of the project was amended to study a bypass connecting the I-90/94 interchange area east of Billings with Old Highway 312.

An environmental impact statement (EIS) is now being prepared toward the continued development of the bypass. For design purposes associated with the EIS, this Design Criteria Technical Memorandum is being prepared to identify the appropriate geometric design criteria applicable to each classification of roadway and corresponding alignment segment to be included within the project boundary. On February 11, 2011 a design standards memorandum was completed and submitted to the Montana Department of Transportation (MDT) as an initial screening of the design criteria used for each bypass alternative. MDT and FHWA approved the design standards memorandum in a teleconference discussion on February 17, 2011. The design criteria identified in that memorandum will be reiterated and expanded upon in this document and ultimately serve as the basis for preliminary design throughout the EIS process.

EXISTING CONDITIONS

Currently, no portion of a bypass exists as a functional roadway or as undeveloped right-of-way for the purpose of future development of a bypass, although some elements or portions of



existing roadways and right-of-way within the study area may be utilized for the development of the final alignment.

EVALUATION GUIDELINES

Design criteria are based on current MDT design guidelines as detailed within the MDT Road Design Manual, and corresponding design manuals. A design criteria matrix was created for initial evaluation purposes for the design standards memorandum. That matrix included MDT design standards and for purposes of comparison, also included Yellowstone County and City of Billings design standards. The matrix is attached to this memorandum for information purposes.

The following table summarizes the design criteria identified in the design standards memorandum and was approved by MDT. The attached figure identifies the locations of the alignment segments corresponding to the ID# in the table below:

Alignment	ID#	MDT Design Criteria	Proposed Design Speed	
South of Yellows	stone Ri	ver		
Johnson Lane	J-1	NHS Urban Principal Arterial	55 mph	
Johnson Lane	J-2	NHS Urban Principal Arterial	55 mph	
Pinehills Interchange	P-1	NHS Rural Principal Arterial	70 mph	
Pinehills Split Interchange	PS-1	NHS Rural Principal Arterial	70 mph	
Yellowstone Rive	er Cross	ing		
All Alignment Options		The bridge options can meet any NH How the chosen alignment enters o dictate the exact design criteria for the	r departs the bridge location may	
North of Yellows	stone Ri	ver		
	M-1a	NHS Rural Principal Arterial	60 mph	
Mary Street	M-1b	NHS Rural Principal Arterial	60 mph	
	M-2	NHS Urban Principal Arterial	55 mph	



	M-3	NHS Urban Principal Arterial	55 mph	
	L-1	NHS Rural Principal Arterial	60 mph	
Legacy Lane	L-2	NHS Rural Principal Arterial	70 mph	
	L-3	NHS Urban Principal Arterial	55 mph	
	O-1	NITIC D. I.D I.A I	70 1	
Oxbow Park	O-2	NHS Rural Principal Arterial	70 mph	
	O-3	NHS Urban Principal Arterial	55 mph	
	F-1	NHS Rural Principal Arterial	70 mph	
Five Mile Road	F-2	NHS Rural Principal Arterial	70 mph	
	F-3	NHS Urban Principal Arterial	55 mph	
	E-1	NHS Rural Principal Arterial	70 mph	
E1-E3	E-2	NHS Rural Principal Arterial	70 mph	
	E-3	NHS Urban Principal Arterial	55 mph	

The design criteria identified in the table above are the maximum criteria to be used for each segment. Ultimately, design criteria will be established individually for each alignment once the preferred alignment is chosen for final evaluation. For example, the Johnson Lane alignments connected to the Mary Street alignments would be designed with urban design criteria for the entire alignment instead of having a rural segment (M-1a or M-1b) between two urban segments (M-2 and J-1 or J-2).

DESIGN ELEMENTS

Vertical/Horizontal Geometry: Vertical profiles and horizontal alignments will be developed based on the design criteria presented herein, and will be evaluated based on standard design



guidelines and project constraints including basic design parameters (design speed, minimum radii, K-values, etc.), utility locations, environmental and social considerations, right-of-way, and minimizing impacts overall. Two-foot contour mapping of the corridor will be used to determine the vertical and horizontal elements of each alignment identified on the alternatives map.

Typical Sections: Typical sections for each of the design criteria alternatives discussed above are provided as attachments to this report. These typical sections are not intended to comprise all instances within the project corridor, but rather are intended to depict the typical sections on which the various roadway segments will be evaluated. Additional typical sections may be necessary as the project progresses.

Cut/Fill Slopes: Cut and fill slopes will follow standard MDT cut and fill slope criteria. Standard slopes are provided on the typical section sheet and the design criteria matrix attached to this memorandum.

Right-of-Way: Standard MDT policy regarding right-of-way is to acquire "sufficient, but not excessive, width to accommodate construction and maintenance operations" including all travel lanes, shoulders, slopes, median, and clear zones. Standard MDT practice is to acquire the minimum amount of right-of-way necessary to contain the roadway construction limits plus a 10-foot buffer. Minimum right-of-way requirements are identified on the design criteria matrix and the typical sections exhibit. Additional right-of-way beyond these minimum widths will be considered as necessary for bridge structures, slopes, ramps, or intersections as determined through the planning and design process.

Bicycle/Pedestrian Facilities: The State of Montana allows bicycle travel on state highways and freeways through Montana Code Annotated (MCA) Title 61 Chapter 8 Part 6, which states:

Every person operating a bicycle shall be granted all of the rights and shall be subject to all of the duties applicable to the driver of any other vehicle by chapter 7, this chapter, and chapter 9 except as to special regulations in this part and except as to those provisions of chapter 7, this chapter, and chapter 9 which by their very nature can have no application.

Because bicycle travel on Montana highways and freeways is allowed, the Montana Department of Transportation (MDT) does not have a comprehensive program to design and install recreational facilities (shared-use detached bike paths). As such, the current highway standard of an 8-foot shoulder is considered adequate to accommodate bicycle travel.

The 2010 Administrative Draft of the Billings Area Bikeway and Trail Master Plan identifies a number of routes within the study corridor as bike routes. Mary Street, Dover Road, and Five Mile Road are classified as primary bike routes; Old Highway 312, Bitterroot Drive and Johnson Lane are classified as arterial bike routes; Coulson Road is classified as a secondary bike route; and a multi-use trail currently terminates at Mary Street between Bench Boulevard and Hawthorne Lane with future plans to cross Mary Street. Due to the existing and planned locations of bicycle and pedestrian facilities within the study corridor, consideration should be



given to underpass or overpass facilities along the bypass. The inclusion of overpass or underpass facilities is also supported by MDT as a means of maintaining the safe movement of pedestrians and bicyclists across MDT facilities.

The inclusion of bicycle facilities along each alignment is not included in the base typical sections at this time. However, bicycle facilities will be considered during the next phase of the planning process.

SUMMARY

This document is intended to identify a set of typical design standards to be incorporated within the planning and design throughout the EIS process. It should be noted, however, that modifications to the standard design criteria may occur through the design process as required or as necessary to develop a viable design based on obstacles encountered in within the study area. Furthermore, actual right-of-way widths necessary to develop the facility will vary from the typical widths identified in this memorandum.

Attachments: Typical Section Exhibit

Design Criteria Matrix

Design Analysis Map (January 2011)



er.			

NHS RURAL PRINCIPAL ARTERIAL DESIGN SPEED: 70 MPH (FLAT TERRAIN), 60 MPH (ROLLING TERRAIN) RIGHT-OF-WAY MEDIAN 12.0' SHLD TRAVEL LANE TRAVEL LANE SHLD SHLD TRAVEL LANE TRAVEL LANE SHLD VARIES ///X//\X// CROSS SLOPE = -2% CROSS SLOPE = -2% CROSS SLOPE = -2% CROSS SLOPE = -2% 10' * FILL SLOPES 20' - 30' 3: 1 OVER 30' 2: 1 NHS URBAN PRINCIPAL ARTERIAL **DESIGN SPEED: 55 MPH** 160.0' (MIN) RIGHT-OF-WAY TRAVEL LANE TRAVEL LANE TWO-WAY LEFT TURN LANE TRAVEL LANE TRAVEL LANE 17/1/17 20: 1± CROSS SLOPE = -2% CROSS SLOPE = -2% * FILL SLOPES * BACK SLOPES NHS URBAN PRINCIPAL ARTERIAL WITH FRONTAGE ROAD **DESIGN SPEED: 55 MPH** 80.0' (MIN) VARIES RIGHT-OF-WAY 22.0' - 32.0' CLEAR ZONE 12.0 12.0' 12.0' TRAVEL LANE 12.0' 8.0' 12.0' EXISTING TRAVEL LANE TRAVEL LANE TRAVEL LANE TWO-WAY LEFT TURN LANE TRAVEL LANE EXISTING TRAVEL LANE SHLD XIVIIXIIIVIIX CROSS SLOPE = -2% CROSS SLOPE = -2% MONTANA DEPARTMENT 2/21/2011 OF TRANSPORTATION

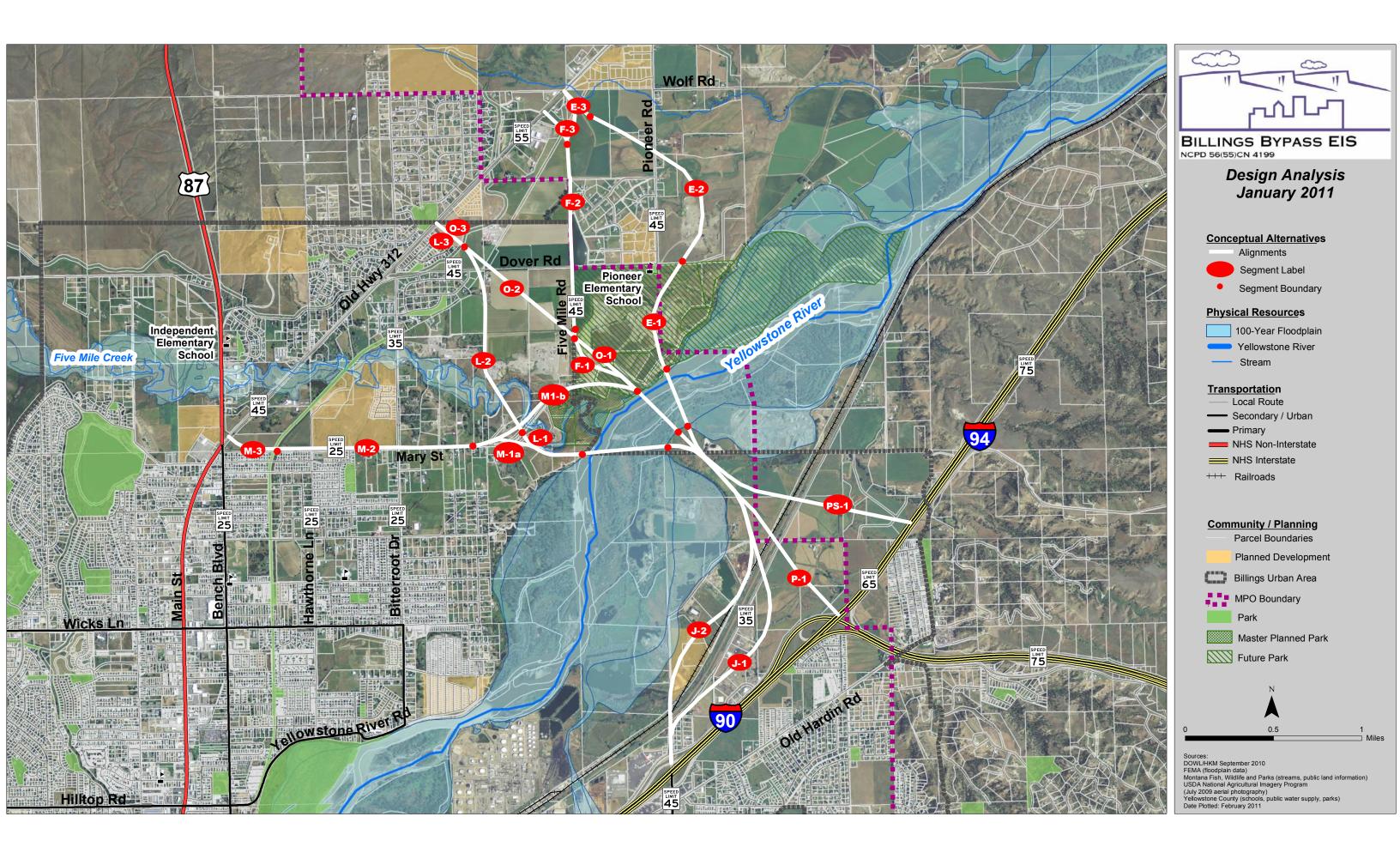
Danium Flamanta		Oite of Dillings	Vallewatena County			
Design Elements	Bypass Mainline - Rural Bypass Mainline - Urban Bypass Mainline - Urban		Bypass Mainline - Urban	City of Billings	Yellowstone County	
Design Standards	NHS - Rural Principal Arterial (MDT Traffic Engr. Manual)	NHS - Urban Principal Arterial (MDT Traffic Engr. Manual)	Non-NHS Urban Principal Arterial ²	Subdivision Regulations, AASHTO	Subdivision Regulations, AASHTO	
Lanes	2 - 4 lanes	4 lanes plus center turn lane	4 lanes plus center turn lane	4 lanes plus center turn lane	4 lanes plus center turn lane	
Design Speed	Level = 70mph Rolling = 60 mph Mountainous = 50 mph	40 - 55 mph (Uncurbed, Multi-lane)	40 mph	-	-	
Vertical Grade (max)	Level = 3% Rolling = 4% Mountainous = 7%	Level = 6% (40-50mph), 5% (55mph) Rolling = 7% (40-50mph), 6% (55mph) Mountainous = 9% (40-50mph), 8% (55mph)	7% max grade (desirable) 10% max grade (with approval)	Per AASHTO	Per AASHTO	
Superelevation	e _{max} = 8%	40-45 mph: $e_{max} = 4\%$ 50-55 mph: $e_{max} = 8\%$	e _{max} = 4%	Per AASHTO	Per AASHTO	
Vertical Curve (Sag)	Level: K = 96 Rolling: K = 136 Mountainous: K = 181	40 mph: K = 64 45 mph: K = 79 50 mph: K = 96 55 mph: K = 115	K = 64 (desirable)	Per AASHTO	Per AASHTO	
Vertical Curve (Crest)	Level: K = 84 Rolling: K = 151 Mountainous: K = 247	40 mph: K = 44 45 mph: K = 61 50 mph: K = 84 55 mph: K = 114	K = 44 (desirable)	Per AASHTO	Per AASHTO	
Horizontal Curve (min)	$ Level = 1810 \text{ ft at } e_{max} $ $ Rolling = 1200 \text{ ft at } e_{max} $ $ Mountainous = 758 \text{ ft at } e_{max} $	40 mph = 533' 45 mph = 711' 50 mph = 760' 55 mph = 960'	533 ft. (40 mph @ e _{max})	Per AASHTO	Per AASHTO	
Access Control	Limited Control of Access at discretion of MDT	Limited Control of Access at discretion of MDT	Limited Control of Access at discretion of MDT	-	-	
Right of Way Requirements						
R/W Width	160 ft. (min.) ³ (80 ft. from C.L. each side)	160 ft. (min.) ³ (80 ft. from C.L. each side)	140 ft. (approx.) ³ (70 ft. from C.L. each side)	130 ft. Desired	120 ft. Desired	
Typical Section Elements						
Driving Lane	12 ft.	4 at 12-ft; Turn Lane at 16 ft.	12' Outside, 11' Inside, 12' Turn Lane	14 ft. TWLTL; 11 ft. inside; 12 ft. outside	14 ft. TWLTL; 12 ft. inside; 14 ft. outside	
Shoulder	Outside = 8 ft. Inside = 4 ft.	Outside = 8 ft.	Outside = 6 ft.	Shoulder project specific 10 ft. boulevard		
Stormwater	Roadside ditches	Project Specific	Project Specific	Project Specific	Roadside ditches or project specific	
Roadway Width	40 ft., Two Lane (min.) or project specific	80 ft.	70 ft.	64 - 86 ft.	92 ft.	
Bicycles	Provided on shoulder (no striped bike lane)	Project Specific	4 ft. (minimum) 5 ft. (desirable)	Bike lanes (case-by-case) 1	Bike lanes (case-by-case) 1	
Sidewalk	NA	5 - 10 ft.	5 ft.	5 ft. & 10 ft. (Min.) 10 ft. & 10 ft. (Desired)	5 ft.	
Median	As Required 14 ft. (min); 50 ft. (desireable)	TWLTL or project specific	4 ft. (raised) (min.)	-	-	
Cross Slope	2% Crown (typical)	2% Crown (typical)	1.5% (minimum) 2% (desirable)	2% Crown (typical)	2% Crown (typical)	
Frontage Road	-	-	-	-	-	

¹ Based on current update to Billings Area Bikeway and Trail Master Plan Draft Report (Jan 2011)

² From the Montana Department of Transportation Geometric Design Standards for Urban and Developed Areas

³ Final rightof-way width will contain all design elements plus 10 feet.

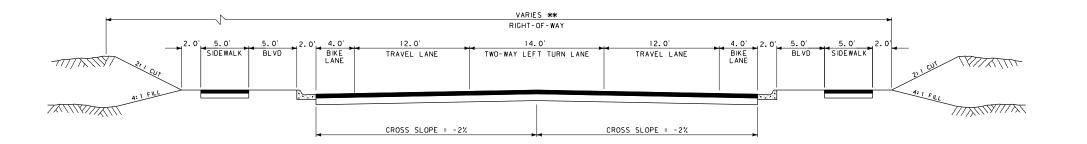
er.			



SECONDARY CORRIDOR IMPROVEMENTS

MARY STREET

CITY OF BILLINGS – PRINCIPAL ARTERIAL PROJECTED 2035 ADT = 9500 VPD



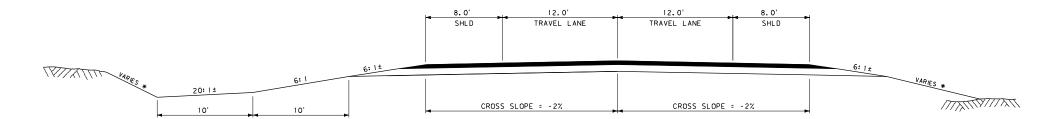
** PER CURRENT CITY OF BILLINGS SUBDIVISION REGULATIONS:
PRINCIPAL ARTERIAL = 130'
MINOR ARTERIAL = 100'

# FILL S	* BA	
0' - 10'	6:1	0' - '
10' - 20'	4: 1	5' -
20' - 30'	3: 1	10' -
OVER 30'	2: 1	15' - :

* BACK SLOPES					
0' - 5'	5: 1				
5' - 10'	4: 1				
10' - 15'	3: 1				
15' - 20'	2: 1				
OVER 20'	1.5:1				

FIVE MILE ROAD

RURAL COLLECTOR ROAD
DESIGN SPEED: 60 MPH (FLAT TERRAIN)
PROJECTED 2035 ADT = 5100 VPD



3	MONTANA DEPARTMENT	L
2	OF TRANSPORTATION	[
4	Z-Z-Z-Z-Z-Z-Z-Z-Z-Z-Z-Z-Z-Z-Z-Z-Z-Z-Z-	Г

	idijpeo i.ugii		-
8/23/2011		REVIEWED BY	
0/23/2011		CHECKED BY	Г
2:31:23 PM	Doug.Enderso	1	Г



BILLINGS BYPASS EIS

SECTION 3: Traffic Signal Warrant Study Report

Billings Bypass **April**, 2012





Table of Cont	ents	Page
INTRODUCTION	I	1
ALTERNATIVE A	ALIGNMENT INTERSECTIONS	2
NON-SIGNALIZE	ED INTERSECTION OPERATIONS	3
SIGNAL WARRA	ANT ANALYSIS	4
Old	Hwy 312 Intersections	5
Bitt	erroot Drive Intersections	5
Fiv	e Mile Road Intersections	6
Joh	nson lane Intersections	7
SIGNALIZED IN	TERSECTION OPERATIONS	7
ALTERNATIVE I	NTERSECTION CONTROL	8
Ca _l	pacity	8
Saf	ety	9
Ge	ometry	10
Adj	acent Land Use Impacts	10
RECOMMENDA	TIONS	10
APPENDIX 1 -	Non-Signalized Intersection Capacity Calculations	
APPENDIX 2 -	Traffic Signal Warrant Summaries	
APPENDIX 3 -	Intersection Capacity with Traffic Signals	
APPENDIX 4 -	Alternative Intersection Control Roundabout Capacity	/



List of Tables	Page
Table 1. Year 2035 Traffic Control Status – Alignment Intersections	2
Table 2. Year 2035 Non-Signalized Intersection Capacity Summary	4
Table 3. Year 2035 Signalized Intersection Capacity Summary	8
Table 4. Year 2035 Roundabout Intersection Capacity Summary	9



INTRODUCTION

This report summarizes traffic signal warrant analysis for intersections associated with the three preliminary alignment alternatives contained within the Draft Environment Impact Statement (EIS). Intersections investigated for traffic signal warrants include those intersections along the alternative alignment and those along the secondary improvement roadways. The alternative alignments and secondary improvement roadways listed below have been described within the Preliminary Traffic Study:

Mary Street Alignment Option 1 with Secondary Improvements to Five Mile Road Mary Street Alignment Option 2 with Secondary Improvements to Five Mile Road Five Mile Road Alignment with Secondary Improvements to Mary Street

Since there is less than 3% difference in year 2035 traffic projections between the Mary Street Alignment Options 1 and 2, traffic signal warrant analysis was based on Mary Street Alignment Option1 traffic projections and the intersections contained within this report refer to the Mary Street Option 1 & 2 Alignment. The signal warrant results can be applied to either of the Mary Street Alignments.

The intersections detailed within this report are limited to existing intersections that are not currently signalized and future intersections that would not operate at acceptable levels of service under year 2035 traffic loadings with stop control. Specific intersections that were excluded from the warrant analysis are discussed in the next section of this report.

The signal warrant calculations were based upon applicable warrants contained within the Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways, 2009 Edition. Those warrants not considered to be applicable to most of the intersections included herein are: Warrant #4 - Pedestrian Volumes, Warrant #5 - School Crossing, Warrant #6 - Coordinated Signal System, Warrant #7 - Crash Experience, Warrant #8 - Roadway Network, and Warrant #9 - Railroad Crossing Proximity. Warrants #1 - Eight-hour Vehicular Volume, Warrant #2 - Four-hour Vehicular Volume, and Warrant #3 - Peak Hour Traffic are applicable to all of the intersections.

Comparisons between non-signalized and signalized capacity are made for all of intersections contained within this report. Justification of traffic signal installation is discussed and alternative traffic control measures, such as 4-way stop control and roundabouts, are evaluated for safety, efficiency, and overall practicality. General design recommendations for each intersection conclude this report.



ALTERNATIVE ALIGNMENT INTERSECTIONS

Table 1 lists all of the alternative alignment intersections and their traffic control status associated with year 2035 traffic volume projections. Two of the intersections are currently signalized and at one intersection (US 87/Old Hwy 312/Bench/Main) a signal is currently being designed as part of the Bench Boulevard reconstruction project.

Table 1. Year 2035 Traffic Control Status - Alignment Intersections

i			
Intersections	Currently Signalized	Two-way Stop LOS > C	Signal Warrant Analysis Req'd
MARY ST. ALIGNMENT OPTIONS 1 & 2:			
US 87/Old Hwy 312/Bench/Main Street	In Design		
Mary St. Alignment & Hawthorne		Stop Hawthorne	
Mary Street & Hawthorne		Stop Hawthorne	
Mary St. Alignment & Bitterroot Dr.			This Study
Mary Street & Bitterroot Drive		Stop Mary	
Old Hwy 312 & Five Mile Road Ext.			This Study
Five Mile Road & Dover Road		Stop Dover	
Mary St. Alignment & Five Mile Road			This Study
Mary St. Alignment & Coulson Road		Stop Coulson	
Mary St. Alignment & Johnson Lane		Stop Johnson	
Johnson Lane & N. Frontage Rd.			This Study
Johnson Ln. & I-90 WB Ramps			This Study
Johnson Ln. & I-90 EB Ramps	Existing		
Johnson Lane & Old Hardin Road	Existing		
FIVE MILE ROAD ALIGNMENT:			
US 87/Old Hwy 312/Bench/Main Street	In Design		
Mary Street & Hawthorne		Stop Hawthorne	
Mary Street & Bitterroot Drive			This Study
Old Hwy 312 & Five Mile Road Align.			This Study
Five Mile Road Align. & Dover Road		Stop Dover	
Five Mile Road Align. & Mary Street			This Study
Five Mile Road Align. & Coulson Rd.		Stop Coulson	
Five Mile Road Align. & Johnson Lane		Stop Johnson	
Johnson Lane & N. Frontage Rd.			This Study
Johnson Ln. & I-90 WB Ramps			This Study
Johnson Ln. & I-90 EB Ramps	Existing		
Johnson Lane & Old Hardin Road	Existing		



Intersections along the alignment alternatives that would operate at acceptable levels of service with stop control on the minor intersection legs are:

Hawthorne Lane & Mary Street
Hawthorne Lane & Mary Alignments
Bitterroot Drive & Mary Street - Mary Alignments
Five Mile Road & Dover Road
Coulson Road & New Project Alignment
Johnson Lane & New Project Alignment
Stop on Hawthorne
Stop on Hawthorne
Stop on Dover Road
Stop on Coulson Road
Stop on Johnson Lane

The ten intersections that are included in the signal warrant analysis and summarized within this report are:

Mary Street Alignment Options 1 and 2 Intersections:

Old Hwy 312 & Five Mile Road Secondary Improvements
Bitterroot Drive & Mary Street Options 1 & 2 Alignment
Five Mile Road & Mary Street - Options 1 & 2 Alignment
Johnson Lane & North Frontage Road - Mary Street Options 1 & 2 Alignment
Johnson Lane & WB I-90 Ramps - Mary Street Options 1 & 2 Alignment

Five Mile Road Alignment Intersections:

Old Hwy 312 & Five Mile Road Alignment Bitterroot Drive & Mary Street - Secondary Improvements Five Mile Road (Mary Street) & Five Mile Road Alignment Johnson Lane & North Frontage Road - Five Mile Road Alignment Johnson Lane & WB I-90 Ramps - Five Mile Road Alignment

NON-SIGNALIZED INTERSECTION OPERATIONS

Year 2035 design hour traffic projections for the warrant study intersections were used to determine measures of effectiveness (MOEs) that would result if the intersections were to operate with stop control. Table 1 present a summary of level-of-service (LOS) and delay, in terms of seconds per vehicle, for each approach leg of the intersection. Capacity calculations for non-signalized conditions can be found in Appendix 1 of this report. For purposes of design, any LOS less than "C" would be considered unacceptable. Table 2 indicates that all of the study intersection would have at least one approach leg that would operate at a LOS less than "C". Eight of the intersections would have at least two approach legs operating at LOS "F".



Intersection Approach NB WB Delay Delay Delay Delay (s/v) (s/v) (s/v) (s/v) Intersection LOS LOS LOS LOS MARY ST. ALIGNMENT OPTIONS 1 & 2: Old Hwy 312 & Five Mile Road Ext. С Е 21 40 Α 8 Α 9 Mary St. Align. & Five Mile Road F 70 F 1159 В 10 Α 9 Mary St. Alignment & Bitterroot Dr. F F 125 459 Α Α 9 Johnson Lane & N. Frontage Rd. F 333 F В 12 В 11 547 Johnson Ln. & I-90 WB Ramps В 14 F 4345 FIVE MILE ROAD ALIGNMENT: Old Hwy 312 & Five Mile Rd. Align. С Ε 20 40 Α 8 Α 9 Five Mile Rd. Align. & Mary Street Α 10 F 119 Mary Street & Bitterroot Drive F F 54 Α 8 79 Α 8 Johnson Lane & N. Frontage Rd. F В 11 F Α 10 2194 988 Johnson Ln. & I-90 WB Ramps 13 3484 = LOS D & E = LOS F

Table 2. Year 2035 Non-Signalized Intersection Capacity Summary

SIGNAL WARRANT ANALYSIS

Signal warrants, as contained in the Manual on Uniform Traffic Control Devices (MUTCD), 2009 Edition were evaluated using year 2035 traffic volume projections at the ten intersections noted in Table 2. It was determined that only three of the nine traffic signal warrants would be applicable to these intersections: Warrant 1. Eight-Hour Vehicular Volumes, Warrant 2. Four-Hour Vehicular Volumes, and Warrant 3. Peak Hour.

The pedestrian volume warrant was not investigated since none of the intersections are located in areas with potential for high pedestrian activities such as the central business district. School crossing warrants were not investigated because none of the alignments are on or cross existing school routes. The crash experience warrant was not analyzed since it requires a history of crash experience. Coordinated signals and roadway network warrants are commonly invoked when quantitative measures are below warrant values or when additional justification is needed for signal installation. In this case, it was felt that quantitative measures would be more appropriate due to the inherent uncertainties associated with long terms projections. Warrant 9 involves intersections near at-grade railroad crossings and would not apply to any of the study intersections.

Vehicular traffic data used in the traffic signal warrant analysis requires hourly volumes for at least a 12 hour period of the average day. For this study, existing electronic traffic counts on existing streets were used to approximate hourly traffic variation percentages and those percentages were applied to the 2035 average daily traffic (ADT) projections on each intersection approach. Existing counts used in this analysis were on Johnson Lane, US 87, Main Street, Bench Boulevard, and Old Hwy 312. Summaries of the warrant calculations for each intersection can be found in Appendix 2 of this report.



Old Hwy 312 Intersections

There are two intersection conditions associated with the Five Mile Road connection to Old Hwy 312: 1 - Five Mile Road as a Secondary Improvement associated with the Mary Street Alignment Options 1 and 2 - Five Mile Road Alignment connection to Old Hwy 312. The Five Mile Road Alignment intersection would have slightly higher traffic volumes (3%) which would not result a distinct difference in the warrant analysis values. The main difference between the two conditions would be the number of approach and departure lanes. Five Mile Road, as a secondary improvement, would have a single approach lane with an auxiliary right-turn lane and a single departure lane. The Five Mile Road Alignment intersection would have two approach lanes with an auxiliary right-turn lane and two departure lanes.

Signal warrant analysis for the Mary Street Alignment Secondary Improvements and the Five Mile Road Alignment alternative intersection conditions indicate that all three vehicular volume warrants would be met for both alternative alignment intersections. Warrant 1 - Eight-Hour Volumes Condition A would range from 141% to 151% of the minimum and Condition B would range from 109% to 112% of the minimum warrant volume. Warrant 2 - Four-Hour Volumes would range from 180% to 205% of the minimum warrant value, while Warrant 3 - Peak Hour Condition B would range from 164% to 185% of the minimum warrant value.

Since capacity calculations indicate that almost all of the approach movements would operate at an acceptable LOS, except the northbound left-turn lane (LOS "D"), justification for a signal would be questionable. If a significant portion or all of the northbound right-turn lane traffic volumes were eliminated from the warrant calculations, then none of the signal warrants would be met and a signal would not be justified for either alternative alignment at this location. Since there would be one movement at the intersection that would operate below the acceptable design LOS "D", alternative intersection traffic control would weigh more heavily, as discussed further within this report.

Bitterroot Drive Intersections

There are two intersections with Bitterroot Drive investigated within this study. The first intersection is the Mary Street Alignment Options 1 & 2 intersection with Bitterroot Drive. That intersection involves issues with adjacent structure impacts and multiple alternatives involving both signals and roundabouts being carried through the EIS process. Therefore, signal warrant analysis contained within this report provides warranting information, but does not fully address alternative traffic control measures. Alternative control measures are addressed as alternative intersection design options within the Preliminary Traffic Study.

Signal warrant analysis indicates that all three vehicular volume warrants would be met for the Mary Street Alignment intersection with Bitterroot Drive. Warrant 1 - Eight-Hour Volumes Condition A would be at 145% of the minimum warrant value. Warrant 2 – Four-Hour Volumes would be at 152% of the minimum warrant value while Warrant 3 – Peak Hour Condition A would be met at 148% of the minimum warrant value and Condition B would be at 151% of the minimum warrant value.



The intersection of Mary Street and Bitterroot Drive with Secondary Improvements to Mary Street would involve an improved typical section along Mary Street with a single through travel lane in each direction and a two-way left-turn lane (TWLTL) in the middle. The Bitterroot Drive approaches would be widened to accommodate auxiliary left-turn lanes for northbound and southbound traffic.

Traffic signal warrant analysis indicates that two of the three vehicular warrants calculated in this study would be met for the Five Mile Road Alignment alternative involving secondary improvements to Mary Street and Bitterroot Drive. Warrant 1 Condition A would be met at only 101% of the minimum warrant value and Warrant 3 Condition A and B would be met with 108% and 171% of the minimum warrant values respectively. Warrant 2 – Four-Hour Volumes would be close to being met at 95% of the minimum warrant value.

Five Mile Road Intersections

There are three alternative alignments that would intersect Five Mile Road at different locations. Two of the intersections, involving Mary Street Alignment Option 1 and Mary Street Alignment Option 2 are at different locations, but both would have very similar traffic projections, and the number of approach and departure lanes would be identical for both intersections. Thus, signal warrant analysis was performed to encompass both Mary Street Alignment Options 1 and 2, even though alternative traffic control measures are addressed separately to account for topographical differences at each respective location.

Warrant analysis for the Mary Street Alignment options indicate that the three vehicular warrants calculated within this study would be met. Warrant 1 – Eight-Hour Vehicular Volumes would be met at 130% of minimum warrant values for condition A and 136% of minimum warrant values for Condition B. Warrant 2 – Four-Hour Vehicular Volumes would be met at 384% of the minimum warrant value and Warrant 3 – Peak Hour would have both Conditions A and B met at 158% and 198% of minimum warrant values, respectively.

The Five Mile Road Alignment intersection with Mary Street would be a "T" type intersection involving a realignment of Mary Street and connection to the Five Mile Road Alignment Alternative. It should be noted that Mary Street is actually Five Mile Road since secondary Improvements to Mary Street would extend northeast of the location where Mary Street veers from its east-west alignment and becomes Five Mile Road on a north-south bearing. At this intersection, Five Mile Road would be a four lane facility, incorporating an auxiliary left-turn lane for northbound traffic, and Mary Street would have one through lane in each direction with an auxiliary left-turn lane on its approach to the Five Mile Road Alignment intersection.

The Five Mile Alignment and Mary Street intersection would also meet the three vehicular warrants evaluated within this study. Warrant 1 – Eight-Hour Vehicular Volumes would be met at 130% of minimum warrant values for condition A, but would



not meet warrant values for Condition B. Warrant 2 – Four-Hour Vehicular Volumes would be met at 220% of the minimum warrant value and Warrant 3 – Peak Hour would have Conditions B met at 238% of the minimum warrant value. Warrant 3, Condition A would not meet the minimum warrant values.

Johnson Lane Intersections

There are two intersections on Johnson Lane that are not currently signalized which are included in this study. The first intersection is Johnson Lane and the I-90 North Frontage Road intersection and the second is the Johnson Lane and I-90 Westbound ramp intersection. Warrant analysis was completed for each of the two intersections using Mary Street Alignment Options 1 and 2 year 2035 traffic projections and Five Mile Road alignment traffic projections.

All three of the signal warrants for the Johnson Lane and North Frontage Road intersection were met for both the Mary Street Alignment traffic volumes and the Five Mile Road Alignment volumes. For both alternative alignments, Warrant 1 – Eight-Hour Vehicular Volumes would meet at least 141% of minimum warrant values for Condition B, but Condition A would not be met. Warrant 2 – Four-Hour Vehicular Volumes would meet at least 278% of the minimum warrant values. Warrant 3 – Peak Hour would meet Conditions A by at least 208% of minimum warrant values and Condition B would be met by at least 324% of the minimum warrant values for each alternative alignment.

At the Johnson Lane and I-90 Westbound Ramp intersection, similar warrant values were met for each of the alternative alignments traffic conditions in the year 2035 with all three vehicular warrants being met. The only exception would be Warrant 1 – Eight-Hour Vehicular Volumes, where Condition A would meet at least 165% of the minimum warrant values, unlike the North Frontage Road and Johnson Lane intersection, where Condition A warrants were not met.

SIGNALIZED INTERSECTION OPERATIONS

Capacity calculations using SigCinema software and year 2035 PM design hour traffic projections were completed for all of the intersections meeting signal warrants and summaries of those calculations can be found in Appendix 3 of this report. The only exception is the intersections of I-90 Westbound Ramps for both the Mary Street Alignments and the Five Mile Road Alignment alternatives. In that case, design options for the Johnson Lane Interchange, as detailed in the Preliminary Traffic Study, do not include a single signalized intersection for the I-90 Westbound Ramp on Johnson Lane. Therefore, that intersection was excluded from further consideration as a signalized intersection.

Approach lane geometry, indicated by the typical sections for each alternative alignment, contained in Section 2 of this document, was used for the major intersection legs and auxiliary turn lanes were added to enhance operations, as necessary. Capacity calculations were made based on the assumption that none of the signals within this report would be part of a future coordinated signal system.



Table 3 presents a summary of level-of-service (LOS) and delay, in terms of seconds per vehicle, for each approach leg of the intersection. Capacity calculations for signalized conditions can be found in Appendix 3 of this report. For purposes of design, any LOS worse than "C" would be considered unacceptable. Table 3 indicates that all of the study intersections would have all approach legs operating at a LOS "C" or better. In comparing Table 3 to Table 2, it can be seen that the extreme delay (300 s/v and greater) associated with stop control would experience a vast improvement with traffic signal operations. The greatest delay shown in Table 3 would be approximately 30 seconds on the Mary Street approach to the Five Mile Road Alignment. It should also be noted that the signalized intersections would actually increase delay on the principal However, the highest increase would only amount to an alignment approaches. increase of three seconds per vehicle. This would result in a net decrease in overall intersection delay at all of the intersections with the exception of the Old Hwy 312 intersections, where the non-signalized delay would only impact a minor volume of traffic.

Table 3. Year 2035 Signalized Intersection Capacity Summary

	Intersection Approach							
	N	NB SB EB WB						/B
		Delay		Delay		Delay		Delay
Intersection	LOS	(s/v)	LOS	(s/v)	LOS	(s/v)	LOS	(s/v)
MARY ST. ALIGNMENT OPTIONS 1 & 2:								
Old Hwy 312 & Five Mile Road Ext.	В	19	В	18	Α	7	Α	7
Mary St. Align. & Five Mile Road	В	13	В	14	Α	9	В	12
Mary St. Alignment & Bitterroot Dr.	В	17	В	15	Α	8	Α	9
Johnson Lane & N. Frontage Rd.	Α	9	В	17	С	23	С	20
FIVE MILE ROAD ALIGNMENT:								
Old Hwy 312 & Five Mile Rd. Align.	В	19	В	18	Α	7	Α	7
Five Mile Rd. Align. & Mary Street	В	13	С	28	С	30		
Mary Street & Bitterroot Drive	В	18	В	17	Α	9	Α	10
Johnson Lane & N. Frontage Rd.	Α	8	В	16	С	23	С	20

ALTERNATIVE INTERSECTION TRAFFIC CONTROL

According to the MDT Traffic Manual, alternative traffic control measures other than traffic signals must be considered and evaluated in the warrant study. In this study, alternatives are limited to roundabouts because 4-way stop control would not be an acceptable alternative since all of the intersections would involve principal arterial roadways with mobility being the prime consideration and interruption of traffic flow could not be justified.

Capacity

Capacity calculations, using Sidra software, were completed for the same intersections included in Table 3 and summaries of those calculations can be found in Appendix 4 of this report. Approach lane geometry, derived from alternative alignment typical sections contained in Section 2 of this document, was used for the major intersection approach



legs. Specific approach and circulating lane usage for each intersection are illustrated in the Preliminary Traffic Study, Section 1 of this document.

Table 4 presents a summary of level-of-service (LOS) and delay, in terms of seconds per vehicle, for each approach leg of the intersection. Capacity calculations for roundabout conditions can be found in Appendix 4 of this report. In Table 4, it can be seen that roundabout operations would result in LOS "A" on all approaches except for the Westbound approach on North Frontage Road at Johnson Lane, which would operate at LOS "B" with 12 seconds delay per vehicle. That same approach with signal operations would operate at LOS "C" and have 20 seconds per vehicle delay.

Each intersection would experience a net savings in total delay with roundabout operations. The savings would range from 13 seconds per vehicle, at the Mary Street Alignment and Five Mile Road intersection, to 47 seconds per vehicle, at the Five Mile Road Alignment and Mary Street intersection. Thus, the result would be a net decrease in overall intersection delay at all of the intersections and from an efficiency perspective, roundabouts would appear to be the preferred alternative.

Table 4. Year 2035 Roundabout Intersection Capacity Summary

	Intersection Approach							
	N	NB SB EB WB						/B
		Delay	Delay		Delay			Delay
Intersection	LOS	(s/v)	LOS	(s/v)	LOS	(s/v)	LOS	(s/v)
MARY ST. ALIGNMENT OPTIONS 1 & 2:								
Old Hwy 312 & Five Mile Road Ext.	Α	9	Α	8	Α	5	Α	7
Mary St. Align. & Five Mile Road	Α	8	В	16	Α	6	Α	5
Mary St. Alignment & Bitterroot Dr.	Α	5	Α	7	А	6	Α	7
Johnson Lane & N. Frontage Rd.	Α	5	Α	4	Α	7	В	12
FIVE MILE ROAD ALIGNMENT:								
Old Hwy 312 & Five Mile Rd. Align.*	Α	9	Α	8	Α	5	Α	7
Five Mile Rd. Align. & Mary Street	Α	10	Α	7	А	7		
Mary Street & Bitterroot Drive	Α	6	Α	8	Α	6	Α	5
Johnson Lane & N. Frontage Rd.*	Α	5	Α	4	Α	7	В	12

^{*} Lane Control Same as Mary Alignment with Less Traffic Capacity Analysis Not Performed

Safety

Within the past 10 years it has been documented in a variety of publications that roundabouts typically produce crash rates that are substantially less than signalized intersections. Reduced crash rates range between 20% and 70% of those associated with traffic signals. Since roundabouts also experience much lower crash severity rates than signalized intersections, due to slower entry speeds, safety benefits would be especially important due to the relatively higher speed of the new roadway facilities that would exist at the study intersections. Thus, from a safety perspective, it would appear that roundabouts would be the preferred alternative for all of the study intersections.



Geometry

All of the roundabouts on the new alternative alignments would have two entry and two departure lanes that would carry the 4 lane typical sections associated with the alternative alignments. The intersecting roadways would have single entry and departure lanes except for situations where an auxiliary right-turn lane would enhance operations. Minor streets would have a single circulation lane within the roundabouts. The inscribed diameter of these roundabouts would range between 170 feet and 200 feet.

Adjacent Land Use Impacts

Existing structures would not be impacted by construction at all but one of the study intersections. The intersection of Mary Street and Bitterroot Drive, constructed as secondary improvements to the Five Mile Road Alignment, could impact a new residence located in the southeast corner of the intersection depending on the alternative intersection improvement.

With the exception of the North Frontage Road and Johnson Lane intersection, adjacent land uses at the remaining intersections are agricultural. Some additional commercial property right-of-way would be required at the North Frontage Road and Johnson Lane intersection.

Access to adjacent properties would be better served by roundabouts at all of the intersections with the exception of the Highway 312 and Five Mile Road intersections. Traffic signals at the Highway 312 intersections would allow the existing adjacent accesses to operate with about the same degree of safety as the roundabout alternatives because existing approaches would be located a sufficient distance beyond the intersections' operational area of influence.

RECOMMENDATIONS

All of the study intersections would meet traffic signal warrants in the design year 2035 and signals would be justified at all intersections except for the *Old Hwy 312 and Five Mile Road intersection*. A traffic signal at that intersection would be less efficient than stop control on Five Mile Road. A roundabout would be the most desirable alternative in terms of safety. However, the ultimate intersection control will be determined in the final design stage of this project.

The intersections of both the *Mary Street Alignment and the Five Mile Road Alignment with the North Frontage Road and the I-90 Westbound Ramp at Johnson Lane* are included in the overall interchange design options. Johnson Lane Interchange design options are described and evaluated in the Preliminary Traffic Study. These intersections were only analyzed within this warrant study to document that traffic signal warrants would be met.

Design options at the intersection of *Mary Street Alignment and Bitterroot Drive* are also detailed in the Preliminary Traffic Study and final design will determine the ultimate configuration and traffic control features. Similar to the Johnson Lane intersections, the Mary Street Alignment and Bitterroot Drive intersection was only included in this study



to document traffic signal warrants.

At the *Mary Street and Bitterroot Drive intersection associated with the Five Mile Road Alignment*, traffic signal warrants would be met and traffic signals would provide a safe and efficient operating environment. While a roundabout would provide measurably better operation in terms of delay and safety, it would require additional right-of-way that would severely impact a structure in the southeast corner. If Mary Street were realigned to the north in order minimize impacts to that structure, there would be additional impacts to residential properties in the northeast corner. Therefore, it is recommended that a traffic signal be designed as the ultimate traffic control device at this intersection.

At the *Mary Street Option 1 and Option 2 Alignments' intersections with Five Mile Road*, traffic signal warrants are met and traffic signals would provide a desirable level of safety and efficiency. However, roundabouts at these intersections would provide a greater degree of safety and efficiency. Roundabouts would have minimal impacts on adjacent land uses and access to adjacent properties would be accommodated to a greater extent than with signals. At the Mary Street Option 1 Alignment and Five Mile Road intersection a roundabout would easily accommodate access to a number of existing driveway and street approaches, while a traffic signal would require numerous road approach realignments and directional access restrictions. For these reasons it is recommended that roundabouts be considered as the preferred alternatives in final design.

The *Five Mile Road Alignment intersection with Mary Street* would be a three-legged "T" intersection for which minimum traffic signal warrants would be met. As with the other intersections, traffic signals would provide a safe and efficient operating environment. However, a high level of turning movements at this intersection would only provide LOS "C" operations on the eastbound and southbound approaches and there would be very little capacity remaining beyond the design year 2035. Since roundabout operation would provide LOS "A" on all approaches, the operational benefits of the roundabout are clearly superior. Because this intersection could be constructed with minimal land use or access impacts, it is recommended that a roundabout be considered as the preferred alternative in final design



er.			

APPENDIX 1

Non-Signalized Intersection Capacity Calculations



er.			

	TW	O-WAY STOP	CONTR	OL SI	JMN	MARY				
General Information	n		Site I	nform	atio	on				
Analyst	R Marvin		Interse	ection			HWY 312	& 5 Mi	ile Ma	ary Opt
Agency/Co.	Marvin A	ssociates	¬II				1			
Date Performed	10/3/201		Jurisdi				MDT			
Analysis Time Period	Design H	our PM	Analys	sis Year	<u>r</u>		2035			
Project Description Bil	llings Bypass						ļ			
East/West Street: HWY			North/S	South S	Stroo	t·				
Intersection Orientation:	-					: 0.25				
Vehicle Volumes ar		nte	Jetas, .	00	(. 0.20				
Major Street		Eastbound		Γ			Westbou	nd		
Movement	1	2	3			4	5	T		6
WOVOINGIN	i i	T T	R			i	T			R
Volume (veh/h)	5	470	20			150	300			<u> </u>
Peak-Hour Factor, PHF	0.90	0.90	0.90)		0.90	0.90			90
Hourly Flow Rate, HFR (veh/h)	5	522	22			166	333			5
Percent Heavy Vehicles	0					3		\neg		_
Median Type	1			Undiv	/idec	1				
RT Channelized			0						(2
Lanes	0	1	0			1	1		()
Configuration	LTR					L			7	R
Upstream Signal		0					0			
Minor Street		Northbound					Southbou	ınd		
Movement	7	8	9			10	11		•	12
	L	Т	R			L	Т			R
Volume (veh/h)	30	5	210			5	5	5		5
Peak-Hour Factor, PHF	0.90	0.90	0.90)		0.60	0.60		0.	60
Hourly Flow Rate, HFR (veh/h)	33	5	233			8	8		ě	8
Percent Heavy Vehicles	3	0	3			0	0		(9
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0						(0
Lanes	0	1	1			0	1		(0
Configuration	LT		R				LTR			
Delay, Queue Length, a	nd Level of Se	rvice								
Approach	Eastbound	Westbound	!	Northbo	ound		S	outhbo	und	
Movement	1	4	7	8		9	10	11		12
Lane Configuration	LTR	L	LT			R		LTR		
v (veh/h)	5	166	38			233		24		
C (m) (veh/h)	1232	1020	132			545		128		
v/c	0.00	0.16	0.29			0.43		0.19	,	
95% queue length	0.01	0.58	1.11			2.12		0.66	;	
Control Delay (s/veh)	7.9	9.2	42.9			16.4		39.5	, †	
LOS	Α	A	E			С		Ε	一	
Approach Delay (s/veh)				20.2	2			39.5		
Approach LOS C						E				
Copyright © 2010 University of Fl	HCS+TM Version 5.6				Generated: 2/24/2012 5:23 Pl					

1		Sita II	nform	ation					
		t		ation	IMon Alic	un ^Q Fino A	tilo Door		
	Associatos					in & Five iv	ille Road		
				•					
		Arialys	is i cai		2000				
	JII I I OGI]							
	1	North/S	South S	treet: Five M	Mile Road				
					mo rtoda				
	nte	100000		()					
			1		Westhou	ınd			
1	1	3		4	_		6		
i	- -	_		Ė	T		R		
5	450	5	1	20	700		230		
0.90	0.90	0.90		0.92	0.92		0.92		
Pate HED			İ				240		
5	500	5		21	760		249		
1				1					
			Undiv	rided		-			
		0					0		
1	2	0		1	2		0		
L	T	TR		L	T		TR		
	0				0				
	Northbound				Southboo	ınd			
7	8	9		10	11		12		
L	Т	R		L	Т		R		
5	50	20		170	10		5		
0.70	0.70	0.70	ĺ	0.80	0.80		0.80		
7	71	28		212	12		6		
0	2	1		2	1		0		
	0				0				
	N				N				
	0	1	T f		0				
1	<u> </u>	0			1	\neg	0		
1	1			1	1	$\overline{}$	0		
L	'	_		<u>.</u> L	† 	_	TR		
	rvice				ı		-		
	7	ı	Vorthbo	ound	Ç	Southbound	<u> </u>		
		+					12		
			-			 ''	TR		
						-	_		
							18		
						ļ	174		
0.01	0.02	0.04		0.69	3.48		0.10		
0.02	0.06	0.11		3.93	22.42		0.34		
10.3	8.5	23.7		73.4	1255		28.1		
В	Α	С		F	F		D		
		1	70.1		1	1159	1		
Approach Delay (s/veh) 70.1 Approach LOS F					F				
	1/25/2012 PM Design PM D	R Marvin Marvin & Associates 1/25/2012 PM Design Hour Ings Bypass Align Opt 1 & 2 East-West	R Marvin	R Marvin Marvin & Associates Jurisdiction Jurisdiction Analysis Year Analysis Year Analysis Year Analysis Ye	R Marvin Marvin & Associates Intersection Jurisdiction Analysis Year Intersection Jurisdiction Analysis Year Intersection Jurisdiction Analysis Year Intersection Intersection Analysis Year	R Marvin	R Marvin & Associates		

	TW	O-WAY STOP	CONTR	OL SI	JMN	//ARY				
General Information	1		Site I	nform	atio	n				
Analyst	R Marvin		Interse	ection			Mary Alig	n & B	ittero	ot Opt 1
Agency/Co.	Marvin A	ssociates	Jurisdi	ction			MDT			
Date Performed	10/8/201		Analys	is Yea	r		Year 203	5		
Analysis Time Period	Design H	lour PM								
Project Description Bill										
East/West Street: Mary						t: <i>Bitteroo</i>	t			
Intersection Orientation:	East-West		Study F	Period	(hrs)	: 0.25				
Vehicle Volumes ar	nd Adjustme	nts								
Major Street		Eastbound					Westbou	nd		
Movement	1	2	3			4	5			6
	L	T	R			L	T			R
Volume (veh/h)	10	360	10			110	520			50
Peak-Hour Factor, PHF	0.90	0.90	0.90	<u> </u>		0.90	0.90			0.90
Hourly Flow Rate, HFR (veh/h)	11	400	11			122	577			55
Percent Heavy Vehicles	1					1				
Median Type			•	Undi	/idea	1	í			
RT Channelized			0							0
Lanes	1	2	0			1	2			0
Configuration	L	T	TR			L	T			TR
Upstream Signal		0					0			
Minor Street		Northbound					Southbou	ınd		
Movement	7	8	9			10	11		12	
	L	T	R			L	Т			R
Volume (veh/h)	20	110	95			40			50	
Peak-Hour Factor, PHF	0.80	0.80	0.80	'		0.80	0.80	0.80		0.80
Hourly Flow Rate, HFR (veh/h)	24	137	118			49	62			37
Percent Heavy Vehicles	0	0	0			0	0			0
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0							0
Lanes	1	1	0			1	1			0
Configuration	L		TR			L				TR
Delay, Queue Length, a	nd Level of Se	ervice								
Approach	Eastbound	Westbound		Northbo	ound		S	outhb	ound	
Movement	1	4	7	8		9	10		1	12
Lane Configuration	L	L	L			TR	L			TR
v (veh/h)	11	122	24			255	49			99
C (m) (veh/h)	953	1152	119			232	17			211
v/c	0.01	0.11	0.20			1.10	2.88			0.47
95% queue length	0.04	0.35	0.20			11.32	6.73	\vdash		2.28
Control Delay (s/veh)	8.8	8.5	42.7			133.2	1314	_		36.3
• • •										
LOS	A	Α	E	155		F	F			Ε
Approach Delay (s/veh)				125.	4			459		
Approach LOS		F			F					

HCS+TM Version 5.6

	TW	O-WAY STOP	CONTR	OL SU	JMN	//ARY				
General Information	n		Site I	nform	atic	n				
Analyst	R Marvin		Interse	ection			N Frntg & 1&2	Johnso	on Mar	y Opt
Agency/Co.	Marvin A	ssociates	Jurisdi	ction			MDT			
Date Performed	10/8/201			is Year			2035			
Analysis Time Period	Design H	lour PM		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			2000			
Project Description Bil	llings Bypass									
East/West Street: N Fro	ontage Road		North/S	South S	tree	t: Johnsoi	n Lane			
Intersection Orientation:	North-South		Study F	Period ((hrs)	: 0.25				
Vehicle Volumes ar	nd Adjustme	nts								
Major Street		Northbound					Southbou	ınd		
Movement	1	2	3			4	5		6	
	L	T	R			L	Т		R	
Volume (veh/h)	190	930	30			5	700		100	
Peak-Hour Factor, PHF	0.90	0.90	0.90	<u>'</u>		0.90	0.90		0.90)
Hourly Flow Rate, HFR (veh/h)	211	1033	33			5	777		111	1
Percent Heavy Vehicles	8					4				
Median Type				Undiv	ridea					
RT Channelized			0						0	
Lanes	1	2	0			1	2		0	
Configuration	L	T	TR			L	T	TR		<u>!</u>
Upstream Signal		0					0			
Minor Street		Eastbound					Westbou	nd		
Movement	7	8	9			10	11			2
	L	T	R			L	Т		R	
Volume (veh/h)	155	25	210	_		25	20		5	
Peak-Hour Factor, PHF	0.85	0.85	0.85			0.60	0.60		0.60	<u>) </u>
Hourly Flow Rate, HFR (veh/h)	182	29	247			41	33		8	
Percent Heavy Vehicles	4	4	8			4	4		4	
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0						0	
Lanes	1	1	0			1	1		0	
Configuration	L		TR			L			TR	!
Delay, Queue Length, a	and Level of Se	rvice								
Approach	Northbound	Southbound	1	Westbo	und		E	Eastbou	nd	
Movement	1	4	7	8		9	10	11		12
Lane Configuration	L	L	L			TR	L			TR
v (veh/h)	211	5	41			41	182			276
C (m) (veh/h)	722	638	0			28	0			175
v/c	0.29	0.01				1.46				1.58
95% queue length	1.22	0.02			\neg	4.82				8.29
Control Delay (s/veh)	12.0	10.7		 	\neg	547.3				32.8
LOS	В	В	F	 	\dashv	F	F		\dashv	F
Approach Delay (s/veh)			- '	<u> </u>		,				
Approach LOS		-								
Copyright © 2010 University of FI			<u> </u>	CS+ TM \			<u> </u>	ated: 1/26		

HCS+TM Version 5.6

Generated: 1/26/2012 12:51 PM

	TW	O-WAY STOP	CONTR	OL SI	UMI	MARY				
General Informatio	 n		Site I	nform	natio	on				
Analyst	R Marvin		Interse				Johnson	& WB	Ram	nps
Agency/Co.	Marvin A		Jurisdi				MDT			1
Date Performed	1/25/2012	2	Analys	is Yea	r		2035 Ma	ry Opt	1&2	Align
Analysis Time Period	PM Desig	gn Hour								
	llings Bypass		•							
East/West Street: Wes		ips				t: Johnso	n Lane			
Intersection Orientation:	North-South		Study I	Period	(hrs)	: 0.25				
Vehicle Volumes a	nd Adjustme									
Major Street		Northbound	,				Southbou	und		
Movement	1 .	2	3			4	5			6
\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	L	T	R			L	T			R
Volume (veh/h) Peak-Hour Factor, PHF	230	950	1.00			1.00	675			260
Hourly Flow Rate, HFR	0.92	0.92	1.00			1.00	0.92	-	- (0.92
(veh/h)	249	1032	0			0	733			282
Percent Heavy Vehicles	5					0				
Median Type			-	Undi	vided	1				
RT Channelized			0							0
Lanes	1	1	0			0	1			0
Configuration	L	T								TR
Upstream Signal		0					0			
Minor Street		Eastbound					Westbou	ınd		
Movement	7	8	9			10	11			12
	L	Т	R			L	Т			R
Volume (veh/h)			<u> </u>			175	1			200
Peak-Hour Factor, PHF	1.00	1.00	1.00)		0.85	0.85		(0.85
Hourly Flow Rate, HFR (veh/h)	0	0	0			205	1			235
Percent Heavy Vehicles	0	0	0			8	8			10
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0							0
Lanes	0	0	0			0	1			0
Configuration							LTR			
Delay, Queue Length, a	and Level of Se	ervice								
Approach	Northbound	Southbound	1	Westbo	ound			Eastbo	ound	
Movement	1	4	7	8		9	10	1	1	12
Lane Configuration	L			LTF	₹					
v (veh/h)	249			441	1					
C (m) (veh/h)	672			43						
v/c	0.37			10.2						
95% queue length	1.71			52.8			†			<u> </u>
Control Delay (s/veh)	13.5			434			 	<u> </u>		
LOS	B			F			 	\vdash		
Approach LOS				4345			<u> </u>			
Approach LOS				F			I			

HCS+TM Version 5.6

Generated: 1/26/2012 12:49 PM

	TW	O-WAY STOP	CONTR	OL SI	JMN	MARY				
General Information	<u> </u>		Site I	nform	atio	on				
Analyst	R Marvin		Interse	ection			HWY 312	& 5 M	lile Fi	∕e Mile
Agency/Co.	Marvin A	ssociates	¬II				Alt			
Date Performed	10/3/201	1	Jurisdi				MDT			
Analysis Time Period	Design H	our PM	Analys	sis Year	ſ		2035			
Project Description Pi	lingo Pungoo									
Project Description Bill East/West Street: HWY			North/9	South S	troo	t: Five Mil	a Roa			
Intersection Orientation:	-					: 0.25	e noa			
Vehicle Volumes ar		nte	Jetas, .	004 ((. 0.20				
Major Street	Aujustine	Eastbound					Westbou	nd		
Movement	1	2	3	- 1		4	5	T		6
INIC VOINICITE	i	 	R	1		L	T	$\neg +$		R
Volume (veh/h)	5	470	20			150	310			5
Peak-Hour Factor, PHF	0.90	0.90	0.90)		0.90	0.90		0.	.90
Hourly Flow Rate, HFR (veh/h)	5	522	22			166	344			5
Percent Heavy Vehicles	0					3				
Median Type				Undiv	/idec	1				
RT Channelized			0							0
Lanes	1	1	0			1	1			0
Configuration	L		TR			L			7	TR
Upstream Signal		0					0			
Minor Street		Northbound					Southbound			
Movement	7	8	9			10	11			12
	L	Т	R			L	Т		R	
Volume (veh/h)	30	5	230			5	5			5
Peak-Hour Factor, PHF	0.90	0.90	0.90)		0.90	0.90		0.	.90
Hourly Flow Rate, HFR (veh/h)	33	5	255			5	5			5
Percent Heavy Vehicles	3	0	3			0	0			0
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0							0
Lanes	0	1	1			0	1			0
Configuration	LT		R				LTR			
Delay, Queue Length, a		1								
Approach	Eastbound	Westbound	!	Northbo	ound		S	outhbo	ound	
Movement	1	4	7	8		9	10	11		12
Lane Configuration	L	L	LT			R		LTF	7	
v (veh/h)	5	166	38			255		15		
C (m) (veh/h)	1221	1020	132			545		118	3	
v/c	0.00	0.16	0.29			0.47		0.13	3	
95% queue length	0.01	0.58	1.11			2.47		0.42	2	
Control Delay (s/veh)	8.0	9.2	42.9			17.3		39.9	9	
LOS	Α	A	E			С		Ε	_	
Approach Delay (s/veh)				20.6	3			39.9		
Approach LOS				C			E E			
Copyright © 2010 University of FI	l	HCS+ TM Version 5.6			: F C	Generated: 2/24/2012 5:31 PN				

	TW	O-WAY STOP	CONTR	OL S	UMN	//ARY				
General Information	 າ		Site I	nform	natio	on .				
Analyst	R Marvin		Interse				Five Mile	Aliann	nent &	& Marv
Agency/Co.	Marvin As	ssociates	Jurisd				MDT	<u>g</u>		
Date Performed	1/25/2012	2	Analys	sis Yea	ır		2035			
Analysis Time Period	PM Desig	n Hour								
Project Description Bil										
East/West Street: Mary							le Road Alignment			
Intersection Orientation:	North-South		Study I	Period	(hrs)	: 0.25				
Vehicle Volumes ar	nd Adjustme	nts								
Major Street		Northbound					Southbou	ınd		
Movement	1	2	3			4	5			6
	L	T	R			L	T			R
Volume (veh/h)	500	280	4.00	,		4.00	30			90
Peak-Hour Factor, PHF	0.92	0.92	1.00	,		1.00	0.80		U	.80
Hourly Flow Rate, HFR (veh/h)	543	304	0			0	37		2	237
Percent Heavy Vehicles	2					0				
Median Type				Undi	vided	1		1		
RT Channelized			0				0			0
Lanes	1	1	0			0	2			0
Configuration	L	T					T			TR
Upstream Signal		0					0			
Minor Street		Eastbound					Westbou	nd		
Movement	7	8	9			10	11			12
	L	T	R			L T			R	
Volume (veh/h)	30		330							
Peak-Hour Factor, PHF	0.90	1.00	0.90)		1.00	1.00		1	.00
Hourly Flow Rate, HFR (veh/h)	33	0	366			0	0			0
Percent Heavy Vehicles	1	0	2			0	0			0
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0							0
Lanes	1	0	1			0	0			0
Configuration	L		R							
Delay, Queue Length, a	nd Level of Se	rvice								
Approach	Northbound	Southbound		Westb	ound		E	Eastbo	und	
Movement	1	4	7	8		9	10	11	1	12
Lane Configuration	L						L			R
v (veh/h)	543						33			366
C (m) (veh/h)	1286						61	\vdash	\dashv	910
v/c	0.42						0.54	 	-	0.40
95% queue length	2.14						2.18	 		1.96
Control Delay (s/veh)	9.8						119.0	 		11.6
LOS	9.6 A	-		 			F	├	-	B
							<i>-</i>			B
Approach Delay (s/veh)							-	20.5)	
Approach LOS	orida, All Rights Res			HCS+ TM				С		12 4:20 PI

HCS+TM Version 5.6

Generated: 1/25/2012 4:20 PM

	TW	O-WAY STOP	CONTR	OL SU	ММ	ARY						
General Information	n		Site II	nforma	atio	n						
Analyot	D Montin		Interse	ection			Mary & B	itterroc	ot .			
Analyst Agency/Co.	R Marvin	ssociates	Jurisdi	ction			MDT					
Date Performed	1/24/201		Analys	is Year			2035 Five	Mile A	Align	Sec		
Analysis Time Period	Design P		— Triarys	1001			Imps					
		171										
Project Description Bil			h									
East/West Street: Mary						Bitterro	ot					
Intersection Orientation:			Study Period (hrs): 0.25									
Vehicle Volumes ar	<u>nd Adjustme</u>											
Major Street		Eastbound	<u> </u>				Westbou	nd _				
Movement	1	2	3			4	5	\rightarrow		6		
	L	T	R			L	T	\rightarrow		R		
Volume (veh/h)	20	310	50			80	390			60		
Peak-Hour Factor, PHF Hourly Flow Rate, HFR	0.90	0.90	0.90			0.90	0.90	\rightarrow	C	0.90		
(veh/h)	22	344	55			88	433			66		
Percent Heavy Vehicles	1					1						
Median Type				Undivided								
RT Channelized					0					0		
Lanes	1	1	0			1	1			0		
Configuration	L		TR			L				TR		
Upstream Signal		0					0					
Minor Street		Northbound					Southbou	ınd				
Movement	7	8	9			10	11			12		
	L	Т	R			L	Т	Т		R		R
Volume (veh/h)	50	100	80			40	60			10		
Peak-Hour Factor, PHF	0.80	0.80	0.80		(0.75	0.75		C).75		
Hourly Flow Rate, HFR (veh/h)	62	124	99			53	80			13		
Percent Heavy Vehicles	0	0	1			1	0	一		0		
Percent Grade (%)	1	0					0					
Flared Approach		N					N					
Storage		0					0					
RT Channelized			0							0		
Lanes	1	1	0			1	1			0		
Configuration	L		TR			L				TR		
Delay, Queue Length, a	nd Level of Se	rvice	•									
Approach	Eastbound	Westbound	1	Vorthbo	und		s	outhbo	ound			
Movement	1	4	7	8	Т	9	10	11		12		
Lane Configuration	L	L	L		寸	TR	L			TR		
v (veh/h)	22	88	62			223	53			93		
C (m) (veh/h)	1070	1165	119		\dashv	286	67			217		
v/c	0.02	0.08	0.52		\dashv	0.78	0.79			0.43		
95% queue length	0.06	0.24	2.43		一	6.02	3.67			1.99		
Control Delay (s/veh)	8.4	8.3	64.3		\dashv	50.9	157.8			33.5		
LOS	A	A	F	 	\dashv	F	F	 		D		
Approach Delay (s/veh)				52.9		•		79 <i>6</i>	:	<i>-</i>		
		 	30.0				•					
Approach LOS Copyright © 2010 University of Fl			HCS+ TM				F		12 5:21 Pľ			

HCS+TM Version 5.6

Generated: 1/24/2012 5:21 PM

	TW	O-WAY STOP	CONTR	OL SUN	MARY					
General Information	<u> </u>		Site I	nforma	tion					
Analyst	R Marvin		Interse	otion			Johnson	5 Mile		
Agency/Co.	Marvin As	esociatos		CHOIT		Align				
Date Performed	10/8/201		— Jurisdi			MDT				
Analysis Time Period	Design H		— Analys	sis Year		2035				
	, ,	our r w								
	lings Bypass		h							
East/West Street: N Fro					eet: Johnson	n Lane				
Intersection Orientation:			Study	eriod (hi	rs): <i>0.25</i>					
Vehicle Volumes ar	<u>nd Adjustme</u>	nts								
Major Street		Northbound	<u> </u>			Southbou	ınd			
Movement	1	2	3		4	5		6		
	L	T	R		<u> L </u>	T		R		
Volume (veh/h)	195	785	30		5	600		90		
Peak-Hour Factor, PHF	0.90	0.90	0.90	' 	0.90	0.90		0.90		
Hourly Flow Rate, HFR (veh/h)	216	872	33		5	666		100		
Percent Heavy Vehicles	8				4					
Median Type				Undivia	led					
RT Channelized								0		
Lanes	1	2	0		1	2		0		
Configuration	L	T	TR		L	Т		TR		
Upstream Signal		0				0				
Minor Street		Eastbound				Westbou	nd			
Movement	7	8	9		10	11		12		
	L	Т	R		L	Т		R		
Volume (veh/h)	135	25	215		25	20		5		
Peak-Hour Factor, PHF	0.85	0.85	0.85	5	0.60	0.60	0.60 0			
Hourly Flow Rate, HFR (veh/h)	158	29	252		41	33		8		
Percent Heavy Vehicles	4	4	8		4	4		4		
Percent Grade (%)	i	0				0				
Flared Approach		N	T			N				
Storage	1	0	†			0				
RT Channelized			0					0		
Lanes	1	1	0		1	1	\neg	0		
Configuration	i i	<i>'</i>	TR		L	,		TR		
Delay, Queue Length, a		rvice				<u> </u>				
Approach	Northbound	Southbound	,	Westbou	nd	[[Eastbound			
Movement	1	4	7	8	9	10	11	12		
Lane Configuration	<u>.</u>	L.	L	_ <u> </u>	TR	1		TR		
v (veh/h)	216	5	41		41	158		281		
C (m) (veh/h)	805	735	12	 	44	11		248		
v/c	0.27	0.01	3.42	 	0.93	14.36		1.13		
95% queue length	1.08	0.02	6.13	 	3.74	21.17	-	12.53		
				-	_		}	_		
Control Delay (s/veh)	11.1	9.9	1719		257.3	6679		140.5		
LOS	В	Α	F		F	F	<u> </u>	F		
Approach Delay (s/veh)				988.0			2494			
Approach LOS				F			F			

HCS+TM Version 5.6

Generated: 1/25/2012 4:35 PM

	TW	O-WAY STOP	CONTR	OL SI	UMN	/IARY				
General Informatio	 n		Site I	nform	natio	on .				
Analyst	R Marvin		Interse	ection			Johnson	& WB	Ram	ps
Agency/Co.	Marvin As		Jurisdi				MDT			,
Date Performed	1/25/2012	2	Analys	is Yea	r		2035 Fiv	e Mile I	Road	d Align
Analysis Time Period	PM Desig	gn Hour								
	llings Bypass		•							
East/West Street: Wes		ips				t: Johnso	n Lane			
Intersection Orientation:	North-South		Study F	Period	(hrs)	: 0.25				
Vehicle Volumes a	nd Adjustme									
Major Street		Northbound					Southboo	und		
Movement	1 1	2	3			4	5			6
\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	L 0.70	T	R			L	T	_		R
Volume (veh/h) Peak-Hour Factor, PHF	270	860	1.00			1.00	640	-		200
Hourly Flow Rate, HFR	0.92	0.92	1.00			1.00	0.92		- (0.92
(veh/h)	293	934	0			0	695		2	217
Percent Heavy Vehicles	5					0				
Median Type				Undi	vided	l				
RT Channelized			0							0
Lanes	1	1	0			0	1			0
Configuration	L	T								TR
Upstream Signal		0					0			
Minor Street		Eastbound					Westbou	ınd		
Movement	7	8	9			10	11			12
	L	Т	R			L	Т			R
Volume (veh/h)						150	1	<u>'</u>		170
Peak-Hour Factor, PHF	1.00	1.00	1.00)		0.85	0.85		0.8	
Hourly Flow Rate, HFR (veh/h)	0	0	0			176	1			199
Percent Heavy Vehicles	0	0	0			8	8			10
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0							0
Lanes	0	0	0			0	1			0
Configuration							LTR			
Delay, Queue Length, a		rvice								
Approach	Northbound	Southbound	\	Westbo				Eastbo	und	
Movement	1	4	7	8		9	10	11		12
Lane Configuration	L			LTF	7					
v (veh/h)	293			376	6					
C (m) (veh/h)	735			45						
v/c	0.40			8.30	6					
95% queue length	1.92			44.5	_					
Control Delay (s/veh)	13.1			348	_			1		
LOS	В			F						-
Approach Delay (s/veh)								<u> </u>		<u> </u>
			3484 F				-			
Apploach LOS										

HCS+TM Version 5.6

APPENDIX 2

Traffic Signal Warrant Summaries



er.			

	Intersec	ction:		Highwa	ay 312		and	F	ive Mil	le Road	t		
		Case:		Ť			ative Optio	ns 1 & 2 Y	ear 2035				
		Date:				Jar	nuary 24, 20	012					
Major Sti	reet:	lighway 3	12	Minor S	treet 1:	F	ive Mile Roa	ad	Minor	Street 2:	Priv	ate Road	d
Major S	treet Dir. (N-S or l	E-W):	E-W			Dir. (N-S or I		N-S			r. (N-S or E-	W):	N-S
			_	A	pproach D	ir. (NB or SI	3)	NB	Aı	proach Dir	. (NB or SB)		SB
Major Stre	et Speed Limit:	50	mph	Major St	reet 85th %	Speed:	55	mph	Total	Intersection	Approaches	: <u>[</u>	4
		0	vay 312			ile Road		Total	High		Total		
Beginning	Hour	EB	WB		NB	SB		Major	Minor		Entering		
7:00 AN	м	213	611		79	2		824	79		905		
8:00 AN		238	510		147	2		748	147		897		
9:00 AN	M	219	350		82	1		569	82		652		
10:00 A	M	232	323		90	1		555	90		646		
11:00 A	M	281	339		98	1		620	98		719		
12:00 A	M	321	332		124	1		653	124		778		
1:00 PN	M	361	327		148	1		688	148		837	< 8th H	lighest
2:00 PN	M	408	337		167	1		745	167		913	< 4th H	lighest
3:00 PM	M	454	352		170	1		806	170		977		
4:00 PN		508	391		190	1		899	190		1090		
5:00 PN		557	364		211	1		921	211		1133	< Peal	k Hour
6:00 PN		412	314		147	1		726	147		874		
7:00 PM	VI.	353	226		106	1		579	106		686		
Ave. Week	kday Volumes =	5500	5700		2050	20		11200	2050		13270		
					Cond	lition A				Condit	ion B		
V	Volume Warrants			Values			Minimums		Va	lues	Minimu	ıms	
			Major (To	otal Entering)	Minor	Major (Tota	al Entering)	Minor	Major	Minor	Major	Minor	
8th Hour V	Vehicular Volume	Warraı		688	148		20	105	688	148	630	53	
4th Hour V	Vehicular Volume	Warraı		745	167		45	93					
	Vehicular Volume			1133	211		00	100	921	211	921	129	
	Experience Warr			688	148		80	120	688	148	720	60	
Roady	way Network War	ran		1133		(10	000)						
Warrant #	1 - Eight-hour	Vehicula	ar Volum	ie			Warrant	# 2 - Four	-hour Vel	nicular Vo	olume		
	Warrant 1 Co	ondition A	Met	YES	141.0%	1		V	Varrant 2 C	onditions M	let	YES	179.6%
	Warrant 1 Co	ondition B	Met	YES	109.2%]	'						
Warrant #	3 - Peak Hour						Warrant	# 4 - Pede	strian Vol	lumes			
	Warrant 3 Co	ndition A.	1 Met	NO	31.3%]		W	arrant 4 Co	ondition A N	/let	N/A	N/A
	Warrant 3 Co			YES	211.0%			W	arrant 4 Co	ondition B M	1et	N/A	N/A
	Warrant 3 Co			YES	141.6%								
L	Warrant 3 Co	ondition B	Met	YES	163.6%	J							
Warrant #	ant #5 - School Crossing					_	Warrant	# 6 - Coor	dinated S	ignal Syst	tem		
	Warrant 5 Conditions Met			NA	NA]		V	Varrant 6 C	onditions M	let	NO	N/A
Warrant #	rrant #7 - Crash Experience						Warrant	# 8 - Road	lway Netv	vork			
	Warrant 7 Condition A Met			NO	N/A			V	Varrant 8 C	onditions M	let	NO	N/A
	Warrant 7 Co	NO	N/A]									
	Warrant 7 Co	NO	N/A										
			,	W 37		Tial.				34 :	D	Mad	
⊢	1	<u> </u>		Warrant Nu			al			Met	Percent		
	1					ehicular V				YES	141.09		
	2			Four-hour Vehicular Volume					YES	179.69			
	<u>3</u>									YES	163.69		
			Peak Hour Pedestrian Volumes						N/A	N/A			

	Warrant Number and Title	Met	Percent Met
1	Eight-hour Vehicular Volume	YES	141.0%
2	Four-hour Vehicular Volume	YES	179.6%
3	Peak Hour	YES	163.6%
4	Pedestrian Volumes	N/A	N/A
5	School Crossing	N/A	N/A
6	Coordinated Signal System	N/A	N/A
7	Crash Experience	N/A	N/A
8	Roadway Network	N/A	N/A
	Total Number of Warrants Met		3

Interse	ection:	F	ive Mil	le Roa	d	and	Mai	y Aligr	n. Opt 1	1&2		
	Case:			Mary St	treet Alte	rnative Option						
	Date:				·	January 25, 2	.012					
Major Street: Mary	Alignment (Opt 1&2	Minor S	treet 1:		Five Mile Roa	ad	Minor S	Minor Street 2: Five Mile Road			
Major Street Dir. (N-S or		E-W		r Street 1 l	Dir. (N-S o		N-S			r. (N-S or E-W		
			A	pproach D	oir. (NB or	SB)	NB	Aı	pproach Dir	. (NB or SB)	SB	
Major Street Speed Limit:	45	mph	Major S	treet 85th 9	% Speed:	50	mph	Tota	ıl Intersectio	n Approaches:	4	
	Mary A	lignment		Five M	lile Road		Total	High		Total		
Beginning Hour	EB	WB		NB	SB		Major	Minor		Entering		
7 00 137	000	005		40	000		1007	000		1050	44. 10. 1	
7:00 AM 8:00 AM	622 518	385 344		19 36	230 222		1007 862	230 222		1256 1120	< 4th Highest	
9:00 AM	356	317		20	169		673	169		862		
10:00 AM	328	335		22	161		663	161		846		
11:00 AM	345	406		24	163		751	163		938		
12:00 AM	338	465		30	142		803	142		975		
1:00 PM	333	521		36	136		854	136		1026	< 8th Highest	
2:00 PM	343	590		41	172		933	172		1146	< out ringilest	
3:00 PM	358	656		42	169		1014	169		1225		
4:00 PM	398	735		46	162		1133	162		1341		
5:00 PM	408	804		52	158		1212	158		1422	< Peak Hour	
6:00 PM	319	595		36	135		914	135		1085		
7:00 PM	230	511		26	92		741	92		859		
Ave. Weekday Volumes =	5800	7950		500	2500		13750	2500		16750		
				Con	dition A				Condit	on D		
Volume Warrants			Values	Cone	uluoli A	Minimums		Vo	lues	Minimu	me	
voiume vurrams		Major (Tot	al Entering)	Minor	Major (T	otal Entering)	Minor	Major	Minor	l	Minor	
8th Hour Vehicular Volume	Warrant	,	54	136	17111/07 (1	420	105	854	136	630	53	
4th Hour Vehicular Volume			007	230		1007	60	004	100	000		
Peak Hour Vehicular Volume	e Warrant	14	122	158		800	100	1212	158	1212	80	
Crash Experience War	rant	8	54	136		480	120	854	136	720	60	
Roadway Network War	rant	14	122		(1000)						
Warrant # 1 - Eight-hour		Volume			,	,	# 2 - Four-	hour Vehi	cular Volu	ıme		
Warrant 1 (Condition A	Met	YES	129.5%	1		v	Varrant 2 C	onditions M	et	YES 383.3%	
Warrant 1 C			YES	135.6%	1			varrant 2 C	onditions 111		123 303.3 70	
Warrant # 3 - Peak Hour	John Liver D		123	155.070		Warrant #	# 4 - Pedes	trian Volu	mes			
Warrant 3 C	ondition A.1	Met	YES	1490.0%	1		W	arrant 4 Co	ndition A M	Tet.	N/A N/A	
Warrant 3 C			YES	158.0%	1				ndition B M		N/A N/A	
Warrant 3 C			YES	177.8%				urrunt 1 co	martion D 111		14/71	
Warrant 3 (YES	197.5%								
Warrant # 5 - School Cros			123	177.570	•	Warrant #	# 6 - Coord	linated Sig	nal Syster	n		
Warrant 5	Conditions I	Met	NA	NA	1		V	Varrant 6 C	onditions M	et	NO N/A	
Warrant #7 - Crash Expe	rience					Warrant #	# 8 - Roady	vay Netwo	ork			
Warrant 7 (Condition A	Met	NO	N/A	1		V	Varrant 8 C	onditions M	et	NO N/A	
Warrant 7 (NO	N/A	1		<u> </u>				. ,,	
Warrant 7 (Condition C	Met	NO	N/A	1							
					-							
		ī	Varrant Nu	mber and	l Title				Met	Percent 1	Met	
1		<u>'</u>		nt-hour V		Volume			YES	129.5%		
2				r-hour V					YES	383.39		
	1		rou	ı-nour V	emcular	v otume			1 52	303.39	U	

	Warrant Number and Title	Met	Percent Met
1	Eight-hour Vehicular Volume	YES	129.5%
2	Four-hour Vehicular Volume	YES	383.3%
3	Peak Hour	YES	197.5%
4	Pedestrian Volumes	N/A	N/A
5	School Crossing	N/A	N/A
6	Coordinated Signal System	N/A	N/A
7	Crash Experience	N/A	N/A
8	Roadway Network	N/A	N/A
	Total Number of Warrants Met		3

Interse	ection:	[Bitterroc	ot Driv	е	and	Mar	v Aligr	n. Opt 1	1&2	
	Case:			Mary St	reet Alternativ	ve Optio					
	Date:				Janua	ry 24, 2	012				
Major Street: Mary	Alignment	Opt 1&2	Minor St	reet 1:	Bitter	root Driv	re e	Minor	Street 2:	Bitte	erroot Drive
Major Street Dir. (N-S or	E-W):	E-W			Dir. (N-S or E-W):	N-S			. (N-S or E-V	
			A	pproach D	ir. (NB or SB)		NB	Al	pproach Dir.	(NB or SB)	SB
Major Street Speed Limit:	45	mph	Major Si	treet 85th %	•	50	mph	Tota	l Intersection	n Approaches	s: 4
	Mary A	lignment		Bitterre	oot Drive		Total	High		Total	
Beginning Hour	EB	WB		NB	SB		Major	Minor		Entering	
7:00 AM	472	266		81	143		738	143		962	< 4th Highest
8:00 AM	393	238		151	137		631	151		919	< 4th Highest
9:00 AM	270	219		84	105		489	105		678	
10:00 AM	249	232		92	100		481	100		673	
11:00 AM	262	281		100	101		543	101		744	
12:00 AM	256	321		127	88		577	127		792	
1:00 PM	252	361		152	85		613	152		850	< 8th Highest
2:00 PM	260	408		172	107		668	172		947	J
3:00 PM	272	454		174	105		726	174		1005	
4:00 PM	302	508		195	100		810	195		1105	
5:00 PM	309	557		217	98		866	217		1181	< Peak Hour
6:00 PM	242	412		151	83		654	151		888	
7:00 PM	175	353		109	57		528	109		694	
Ave. Weekday Volumes =	4400	5500		2100	1550		9900	2100		13550	
				Conc	lition A				Conditi	on B	
Volume Warrants											
voiume warranis			Values			nimums			lues	Minim	ums
			tal Entering)	Minor	Major (Total E		Minor	Major	lues Minor	Minim Major	Minor
8th Hour Vehicular Volume		6	tal Entering) 613	152	Major (Total E		105		lues	Minim	
8th Hour Vehicular Volume 4th Hour Vehicular Volume	Warrant	7	tal Entering) 613 738	152 143	Major (Total En 420 738		105 94	Major 613	Minor	Minimu Major 630	Minor 53
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume	Warrant Warrant	7	tal Entering) 613 738 181	152 143 217	Major (Total En 420 738 800		105 94 100	Major 613 866	Minor 152 217	Minimu Major 630 866	Minor 53
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warn	Warrant Warrant rant	1 6	tal Entering) 613 738 181 613	152 143	Major (Total Ed 420 738 800 480		105 94	Major 613	Minor	Minimu Major 630	Minor 53
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume	Warrant Warrant rant	1 6	tal Entering) 613 738 181	152 143 217	Major (Total En 420 738 800		105 94 100	Major 613 866	Minor 152 217	Minimu Major 630 866	Minor 53
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Wari Roadway Network War	Warrant e Warrant rant rant	1 1	tal Entering) 613 738 181 613	152 143 217	Major (Total E) 420 738 800 480 (1000)	ntering)	105 94 100 120	Major 613 866 613	Minor 152 217 152	Minimu Major 630 866 720	Minor 53
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warr Roadway Network War	Warrant e Warrant rant rant Vehicular	7 1 6 1 1 Volume	tal Entering) 513 738 181 513 181	152 143 217 152	Major (Total E) 420 738 800 480 (1000)	ntering)	105 94 100 120 ‡ 2 - Four-	Major 613 866 613 hour Vehi	lues Minor 152 217 152 cular Volu	Minimu	Minor 53 144 60
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warr Roadway Network War Warrant # 1 - Eight-hour Warrant 1 C	Warrant Warrant rant rant Vehicular Condition A	7 1 1 6 1 1 Volume Met	tal Entering) 513 738 181 513 181 YES	152 143 217 152	Major (Total E) 420 738 800 480 (1000)	ntering)	105 94 100 120 ‡ 2 - Four-	Major 613 866 613 hour Vehi	Minor 152 217 152	Minimu	Minor 53
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warr Roadway Network War	Warrant Warrant rant rant Vehicular Condition A	7 1 1 6 1 1 Volume Met	tal Entering) 513 738 181 513 181	152 143 217 152	Major (Total E) 420 738 800 480 (1000)	ntering)	105 94 100 120 ‡ 2 - Four-	Major 613 866 613 hour Vehi	lues Minor 152 217 152 cular Volu	Minimu	Minor 53 144 60
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warr Roadway Network War Warrant # 1 - Eight-hour Warrant 1 C	Warrant Warrant rant rant Vehicular Condition A	7 1 1 6 1 1 Volume Met	tal Entering) 513 738 181 513 181 YES	152 143 217 152	Major (Total Ed. 420 738 800 480 (1000)	ntering)	105 94 100 120 ‡ 2 - Four-	Major 613 866 613 hour Vehi	lues Minor 152 217 152 cular Voluonditions Me	Minimu	Minor 53 144 60
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warr Roadway Network War Warrant # 1 - Eight-hour Warrant 1 C	Warrant e Warrant rant rant Vehicular Condition B	Volume Met Met	tal Entering) 513 738 181 513 181 YES NO	152 143 217 152 144.8% 97.3%	Major (Total Ed. 420 738 800 480 (1000)	ntering)	105 94 100 120 ‡ 2 - Four-J	Major 613 866 613 hour Vehi Varrant 2 C	lues Minor 152 217 152 cular Voluonditions Me	Minimu	Minor 53 144 60 YES 152.1%
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warr Roadway Network War Warrant # 1 - Eight-hour Warrant 1 C Warrant 1 C Warrant 1 C	Warrant e Warrant rant rant Vehicular Condition A Condition A.1	Volume Met Met	tal Entering) 513 738 181 513 181 YES	152 143 217 152 144.8% 97.3%	Major (Total Ed. 420 738 800 480 (1000)	ntering)	105 94 100 120 \$2 - Four-1 \$\text{V}\$	Major 613 866 613 hour Vehi Varrant 2 Co	lues Minor 152 217 152 cular Volu onditions Means	Minimu	Minor 53 144 60 YES 152.1%
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warr Roadway Network War Warrant # 1 - Eight-hour Warrant 1 C Warrant 1 C Warrant 3 - Peak Hour Warrant 3 C	Warrant e Warrant rant rant Vehicular Condition A Condition A.1 ondition A.2	Volume Met Met Met Met	tal Entering) 513 738 181 513 181 YES NO YES YES	152 143 217 152 144.8% 97.3% 382.5% 217.0%	Major (Total Ed. 420 738 800 480 (1000)	ntering)	105 94 100 120 \$2 - Four-1 \$\text{V}\$	Major 613 866 613 hour Vehi Varrant 2 Co	lues Minor 152 217 152 cular Volu onditions Means ondition A M	Minimu	Minor 53 144 60 YES 152.1%
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warr Roadway Network War Warrant # 1 - Eight-hour Warrant 1 C Warrant 1 C Warrant 3 - Peak Hour Warrant 3 C Warrant 3 C	Warrant e Warrant rant rant Vehicular Condition A Condition A.1 ondition A.2	Volume Met Met Met Met Met Met Met	tal Entering) 513 738 181 513 181 YES NO	152 143 217 152 144.8% 97.3%	Major (Total Ed. 420 738 800 480 (1000)	ntering)	105 94 100 120 ‡ 2 - Four-l v	Major 613 866 613 hour Vehi Varrant 2 Co	lues Minor 152 217 152 cular Volu onditions Means ondition A M	Minimu	Minor 53 144 60 YES 152.1%
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warn Roadway Network War Warrant # 1 - Eight-hour Warrant 1 C Warrant 1 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C	Warrant e Warrant rant Condition A Condition A.2 condition A.3 Condition B	Volume Met Met Met Met Met Met Met	tal Entering) 513 738 181 513 181 YES NO YES YES YES YES	152 143 217 152 144.8% 97.3% 382.5% 217.0% 147.6%	Major (Total Ed. 420 738 800 480 (1000) Wa	arrant #	105 94 100 120 \$\frac{1}{2}\$ 2 - Four-1 \$\frac{1}{2}\$ \text{W}\$ \text{W}	Major 613 866 613 hour Vehi Varrant 2 Co	lues Minor 152 217 152 cular Volu onditions Means ondition A M	Minimum Major 630 866 720 mme et	Minor 53 144 60 YES 152.1%
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warr Roadway Network War Warrant # 1 - Eight-hour Warrant 1 C Warrant 1 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C	Warrant e Warrant rant Trant Condition A Condition A.1 ondition A.2 ondition B Condition B	Volume Met Met Met Met Met Met Met Met Met Me	tal Entering) 513 738 181 513 181 YES NO YES YES YES YES	152 143 217 152 144.8% 97.3% 382.5% 217.0% 147.6%	Major (Total Ed. 420 738 800 480 (1000) Wa	arrant #	105 94 100 120 \$\delta 2 - Four-1 V \$\delta 4 - Pedess \$\text{W}\$ \$\text{W}\$	Major 613 866 613 hour Vehi Varrant 2 Co	ues Minor 152 217 152 cular Volumentions Mondition A Mondition B Monditio	Minimum Major 630 866 720 mme	Minor 53 144 60 YES 152.1%
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warr Roadway Network War Warrant # 1 - Eight-hour Warrant 1 C Warrant 1 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 5 - School Cros	Warrant e Warrant rant Trant Condition A Condition A.2 Condition A.3 Condition B Condition B Condition B Condition B Condition B Condition B Condition B	Volume Met Met Met Met Met Met Met Met Met Me	tal Entering) 513 738 181 513 181 YES NO YES YES YES YES YES	152 143 217 152 144.8% 97.3% 382.5% 217.0% 147.6% 150.7%	Was Was Was Was Was Was Was Was Was Was	arrant #	105 94 100 120 \$\delta 2 - Four-1 V \$\delta 4 - Pedess \$\text{W}\$ \$\text{W}\$	Major 613 866 613 hour Vehi Varrant 2 Co	ues Minor 152 217 152 cular Volumentions Mondition A Mondition B Monditions Monditions Mondition B Mondition B Mondition B Mondition B Mondition B Mondition B Monditions M	Minimum Major 630 866 720 mme	Minor 53 144 60 YES 152.1% N/A N/A N/A N/A
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warrant Roadway Network War Warrant # 1 - Eight-hour Warrant 1 C Warrant 1 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 5 C Warrant 5 C Warrant 7 - Crash Expension	Warrant e Warrant rant Vehicular Condition A Condition B ondition A.2 ondition B condition B condition B condition B	Volume Met Met Met Met Met Met Met Met Met Me	ral Entering) 613 738 181 613 181 YES NO YES YES YES YES YES NA	152 143 217 152 144.8% 97.3% 382.5% 217.0% 147.6% 150.7%	Was Was Was Was Was Was Was Was Was Was	arrant #	105 94 100 120 \$\frac{1}{2}\$ 2 - Four	Major 613 866 613 hour Vehi Varrant 2 Co trian Volu farrant 4 Co farrant 4 Co farrant 6 Co vay Netwo	ues Minor 152 217 152 cular Volu onditions Mondition B Mondition B Monditions Mondi	Minimum Major 630 866 720 mme et	Minor 53 144 60 YES 152.1% N/A N/A N/A N/A N/A N/A N/A N/A N/A N/A
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warr Roadway Network War Warrant 1 C Warrant 1 C Warrant 2 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 5 C Warrant 5 C Warrant 7 C Warrant 7 C	Warrant e Warrant rant Vehicular Condition A Condition B ondition A.2 condition B sing Conditions I rience Condition A	Volume Met Met Met Met Met Met Met Met Met	YES	152 143 217 152 144.8% 97.3% 382.5% 217.0% 147.6% 150.7% NA	Was Was Was Was Was Was Was Was Was Was	arrant #	105 94 100 120 \$\frac{1}{2}\$ 2 - Four	Major 613 866 613 hour Vehi Varrant 2 Co trian Volu farrant 4 Co farrant 4 Co farrant 6 Co vay Netwo	ues Minor 152 217 152 cular Volumentions Mondition A Mondition B Monditions Monditions Mondition B Mondition B Mondition B Mondition B Mondition B Mondition B Monditions M	Minimum Major 630 866 720 mme et	Minor 53 144 60 YES 152.1% N/A N/A N/A N/A
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warrant Roadway Network War Warrant # 1 - Eight-hour Warrant 1 C Warrant 1 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 5 C Warrant 5 C Warrant 7 - Crash Expension	Warrant e Warrant rant Vehicular Condition A Condition A.3 Condition B Sing Conditions I rience Condition A Condition B	Volume Met Met Met Met Met Met Met Met Met	ral Entering) 613 738 181 613 181 YES NO YES YES YES YES YES NA	152 143 217 152 144.8% 97.3% 382.5% 217.0% 147.6% 150.7%	Was Was Was Was Was Was Was Was Was Was	arrant #	105 94 100 120 \$\frac{1}{2}\$ 2 - Four	Major 613 866 613 hour Vehi Varrant 2 Co trian Volu farrant 4 Co farrant 4 Co farrant 6 Co vay Netwo	ues Minor 152 217 152 cular Volu onditions Mondition B Mondition B Monditions Mondi	Minimum Major 630 866 720 mme et	Minor 53 144 60 YES 152.1% N/A N/A N/A N/A N/A N/A N/A N/A N/A N/A
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warr Roadway Network War Warrant 1 C Warrant 1 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 5 C Warrant 7 C Warrant 7 C Warrant 7 C Warrant 7 C	Warrant e Warrant rant Vehicular Condition A Condition A.3 Condition B Sing Conditions I rience Condition A Condition B	Volume Met Met Met Met Met Met Met Met Met	YES	152 143 217 152 144.8% 97.3% 382.5% 217.0% 147.6% 150.7% NA	Was Was Was Was Was Was Was Was Was Was	arrant #	105 94 100 120 \$\frac{1}{2}\$ 2 - Four	Major 613 866 613 hour Vehi Varrant 2 Co trian Volu farrant 4 Co farrant 4 Co farrant 6 Co vay Netwo	ues Minor 152 217 152 cular Volu onditions Mondition B Mondition B Monditions Mondi	Minimum Major 630 866 720 mme et	Minor 53 144 60 YES 152.1% N/A N/A N/A N/A N/A N/A N/A N/A N/A N/A
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warr Roadway Network War Warrant 1 C Warrant 1 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 5 C Warrant 7 C Warrant 7 C Warrant 7 C Warrant 7 C	Warrant e Warrant rant Vehicular Condition A Condition A.3 Condition B Sing Conditions I rience Condition A Condition B	Volume Met Met Met Met Met Met Met Met Met Me	YES	152 143 217 152 144.8% 97.3% 382.5% 217.0% 147.6% 150.7% NA	W: W: W: W: W: W: W: W: W: W:	arrant #	105 94 100 120 \$\frac{1}{2}\$ 2 - Four	Major 613 866 613 hour Vehi Varrant 2 Co trian Volu farrant 4 Co farrant 4 Co farrant 6 Co vay Netwo	ues Minor 152 217 152 cular Volu onditions Mondition B Mondition B Monditions Mondi	Minimum Major 630 866 720 mme et	Minor 53 144 60 YES 152.1% N/A N/A N/A NO N/A
8th Hour Vehicular Volume 4th Hour Vehicular Volume Peak Hour Vehicular Volume Crash Experience Warr Roadway Network War Warrant 1 C Warrant 1 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 5 C Warrant 7 C Warrant 7 C Warrant 7 C Warrant 7 C	Warrant e Warrant rant Vehicular Condition A Condition A.3 Condition B Sing Conditions I rience Condition A Condition B	Volume Met Met Met Met Met Met Met Met Met Me	YES	152 143 217 152 144.8% 97.3% 382.5% 217.0% 147.6% 150.7% NA N/A N/A	W: W: W: W: W: W: W: W: W: W:	arrant #	105 94 100 120 \$\frac{1}{2}\$ 2 - Four	Major 613 866 613 hour Vehi Varrant 2 Co trian Volu farrant 4 Co farrant 4 Co farrant 6 Co vay Netwo	ues Minor 152 217 152 cular Volu onditions Mondition A Mondition B Monditions Mondi	Minimum Major 630 866 720 mme et	Minor 53 144 60 YES 152.1% N/A N/A N/A NO N/A Mo N/A

	Warrant Number and Title	Met	Percent Met
1	Eight-hour Vehicular Volume	YES	144.8%
2	Four-hour Vehicular Volume	YES	152.1%
3	Peak Hour	YES	147.6%
4	Pedestrian Volumes	N/A	N/A
5	School Crossing	N/A	N/A
6	Coordinated Signal System	N/A	N/A
7	Crash Experience	N/A	N/A
8	Roadway Network	N/A	N/A
	Total Number of Warrants Met		3

	Interse	ction:	Noi	rth Fron	itage R	.oad	and		Johnso	n Lane			
ĺ		Case:			Ma		ment Opt 18		35				
İ		Date:				Ji	anuary 25, 20	012					
Major		Johnson La		Minor S			orth Frontage I			Street 2:	North Frontage Road		
Major	r Street Dir. (N-S or	· E-W):	N-S		or Street 1 I	_				Street 2 Dir. (N-S or E- proach Dir. (EB or WB)		W):	E-W EB
14		0.5	ı .					WB	•				
Major Si	treet Speed Limit:		mph	Major S	treet 85th %	•	40	mph Total		Intersection	Approaches	:	4
Beginnir	ng Hour	Jonnso NB	on Lane SB		WB	Frontage EB		Major	High Minor		Total Entering		
2 vg		112	52		****	LD		1714101	1711101		Entering		
7:00		346	911		31	126		1257	126		1414	< 8th	Highest
8:00		646	877		28	141		1523	141		1692		
9:00		361	668		24	168		1029	168		1221		
10:00		395	638		38	165		1033	165		1236		
11:00		429	644		27	181		1073	181		1281		
12:00		542 649	563 540		30 27	197 206		1105	197 206		1332 1422		
1:00		735	682					1189			1657		
2:00 3:00		735 747	668		30 30	210 233		1417 1415	210 233		1678	4 14h	Highest
4:00		836	641		30	292		1477	292		1799	< 401	nighest
5:00		928	628		31	339		1556	339		1926	- Pes	ak Hour
6:00		646	533		27	244		1179	244		1450	~ 1 00	ik i ioui
7:00		466	364		20	168		830	168		1018		
7.00	1141	400	304					000	100		1010		
Ave. W	eekday Volumes =	9000	9900		500	3400		18900	3400		22800		
					Cond	lition A				Condit	ion B		1
	Volume Warrants			Values			Minimums		Va	lues	Minim	ıms	
			Major (To	tal Entering)	Minor	Major (Te	otal Entering)	Minor	Major	Minor	Major	Minor	
8th Hou	ır Vehicular Volum	e Warraı	1	257	126		500	150	1257	126	750	75	
4th Hou	ır Vehicular Volum	e Warraı	1	415	233		1415	80					i
Peak Ho	ur Vehicular Volum	ne Warraı	1	926	339		800	100	1556	339	1556	100	i
Cra	ash Experience War	ran	1	257	126		400	120	1257	126	600	60	i
Roa	adway Network Wa	rran	1	926		(1000)						i
Warrant	# 1 - Eight-hou	r Vehicula	ar Volum	ie		_	Warrant	# 2 - Four	-hour Vel	hicular Vo	olume		
	Warrant 1 (Condition A	Met	NO	84.0%			V	Varrant 2 C	onditions M	let	YES	291.3%
	Warrant 1 (Condition B	Met	YES	167.6%								
Warrant	# 3 - Peak Hour	r					Warrant	# 4 - Ped e	strian Vol	lumes			
	Warrant 3 C	ondition A.	1 Met	YES	1040.0%			W	arrant 4 Co	ondition A N	Aet	N/A	N/A
	Warrant 3 C	ondition A.2	2 Met	YES	339.0%			W	arrant 4 Co	ondition B M	1 et	N/A	N/A
	Warrant 3 C			YES	240.8%		ļ						
	Warrant 3 (Condition B	Met	YES	339.0%								
Warrant	# 5 - School Cre	ossing					Warrant	# 6 - Coor	dinated S	ignal Syst	tem		
	Warrant 5	Conditions	Met	NA	NA			V	Varrant 6 C	onditions M	let	NO	N/A
Warrant	#7 - Crash Exp	erience				=	Warrant	# 8 - Road	lway Netv	vork			<u></u>
	Warrant 7 (Condition A	Met	NO	N/A			V	Varrant 8 C	onditions M	let	NO	N/A
	Warrant 7 (NO	N/A		l		0				,,, ,
	Warrant 7 (NO	N/A								
			1	Warrant Nu	ımher and	l Title				Met	Percent	Met	ł
	1		'				Volume			YES	167.69		1
	1	+			t-hour Vo								1
	2	1		Fou	r-hour Ve	mcular	v otume			YES	291.39	70	1

	Warrant Number and Title	Met	Percent Met
1	Eight-hour Vehicular Volume	YES	167.6%
2	Four-hour Vehicular Volume	YES	291.3%
3	Peak Hour	YES	339.0%
4	Pedestrian Volumes	N/A	N/A
5	School Crossing	N/A	N/A
6	Coordinated Signal System	N/A	N/A
7	Crash Experience	N/A	N/A
8	Roadway Network	N/A	N/A
	Total Number of Warrants Met		3

	7 /	,•		WID ()(1	1	1			
ĺ	Interse	_		WB Off			and		ohnso	n Lane			
ı		Case: Date:			IVIA		nent Opt 18 nuary 25, 20		<u>ა</u>				
Maiar	r Street:	Johnson La	200	Minon S	tmost 1.		NB Off Ram		Minon	Samuel 2			
	or Street: (N-S or		N-S	Minor S Mino	or Street 1 D			E-W	Minor Street 2: Minor Street 2 Dir. (N-S or E-			W):	
		,.			pproach Di		,	WB			(EB or WB)		
Major S	Street Speed Limit:	35	mph	Major St	treet 85th %	Speed:	35	mph	Total	al Intersection Approaches:			3
		Johnso	on Lane		WB Of	f Ramp		Total	High		Total		
Beginni	ing Hour	NB	SB		WB			Major	Minor		Entering		
7:00	O AM	381	888		276			1269	276		1545		
	O AM	711	855		246			1566	246		1812		
9:00) AM	398	651		212			1049	212		1261		
10:0	0 AM	435	622		336			1057	336		1393		
	0 AM	472	628		234			1100	234		1334		
	0 AM	596	549		262			1145	262		1407	< 8th I	Highest
	0 PM	714	526		238			1240	238		1478		
	0 PM <mark>0 PM</mark>	809 822	664 651		260 264			1473 1473	260 264		1733 1737	- 14h l	Highest
	0 PM	920	625		264			1545	264		1809	< 4011	nighest
	0 PM	1021	612		270			1633	270		1903	< Pea	k Hour
	0 PM	711	520		236			1231	236		1467		
7:00	7:00 PM 512				174			867	174		1041		
Ave. W	Veekday Volumes =	9900	9650		4400			19550	4400		23950		
	Volume Warrants		-	Values	Cona	ition A	Minimums		Val	Conditi	on B Minimi	ıme	
	voiume warranis		Major (To	tal Entering)	Minor	Major (Tota	al Entering)	Minor	Major	Minor	Major	Minor	
8th Ho	ur Vehicular Volume	e Warraı		145	262		00	150	1145	262	750	75	
	ur Vehicular Volume		1	473	276	14	473	80		-			
Peak Ho	our Vehicular Volum	e Warraı		903	270		50	100	1633	270	1633	100	
	rash Experience War			145	262		00	120	1145	262	600	60	
Ro	oadway Network Wa	rran	1	903		(10	000)						
Warran													
	t # 1 - Eight-hou	r Vehicul	ar Volum	ne			Warrant	# 2 - Four	hour Veh	icular Vo	lume		
	t # 1 - Eight-hour				174 70/		Warrant					VEC	245 00/
	Warrant 1 (Condition A	Met	YES	174.7%		Warrant :		-hour Veh Varrant 2 Co			YES	345.0%
Warran	Warrant 1 (Condition A Condition B	Met		174.7% 152.7%		l	V	arrant 2 Co	onditions M		YES	345.0%
Warran	Warrant 1 C Warrant 1 C	Condition A Condition B	Met Met	YES YES	152.7%		Warrant	W # 4 - Pedes	arrant 2 Co strian Vol	onditions M umes	et		
Warran	Warrant 1 C Warrant 1 C at #3 - Peak Hour	Condition A Condition B condition A.	Met Met	YES YES	152.7% 13300.0%		l	# 4 - Pede s	Varrant 2 Co strian Vol arrant 4 Co	onditions M umes ndition A M	et	N/A	N/A
Warran	Warrant 1 C Warrant 1 C	Condition A Condition B ondition A. condition A.	Met Met 1 Met 2 Met	YES YES YES	152.7% 13300.0% 270.0%		l	# 4 - Pede s	arrant 2 Co strian Vol	onditions M umes ndition A M	et	N/A	
Warran	Warrant 1 C Warrant 1 C at #3 - Peak Hour Warrant 3 C Warrant 3 C	Condition A Condition B condition A. condition A. condition A. condition A.	Met Met 1 Met 2 Met 3 Met	YES YES	152.7% 13300.0%		l	# 4 - Pede s	Varrant 2 Co strian Vol arrant 4 Co	onditions M umes ndition A M	et	N/A	N/A
	Warrant 1 C Warrant 1 C at #3 - Peak Hour Warrant 3 C Warrant 3 C Warrant 3 C	Condition A Condition B condition A. condition A. condition A. Condition B	Met Met 1 Met 2 Met 3 Met	YES YES YES YES YES	152.7% 13300.0% 270.0% 292.8%		l	# 4 - Pedes	varrant 2 Co estrian Vol arrant 4 Co arrant 4 Co	umes ndition A M	let let	N/A	N/A
	Warrant 1 (Warrant 1 (Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C	condition A Condition B condition A condition A condition A Condition B condition B	Met Met 1 Met 2 Met 3 Met Met	YES YES YES YES YES	152.7% 13300.0% 270.0% 292.8%		Warrant :	# 4 - Pedes W W	varrant 2 Co estrian Vol arrant 4 Co arrant 4 Co	umes ndition A M ndition B M	let let let	N/A	N/A
Warran	Warrant 1 (Warrant 1 (Warrant 1 (Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C	Condition A Condition B Condition A Condition A Condition B Condition B Condition B Condition B	Met Met 1 Met 2 Met 3 Met Met	YES YES YES YES YES YES YES	152.7% 13300.0% 270.0% 292.8% 270.0%		Warrant :	# 4 - Pedes W W	strian Vol arrant 4 Co arrant 4 Co dinated Si	umes ndition A M ndition B M agnal Syst	let let let	N/A N/A	N/A N/A
Warran	Warrant 1 (Warrant 1 (Warrant 1 (Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 5 C Warrant 5 School Cre	Condition A Condition B condition A condition A condition A Condition B condition B condition B conditions	Met Met 1 Met 2 Met 3 Met Met	YES YES YES YES YES YES YES	152.7% 13300.0% 270.0% 292.8% 270.0%		Warrant	# 4 - Pedes W W # 6 - Coor W # 8 - Road	varrant 2 Constrian Volument 4 Constraint 4 Constraint 4 Constraint 4 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constr	umes ndition A M ndition B M ignal Syst	et let let let em	N/A N/A	N/A N/A
Warran	Warrant 1 (Warrant 1 (Warrant 1 (Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 5 - School Cree Warrant 5	Condition A Condition B condition A condition A condition A Condition B conditions conditions conditions conditions	Met Met 1 Met 2 Met 3 Met Met Met	YES YES YES YES YES YES YES NA	152.7% 13300.0% 270.0% 292.8% 270.0%		Warrant	# 4 - Pedes W W # 6 - Coor W # 8 - Road	strian Vol arrant 4 Co arrant 4 Co dinated Si	umes ndition A M ndition B M ignal Syst	et let let let em	N/A N/A	N/A N/A
Warran	Warrant 1 (Warrant 1 (Warrant 1 (Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 5 C At #5 - School Cree Warrant 5 C Warrant 7 C Warrant 7 (Condition A Condition B condition A condition A condition B condition B conditions conditions conditions conditions condition A	Met Met 1 Met 2 Met 3 Met Met Met Met	YES YES YES YES YES YES YES NA	152.7% 13300.0% 270.0% 292.8% 270.0% NA		Warrant	# 4 - Pedes W W # 6 - Coor W # 8 - Road	varrant 2 Constrian Volument 4 Constraint 4 Constraint 4 Constraint 4 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constr	umes ndition A M ndition B M ignal Syst	et let let let em	N/A N/A	N/A N/A
Warran	Warrant 1 (Warrant 1 (Warrant 1 (Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 5 C At # 5 - School Cree Warrant 5 C Warrant 7 C Warrant 7 (Warrant 7 (Condition A Condition B condition A condition A condition B condition B conditions conditions conditions conditions condition A	Met Met 1 Met 2 Met 3 Met Met Met Met	YES YES YES YES YES YES YES NA NO NO	152.7% 13300.0% 270.0% 292.8% 270.0% NA		Warrant	# 4 - Pedes W W # 6 - Coor W # 8 - Road	varrant 2 Constrian Volument 4 Constraint 4 Constraint 4 Constraint 4 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constr	umes ndition A M ndition B M ignal Syst	et let let let em	N/A N/A	N/A N/A
Warran	Warrant 1 (Warrant 1 (Warrant 1 (Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 5 C At # 5 - School Cree Warrant 5 C Warrant 7 C Warrant 7 (Warrant 7 (Condition A Condition B condition A condition A condition B condition B conditions conditions conditions conditions condition A	Met Met I Met 2 Met 3 Met Met Met Met Met	YES YES YES YES YES YES NA NO NO NO	152.7% 13300.0% 270.0% 292.8% 270.0% NA N/A N/A N/A	Title	Warrant	# 4 - Pedes W W # 6 - Coor W # 8 - Road	varrant 2 Constrian Volument 4 Constraint 4 Constraint 4 Constraint 4 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constr	umes Indition A Mandition B Mandition B Manditions Mand	et l	N/A N/A N/A NO NO	N/A N/A
Warran	Warrant 1 (Warrant 1 (Warrant 1 (Warrant 3 C Warrant 3 C Warrant 3 C Warrant 3 C Warrant 5 C At # 5 - School Cree Warrant 5 C Warrant 7 C Warrant 7 (Warrant 7 (Condition A Condition B condition A condition A condition B condition B conditions conditions conditions conditions condition A	Met Met I Met 2 Met 3 Met Met Met Met Met	YES YES YES YES YES YES NA NO NO NO Warrant Nu	152.7% 13300.0% 270.0% 292.8% 270.0% NA N/A N/A N/A		Warrant ; Warrant ;	# 4 - Pedes W W # 6 - Coor W # 8 - Road	varrant 2 Constrian Volument 4 Constraint 4 Constraint 4 Constraint 4 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constraint 6 Constr	umes ndition A M ndition B M ignal Syst	et let let let em	N/A N/A N/A NO Mo	N/A N/A

	Warrant Number and Title	Met	Percent Met
1	Eight-hour Vehicular Volume	YES	152.7%
2	Four-hour Vehicular Volume	YES	345.0%
3	Peak Hour	YES	270.0%
4	Pedestrian Volumes	N/A	N/A
5	School Crossing	N/A	N/A
6	Coordinated Signal System	N/A	N/A
7	Crash Experience	N/A	N/A
8	Roadway Network	N/A	N/A
	Total Number of Warrants Met		3

	Inter	section:		Highwa	ay 312		and	F	ive Mil	e Road	d		
		Case:			Five		Alignment		y 312				
		Date:				Ja	nuary 24, 20)12					
Major S		Highway 3		Minor S			Five Mile Roa			Street 2:		ate Road	
Major	Street Dir. (N-	S or E-W):	E-W			Oir. (N-S or ir. (NB or S		N-S NB			r. (N-S or E-V . (NB or SB)	W): N-S	
Major Sti	reet Speed Limit	t: 50	mph		reet 85th %			mph		_	Approaches:		
		Highv	vay 312		Five M	lile Road		Total	High		Total	·	
Beginnin	g Hour	EB	WB		NB	SB		Major	Minor		Entering		
7:00 A	AM	219	627		85	2		846	85		933		
8:00 A		244	523		158	2		767	158		933		
9:00 A		225	359		88	1		584	88		673		
10:00	AM	238	331		97	1		569	97		667		
11:00	AM	288	348		105	1		636	105		742		
12:00	AM	330	341		133	1		671	133		805		
1:00 1	PM	370	335		159	1		705	159		865	< 8th Highe	est
2:00 1	PM	419	346		180	1		765	180		946	< 4th Highe	est
3:00 1	PM	466	361		183	1		827	183		1011		
4:00 1		522	401		204	1		923	204		1128		
5:00 1		572	374		227	1		946	227		1174	< Peak Ho	ur
6:00 1		423	322		158	1		745	158		904		
7:00 1	PM	363	232		114	1		595	114		710		
Ave. We	ekday Volumes	s = 5650	5850		2200	20		11500	2200		13720		
					σ.	1				G III	. n		
	Volume Warrai	nts		Values	Conc	lition A	Minimums		Va	Condition Condit	Minimu	ıms	
			Major (To	tal Entering)	Minor	Major (To	tal Entering)	Minor	Major	Minor		Minor	
8th Hour	r Vehicular Vol	ume Warrai		705	159		120	105	705	159	630	53	
4th Hour	r Vehicular Vol	ume Warrai		765	180	7	765	88					
Peak Hou	ır Vehicular Vo	lume Warraı		174	227		300	100	946	227	946	123	
	sh Experience \			705	159		180	120	705	159	720	60	
Roa	dway Network	Warran	1	174		(1	000)						
Warrant	# 1 - Eight-h	our Vehicul:	ar Volum	e			Warrant	# 2 - Four	-hour Vel	nicular Vo	dume		
		t 1 Condition A		YES	151.4%	1			Varrant 2 C			YES 204.	5%
		t 1 Condition B		YES	111.9%							. 20	5 70
Warrant	# 3 - Peak H	our				•	Warrant :	# 4 - Pede:	strian Vol	umes			
	Warrant	3 Condition A.	1 Met	NO	33.8%	1		W	arrant 4 Co	ndition A N	I et	N/A N/	/A
	Warrant	3 Condition A.:	2 Met	YES	227.0%			W	arrant 4 Co	ndition B N	1et	N/A N/	
	Warrant	3 Condition A.	3 Met	YES	146.8%		ı					<u> </u>	
	Warran	t 3 Condition B	Met	YES	184.6%								
Warrant	rrant # 5 - School Crossing					_	Warrant	# 6 - Coor	dinated S	ignal Syst	tem		
	Warrant 5 Conditions Met				NA	1		V	Varrant 6 C	onditions M	let	NO N/	/A
Warrant	#7 - Crash I	Experience				•	Warrant	# 8 - Road	way Netv	vork		·	
	Warran	t 7 Condition A	NO	N/A	1		V	Varrant 8 C	onditions M	let	NO N/	/A	
	Warran	NO	N/A			·	· urrunt o c	0114110115 111		110	•		
F	Warrant 7 Condition C Met NO												
1	Warrant 7 Condition C Met NO N/A												
<u> </u>				Warrant Ni									
										Met	Percent		
	1		1	Eigh	t-hour V	ehicular V				YES	111.9%	'o	
	2		1	Eigh	t-hour Vo r-hour Vo	ehicular V ehicular V				YES YES	111.9% 204.59	6 6	
	2 3		1	Eigh Four	t-hour Vo r-hour Vo Peal	ehicular V ehicular V k Hour	olume			YES	111.9% 204.5% 184.6%	6 6	
	2		1	Eigh Four	t-hour Vo r-hour Vo Peal Pedestria	ehicular V ehicular V	olume			YES YES	111.9% 204.59	6 6	

	Warrant Number and Title	Met	Percent Me
1	Eight-hour Vehicular Volume	YES	111.9%
2	Four-hour Vehicular Volume	YES	204.5%
3	Peak Hour	YES	184.6%
4	Pedestrian Volumes	N/A	N/A
5	School Crossing	N/A	N/A
6	Coordinated Signal System	N/A	N/A
7	Crash Experience	N/A	N/A
8	Roadway Network	N/A	N/A
	Total Number of Warrants Met		3

Interse	ction:		Five Mil	le Roa	<u></u>	and	Fiv	e Mile	Rd Ali	gn	
	Case:					Road Alignm				3	
	Date:					January 25, 2	2012				
Major Street: Mary S	reet Secon	dary Imp.	Minor S	treet 1:	F	ive Mile Road	Align	Minor	Street 2:		
Major Street Dir. (N-S or I	E-W):	E-W	Mino	r Street 1 l	Dir. (N-S	or E-W):	N-S			. (N-S or E-V	V):
			A	Approach D	oir. (NB or	· SB)	NB	Ap	proach Dir.	(EB or WB)	
Major Street Speed Limit:	45	mph	Major S	treet 85th %	% Speed:	50	mph		l Intersectio	n Approaches.	: 3
	Five M	ile Road		Mary	Street		Total	High		Total	
Beginning Hour	NB	SB		EB	WB		Major	Minor		Entering	
7:00 AM	697	126		169			823	169		992	< 4th Highest
8:00 AM	581	112		316			693	316		1009	
9:00 AM	399	104		177			503	177		680	
10:00 AM	368	110		193			478	193		671	
11:00 AM	387	133		210			520	210		730	
12:00 AM	378	152		265			530	265		795	4 Oth Highaut
1:00 PM 2:00 PM	373 384	170 193		317 359			543 577	317 359		860 936	< 8th Highest
3:00 PM	402	215		365			617	365		982	
4:00 PM	446	240		409			686	409		1095	
5:00 PM	457	263		454			720	454		1174	< Peak Hour
6:00 PM	358	195		316			553	316		869	VI ball Hoal
7:00 PM	258	167		228			425	228		653	
Ave. Weekday Volumes =	6500	2600		4400			9100	4400		13500	
		1		Com	dition A			I	Condit	law D	
Volume Warrants			Values	Cone	illuon A	Minimums		Vo	lues	ЮП Б Minimu	ıme
voiume warrants		Major (To	tal Entering)	Minor	Major (Total Entering)	Minor	Major Na	Minor	Major	Minor
8th Hour Vehicular Volume V	Warrant		543	317	major (420	105	543	317	630	53
4th Hour Vehicular Volume V			323	169		823	77	010	017	000	
Peak Hour Vehicular Volume	Warrant	1	174	454		650	100	720	454	720	191
Crash Experience Warr	ant	5	543	317		480	120	543	317	720	60
Roadway Network Warr		1	174			(1000)					
Warrant # 1 - Eight-hour V	/ehicular	Volume				Warrant :	# 2 - Four-	hour Vehi	cular Volu	ıme	
			\/FC	100 20/	1	vvariane,					VEC 210 50/
Warrant 1 Co			YES	129.3%	ł		V	Varrant 2 C	onatuons M	et	YES 219.5%
Warrant # 3 - Peak Hour	onunuon b	Met	NO	86.2%	j	Wannant	# 4 - Pede s	trian Valu	mag		
	77.7	3.5 .				vv arramt					
Warrant 3 Co Warrant 3 Co			NO YES	41.0%	ŀ			arrant 4 Co arrant 4 Co			N/A N/A
Warrant 3 Co			YES	454.0% 180.6%				arrant 4 Co	munnon b w	let	N/A N/A
Warrant 3 Co			YES	237.7%	i						
Warrant # 5 - School Cross	sing				4	Warrant 7	# 6 - Coord	linated Sig	nal Syster	n	
Warrant 5 C	Conditions I	Met	NA	NA	1		V	Varrant 6 C	onditions M	et	NO N/A
Warrant #7 - Crash Exper	ience				•	Warrant a	# 8 - Roady	way Netwo	ork		
Warrant 7 Co	ondition A	Met	NO	N/A	1		V	Varrant 8 C	onditions M	et	NO N/A
Warrant 7 Co	ondition B	Met	NO	N/A	1						
Warrant 7 Co	ondition C	Met	NO	N/A]						
	-		Warrant Nu	ımber ana	l Title				Met	Percent 1	Met
1			Eigh	ht-hour V	ehicular	· Volume			YES	129.39	/ 6
2	Ì			r-hour V					YES	219.59	%
	1			n.	1. TT				VEC	227.70	

	Warrant Number and Title	Met	Percent Met
1	Eight-hour Vehicular Volume	YES	129.3%
2	Four-hour Vehicular Volume	YES	219.5%
3	Peak Hour	YES	237.7%
4	Pedestrian Volumes	N/A	N/A
5	School Crossing	N/A	N/A
6	Coordinated Signal System	N/A	N/A
7	Crash Experience	N/A	N/A
8	Roadway Network	N/A	N/A
	Total Number of Warrants Met		3

Interse	ction	P	itterro	ot Driv	e and		Mary	Street		
11110150	Case:				Alignment Second	dary Improve				
	Date:				January 24					
Major Street:	Mary Stree	et	Minor S	treet 1:	Bitterroot D	Orive	Minor	Street 2:	Bitter	rroot Drive
Major Street Dir. (N-S or		E-W			Oir. (N-S or E-W):	N-S			r. (N-S or E-V	,
			A	pproach D	ir. (NB or SB)	NB	A	proach Dir	. (NB or SB)	SB
Major Street Speed Limit:	35	mph	Major S	treet 85th %	6 Speed: 40	mph	Tota	l Intersectio	n Approaches	: 4
	Mary	Street		Bitterre	oot Drive	Total	High		Total	
Beginning Hour	EB	WB		NB	SB	Major	Minor		Entering	
7:00 AM	472	213		81	175	685	175		941	< 4th Highest
8:00 AM	393	190		151	168	583	168		902	< til Highest
9:00 AM	270	176		84	128	446	128		658	
10:00 AM	249	186		92	122	435	122		649	
11:00 AM	262	225		100	124	487	124		711	
12:00 AM	256	257		127	108	513	127		748	
1:00 PM	252	289		152	104	541	152		797	< 8th Highest
2:00 PM	260	326		172	131	586	172		889	
3:00 PM	272	363		174	128	635	174		937	
4:00 PM	302	407		195	123	709	195		1027	
5:00 PM	309	445		217	120	754	217		1091	< Peak Hour
6:00 PM	242	329		151	102	571	151		824	
7:00 PM	175	283		109	70	458	109		637	
Ave. Weekday Volumes =	4400	4400		2100	1900	8800	2100		12800	
				Conc	lition A			Condit		
Volume Warrants			Values	T.	Minimun			lues	Minimu	
			al Entering)	Minor	Major (Total Entering	,,	Major	Minor	Major	Minor
8th Hour Vehicular Volume			41	152	500	150	541	152	750	<i>7</i> 5
4th Hour Vehicular Volume			85	175	685	185				10-
Peak Hour Vehicular Volume)91	217	800	100	754	217	754	127
Crash Experience Warr			41 091	152	400 (1000)	120	541	152	600	60
Roadway Network War	гаш	10	J y I		(1000)					
Warrant # 1 - Eight-hour V	Vahicular	Volume			Warran	nt # 2 - Four-	hour Vohi	cular Valı	ıma	
					, , , , , , , , , , , , , , , , , , ,					
Warrant 1 C			YES	101.3%		V	Varrant 2 C	onditions M	et	NO 94.6%
Warrant 1 C	ondition B	Met	NO	72.1%						
Warrant # 3 - Peak Hour					Warran	nt # 4 - Pedes	trian Volu	mes		
Warrant 3 Co	ndition A.1	Met	YES	107.5%		W	arrant 4 Co	ndition A M	1et	N/A N/A
Warrant 3 Co			YES	217.0%			arrant 4 Co			N/A N/A
Warrant 3 Co			YES	136.4%						. ,,
Warrant 3 C	ondition B	Met	YES	170.9%						
Warrant # 5 - School Cross	sing				Warran	nt # 6 - Coord	linated Sig	nal Syster	m	
Warrant 5 (Conditions I	Met	NA	NA			Varrant 6 C			NO N/A
Warrant # 7 - Crash Expe	rience				Warran	nt # 8 - Roady	way Netwo	ork		
Warrant 7 C	ondition A	Met	NO	N/A		V	Varrant 8 C	onditions M	et	NO N/A
Warrant 7 C			NO	N/A						
Warrant 7 C			NO	N/A						
					· 					
		V	Varrant Nu	ımber and	Title			Met	Percent .	Met
1			Eigl	ht-hour V	ehicular Volume			YES	101.39	6
2			Fou	ır-hour V	ehicular Volume			NO	94.6%	6

	Warrant Number and Title	Met	Percent Met
1	Eight-hour Vehicular Volume	YES	101.3%
2	Four-hour Vehicular Volume	NO	94.6%
3	Peak Hour	YES	107.5%
4	Pedestrian Volumes	N/A	N/A
5	School Crossing	N/A	N/A
6	Coordinated Signal System	N/A	N/A
7	Crash Experience	N/A	N/A
8	Roadway Network	N/A	N/A
	Total Number of Warrants Met		3

										•	
Intersection	: No	rth Fror	ntage R	load	and		Johnsc	n Lane			
Ca	ie:		Fiv	/e Mile Roa			035				
De	te:			Jan	uary 25, 20)12					
Major Street: Johnson	Lane	Minor	Street 1:	North	n Frontage I	Road	Minor	Street 2:	North F	rontage	Road
Major Street Dir. (N-S or E-W):	N-S	_		Dir. (N-S or E		E-W		r Street 2 Di	-		E-W
				ir. (EB or WI		WB	-	pproach Dir.			EB
Major Street Speed Limit: 38	-	Major S	Street 85th %	•	40	mph		l Intersection	11	s:	4
	nson Lane			Frontage		Total	High		Total		
Beginning Hour N	SB		WB	EB		Major	Minor		Entering		
7:00 AM 29	764		31	121		1056	121		1208	< 8th F	Highest
8:00 AM 54	736		28	135		1282	135		1445		
9:00 AM 30	560		24	161		865	161		1050		
10:00 AM 33	535		38	158		869	158		1065		
11:00 AM 36	2 540		27	173		902	173		1102		
12:00 AM 45	3 472		30	188		930	188		1148		
1:00 PM 54	453		27	197		1001	197		1225		
2:00 PM 62	571		30	201		1192	201		1423		
3:00 PM 63	560		30	222		1191	222		1443	< 4th F	Highest
4:00 PM 70	537		30	279		1243	279		1552		
5:00 PM 78	526		31	324		1310	324		1665	< Pea	k Hour
6:00 PM 54			27	233		993	233		1253		
7:00 PM 39			20	160		699	160		879		
Ave. Weekday Volumes = 760	0 8300		500	3250		15900	3250		19650		
			Conc	dition A				Condit	ion B		
Volume Warrants		Values	Conc	dition A	Minimums		Va	Condit alues	ion B Minim	ums	
Volume Warrants	Major (T	Values otal Entering)	Conc Minor	dition A Major (Tota		Minor	Va Major			ums Minor	
Volume Warrants 8th Hour Vehicular Volume Warr	1	otal Entering) 1056	<u> </u>	Major (Tota	l Entering) 10	Minor 150		lues	Minim		
	1	otal Entering)	Minor	Major (Tota	l Entering) 10		Major	Minor	Minim Major	Minor	
8th Hour Vehicular Volume Warr	1	otal Entering) 1056	Minor 121	Major (Tota	l Entering) 00 91	150	Major	Minor	Minim Major	Minor	
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr	1	otal Entering) 1056 1191	Minor 121 222	Major (Tota 50	l Entering) 00 91	150 80	Major 1056	Minor 121	Minim Major 750	<i>Minor</i> 75	
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume War	i i	otal Entering) 1056 1191 1665	Minor 121 222 324	Major (Tota 50 111	l Entering) 00 91 00	150 80 100	Major 1056 1310	Minor 121 324	Minim <i>Major</i> 750	<i>Minor</i> 75 100	
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume War Crash Experience Warran	i i	otal Entering) 1056 1191 1665 1056	Minor 121 222 324	Major (Tota 50 111 80 40	l Entering) 00 91 00	150 80 100	Major 1056 1310	Minor 121 324	Minim <i>Major</i> 750	<i>Minor</i> 75 100	
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume War Crash Experience Warran	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	otal Entering) 1056 1191 1665 1056 1665	Minor 121 222 324	Major (Tota 50 11: 80 40 (10)	l Entering) 00 91 00 00 00 00 00 00 00	150 80 100 120	Major 1056 1310 1056	Minor 121 324	Minim <i>Major</i> 750 1310 600	<i>Minor</i> 75 100	
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume Warr Crash Experience Warran Roadway Network Warran Warrant # 1 - Eight-hour Vehi	cular Volum	otal Entering) 1056 1191 1665 1056 1665 me	Minor 121 222 324 121 80.7%	Major (Tota 50 11: 80 40 (10)	l Entering) 00 91 00 00 00 00 00 00 00	150 80 100 120 # 2 - Four	Major 1056 1310 1056 -hour Ve	Minor 121 324 121	Minim	Minor 75 100 60	277.5%
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume Warr Crash Experience Warran Roadway Network Warran Warrant #1 - Eight-hour Vehi	cular Volum	otal Entering) 1056 1191 1665 1056 1665	Minor 121 222 324 121	Major (Tota 50 11: 80 40 (10)	l Entering) 00 91 00 00 00 00 00 00 00	150 80 100 120 # 2 - Four	Major 1056 1310 1056 -hour Ve	Minor 121 324 121 hicular Vo	Minim	Minor 75 100 60	277.5%
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume Warr Crash Experience Warran Roadway Network Warran Warrant # 1 - Eight-hour Vehi	cular Volum	otal Entering) 1056 1191 1665 1056 1665 me	Minor 121 222 324 121 80.7%	Major (Tota 50 111 80 40 (10)	l Entering) 00 91 00 00 00 00 Warrant	150 80 100 120 # 2 - Four	Major 1056 1310 1056 -hour Ve	Minor 121 324 121 hicular Vo	Minim	Minor 75 100 60	277.5%
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume Warr Crash Experience Warran Roadway Network Warran Warrant # 1 - Eight-hour Vehi Warrant 1 Condition	cular Volum	otal Entering) 1056 1191 1665 1056 1665 me	Minor 121 222 324 121 80.7%	Major (Tota 50 111 80 40 (10)	l Entering) 00 91 00 00 00 00 Warrant	150 80 100 120 # 2 - Four V	Major 1056 1310 1056 -hour Ve Varrant 2 C	Minor 121 324 121 hicular Vo	Minim Major 750 1310 600 blume	Minor 75 100 60	277.5%
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume Warr Crash Experience Warran Roadway Network Warran Warrant # 1 - Eight-hour Vehi Warrant 1 Conditi Warrant 1 Conditi Warrant 4 3 - Peak Hour	cular Volum n A Met n B Met	otal Entering) 1056 1191 1665 1056 1665 me	Minor 121 222 324 121 80.7% 140.8%	Major (Tota 50 111 80 40 (10)	l Entering) 00 91 00 00 00 00 Warrant	150 80 100 120 # 2 - Four v	Major 1056 1310 1056 -hour Ve Varrant 2 C	Minor 121 324 121 hicular Vo	Minim Major 750 1310 600 blume let	Minor 75 100 60	
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume Warr Crash Experience Warran Roadway Network Warran Warrant # 1 - Eight-hour Vehi Warrant 1 Conditi Warrant 1 Conditi Warrant 3 - Peak Hour Warrant 3 Conditio	cular Volum n A Met n B Met A.1 Met A.2 Met	otal Entering) 1056 1191 1665 1056 1665 me NO	Minor 121 222 324 121 80.7% 140.8%	Major (Tota 50 111 80 40 (10)	l Entering) 00 91 00 00 00 00 Warrant	150 80 100 120 # 2 - Four v	Major 1056 1310 1056 -hour Ve Varrant 2 C	Minor 121 324 121 hicular Vo Conditions M blumes ondition A M	Minim Major 750 1310 600 blume let	Minor 75 100 60 YES	N/A
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume Warr Crash Experience Warran Roadway Network Warran Warrant # 1 - Eight-hour Vehi Warrant 1 Conditio Warrant 1 Conditio Warrant 3 Conditio Warrant 3 Conditio Warrant 3 Conditio	cular Volum n A Met n B Met A.1 Met A.2 Met A.3 Met	otal Entering) 1056 1191 1665 1056 1665 me NO YES YES YES	Minor 121 222 324 121 80.7% 140.8% 647.5% 324.0%	Major (Tota 50 111 80 40 (10)	l Entering) 00 91 00 00 00 00 Warrant	150 80 100 120 # 2 - Four v	Major 1056 1310 1056 -hour Ve Varrant 2 C	Minor 121 324 121 hicular Vo Conditions M blumes ondition A M	Minim Major 750 1310 600 blume let	Minor 75 100 60 YES	N/A
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume Warr Crash Experience Warran Roadway Network Warran Warrant # 1 - Eight-hour Vehi Warrant 1 Condition Warrant 1 Condition Warrant 3 Condition Warrant 3 Condition Warrant 3 Condition Warrant 3 Condition Warrant 3 Condition Warrant 3 Condition	cular Volum n A Met n B Met A.1 Met A.2 Met A.3 Met	otal Entering) 1056 1191 1665 1056 1665 me NO YES YES YES YES	Minor 121 222 324 121 80.7% 140.8% 647.5% 324.0% 208.1%	Major (Tota 50 11: 80 40 (10)	Warrant	150 80 100 120 # 2 - Four V # 4 - Pede W	Major 1056 1310 1056 -hour Ve Varrant 2 C strian Vo Varrant 4 C	Minor 121 324 121 hicular Vo Conditions M blumes ondition A M	Minim Major 750 1310 600 Olume let Met	Minor 75 100 60 YES	N/A
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume Warr Crash Experience Warran Roadway Network Warran Warrant # 1 - Eight-hour Vehi Warrant 1 Conditio Warrant 1 Conditio Warrant 3 Conditio Warrant 3 Conditio Warrant 3 Conditio Warrant 3 Conditio Warrant 3 Conditio	eular Volum n A Met n B Met A.1 Met A.2 Met A.3 Met n B Met	otal Entering) 1056 1191 1665 1056 1665 me NO YES YES YES YES	Minor 121 222 324 121 80.7% 140.8% 647.5% 324.0% 208.1%	Major (Tota 50 11: 80 40 (10)	Warrant	# 2 - Four # 4 - Pede W # 6 - Coor	Major 1056 1310 1056 -hour Ve Varrant 2 C strian Vo Varrant 4 C Varrant 4 C	hives Minor 121 324 121 hicular Vo Conditions M output	Minim Major 750 1310 600 Olume Met Met Met	Minor 75 100 60 YES	N/A
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume Warr Crash Experience Warran Roadway Network Warran Warrant # 1 - Eight-hour Vehi Warrant 1 Conditi Warrant 1 Conditi Warrant 3 - Peak Hour Warrant 3 Conditio Warrant 3 Conditio Warrant 3 Conditio Warrant 3 Conditio Warrant 3 Conditio Warrant 5 - School Crossing	cular Volum A Met n B Met A.1 Met A.2 Met A.3 Met n B Met	otal Entering) 1056 1191 1665 1056 1665 me NO YES YES YES YES YES YES	Minor 121 222 324 121 80.7% 140.8% 647.5% 324.0% 208.1% 324.0%	Major (Tota 50 11: 80 40 (10:	Warrant Warrant	# 2 - Four # 4 - Pede W # 6 - Coor	Major 1056 1310 1056 -hour Ve Varrant 2 C varrant 4 C varrant 4 C varrant 4 C	hives Minor 121 324 121 hicular Vo Conditions M ondition B M Signal Syst Conditions M	Minim Major 750 1310 600 Olume Met Met Met	Minor 75 100 60 YES N/A N/A	N/A N/A
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume Warr Crash Experience Warran Roadway Network Warran Warrant # 1 - Eight-hour Vehi Warrant 1 Condition Warrant 2 Condition Warrant 3 Condition Warrant 3 Condition Warrant 3 Condition Warrant 3 Condition Warrant 4 Condition Warrant 5 Condition Warrant 5 - School Crossing Warrant 5 Condition Warrant 5 Condition Warrant 5 Condition	cular Volum n A Met n B Met A.1 Met A.2 Met A.3 Met n B Met	otal Entering) 1056 1191 1665 1056 1665 me NO YES YES YES YES YES NA	Minor 121 222 324 121 80.7% 140.8% 647.5% 324.0% 208.1% 324.0%	Major (Tota 50 11: 80 40 (10:	Warrant Warrant	# 2 - Four # 2 - Four W # 4 - Pede W W # 6 - Coor	Major 1056 1310 1056 -hour Ve Varrant 2 C strian Vo Varrant 4 C Varrant 4 C Varrant 4 C	hives Minor 121 324 121 hicular Vo Conditions M ondition B M ondition B M onditions M work	Minim Major 750 1310 600 Dlume let Met Met Met Met	Minor 75 100 60 YES N/A N/A NO	N/A N/A
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume Warr Crash Experience Warran Roadway Network Warran Warrant # 1 - Eight-hour Vehi Warrant 1 Condition Warrant 2 Condition Warrant 3 Condition Warrant 3 Condition Warrant 3 Condition Warrant 3 Condition Warrant 4 Sechool Crossing Warrant 5 Condition	cular Volum n A Met n B Met A.1 Met A.2 Met A.3 Met n B Met	otal Entering) 1056 1191 1665 1056 1665 me NO YES YES YES YES YES NA	Minor 121 222 324 121 80.7% 140.8% 647.5% 324.0% 208.1% 324.0%	Major (Tota 50 11: 80 40 (10:	Warrant Warrant	# 2 - Four # 2 - Four W # 4 - Pede W W # 6 - Coor	Major 1056 1310 1056 -hour Ve Varrant 2 C strian Vo Varrant 4 C Varrant 4 C Varrant 4 C	hives Minor 121 324 121 hicular Vo Conditions M ondition B M Signal Syst Conditions M	Minim Major 750 1310 600 Dlume let Met Met Met Met	Minor 75 100 60 YES N/A N/A	N/A N/A
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume Warr Crash Experience Warran Roadway Network Warran Warrant # 1 - Eight-hour Vehi Warrant 1 Condition Warrant 1 Condition Warrant 3 - Peak Hour Warrant 3 Condition Warrant 3 Condition Warrant 3 Condition Warrant 5 Condition Warrant 5 - School Crossing Warrant 5 Condition Warrant 7 - Crash Experience	cular Volum n A Met n B Met A.1 Met A.2 Met A.3 Met n B Met B Met and A Met n B Met	otal Entering) 1056 1191 1665 1056 1665 me NO YES YES YES YES YES NA	Minor 121 222 324 121 80.7% 140.8% 647.5% 324.0% 208.1% 324.0%	Major (Tota 50 11: 80 40 (10:	Warrant Warrant	# 2 - Four # 2 - Four W # 4 - Pede W W # 6 - Coor	Major 1056 1310 1056 -hour Ve Varrant 2 C strian Vo Varrant 4 C Varrant 4 C Varrant 4 C	hives Minor 121 324 121 hicular Vo Conditions M ondition B M ondition B M onditions M work	Minim Major 750 1310 600 Dlume let Met Met Met Met	Minor 75 100 60 YES N/A N/A NO	N/A N/A
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume Warr Crash Experience Warran Roadway Network Warran Warrant # 1 - Eight-hour Vehi Warrant 1 Condition Warrant 2 Condition Warrant 3 Condition Warrant 3 Condition Warrant 3 Condition Warrant 3 Condition Warrant 5 Condition Warrant 5 - School Crossing Warrant 5 Condition Warrant 7 Condition Warrant 7 Condition	cular Volum n A Met n B Met A.1 Met A.2 Met A.3 Met n B Met B Met and A Met n B Met	NO	Minor 121 222 324 121 80.7% 140.8% 647.5% 324.0% 208.1% 324.0% NA N/A N/A N/A	Major (Tota 50 11: 80 40 (10:	Warrant Warrant	# 2 - Four # 2 - Four W # 4 - Pede W W # 6 - Coor	Major 1056 1310 1056 -hour Ve Varrant 2 C strian Vo Varrant 4 C Varrant 4 C Varrant 4 C	hiues Minor 121 324 121 hicular Vo Conditions M ondition B M ondition B M work Conditions M	Minim Major 750 1310 600 Olume Iet Met Met Met Met	Minor 75 100 60 YES	N/A N/A
8th Hour Vehicular Volume Warr 4th Hour Vehicular Volume Warr Peak Hour Vehicular Volume Warr Crash Experience Warran Roadway Network Warran Warrant # 1 - Eight-hour Vehi Warrant 1 Condition Warrant 2 Condition Warrant 3 Condition Warrant 3 Condition Warrant 3 Condition Warrant 3 Condition Warrant 5 Condition Warrant 5 - School Crossing Warrant 5 Condition Warrant 7 Condition Warrant 7 Condition	cular Volum n A Met n B Met A.1 Met A.2 Met A.3 Met n B Met B Met and A Met n B Met	NO	Minor 121 222 324 121 80.7% 140.8% 140.8% 647.5% 324.0% 208.1% 324.0% NA N/A N/A N/A N/A	Major (Tota 50 11: 80 40 (10:	Warrant Warrant Warrant	# 2 - Four # 2 - Four W # 4 - Pede W W # 6 - Coor	Major 1056 1310 1056 -hour Ve Varrant 2 C strian Vo Varrant 4 C Varrant 4 C Varrant 4 C	hives Minor 121 324 121 hicular Vo Conditions M ondition B M ondition B M onditions M work	Minim Major 750 1310 600 Dlume let Met Met Met Met	Minor 75 100 60 YES	N/A N/A

	Warrant Number and Title	Met	Percent Met
1	Eight-hour Vehicular Volume	YES	140.8%
2	Four-hour Vehicular Volume	YES	277.5%
3	Peak Hour	YES	208.1%
4	Pedestrian Volumes	N/A	N/A
5	School Crossing	N/A	N/A
6	Coordinated Signal System	N/A	N/A
7	Crash Experience	N/A	N/A
8	Roadway Network	N/A	N/A
	Total Number of Warrants Met		3

Intersec	tion:	١	WB Off	-Ramı)	and		Johnsc	n Lane			
	Case:				ve Mile Ro	ad Alignm	ent Year 2	035			1	
	Date:					uary 25, 2					1	
,	hnson La		Minor S			/B Off Ram			Street 2:			
Major Street Dir. (N-S or E-	W):	N-S			Dir. (N-S or E		E-W		Street 2 Dir	-	-	
			A	pproach Di	r. (EB or WB	5)	WB	A	proach Dir.	(EB or WB)	
Major Street Speed Limit:	35	mph	Major S	Street 85th %	Speed:	35	mph	Tota	al Intersection	n Approache	es:	3
	Johns	on Lane		WB O	ff Ramp		Total	High		Total		
Beginning Hour	NB	SB		WB			Major	Minor		Entering		
7.00.434	040	745		000			4004	000		4004		
7:00 AM	319	745		260			1064	260		1324		
8:00 AM	596	718		232			1314	232		1546		
9:00 AM	333	547		200			880	200		1080		
10:00 AM	364	522		317			886	317		1203		
11:00 AM	396	527		221			923	221		1144	. 04%	Himbook
12:00 AM	500	461		247			961	247		1208	< otn	Highest
1:00 PM 2:00 PM	599	442		225			1041	225		1266		
	678	558		245			1236	245		1481	- 14h	Highest
3:00 PM 4:00 PM	689 771	547 525		249 249			1236 1296	249		1485	< 401	підпезі
5:00 PM	856	525 513		249 255			1369	249 255		1545 1624	, Do	ak Hour
6:00 PM	596	436		223			1032	223		1255	< Fee	ak Houi
7:00 PM	429	298		164			727	164		891		
Ave. Weekday Volumes =	8300	8100		4150			16400	4150		20550		
				Conc	lition A				Conditi	on B		I
Volume Warrants			Values			Minimums		Va	lues	Minin	ums	
			al Entering)	Minor	Major (Tota	<u> </u>	Minor	Major	Minor	Major	Minor	1
8th Hour Vehicular Volume W			61	247	50		150	961	247	750	<i>7</i> 5	
4th Hour Vehicular Volume W			236	260	123		80					
Peak Hour Vehicular Volume W			624	255	65		100	1369	255	1369	117	
Crash Experience Warrar			61	247	40		120	961	247	600	60	
Roadway Network Warra	nt	16	<u>824</u>		(100)()						
Warrant # 1 - Eight-hour Ve	hicular	Volume				Warrant 7	# 2 - Four-	hour Vehi	cular Volu	me		
Warrant 1 Con	dition A	Met	YES	164.7%			V	Varrant 2 C	onditions Me	et	YES	325.0%
Warrant 1 Con			YES	128.1%								1000000
Warrant # 3 - Peak Hour					•	Warrant 7	# 4 - Pedes	trian Volu	imes			
Warrant 3 Cond	dition A.1	l Met	YES	7765.0%			W	arrant 4 Co	ondition A M	et	N/A	N/A
Warrant 3 Cond	dition A.2	2 Met	YES	255.0%					ondition B M		N/A	N/A
Warrant 3 Cond	dition A.3	3 Met	YES	249.8%								
Warrant 3 Con	dition B	Met	YES	160.2%								
-												

Warrant 5 Conditions Met	NA	NA

Warrant #7 - Crash Experience

Warrant 7 Condition A Met	NO	N/A
Warrant 7 Condition B Met	NO	N/A
Warrant 7 Condition C Met	NO	N/A

Warrant 4 Condition A Met	N/A	N/A
Warrant 4 Condition B Met	N/A	N/A

Warrant # 6 - Coordinated Signal System

	Warrant 6 Conditions Met	NO	N/A
--	--------------------------	----	-----

Warrant #8 - Roadway Network

Warrant 8 Conditions Met	NO	N/A

	Warrant Number and Title	Met	Percent Met
1	Eight-hour Vehicular Volume	YES	128.1%
2	Four-hour Vehicular Volume	YES	325.0%
3	Peak Hour	YES	160.2%
4	Pedestrian Volumes	N/A	N/A
5	School Crossing	N/A	N/A
6	Coordinated Signal System	N/A	N/A
7	Crash Experience	N/A	N/A
8	Roadway Network	N/A	N/A
	Total Number of Warrants Met		3

APPENDIX 3

Intersection Capacity with Traffic Signals



er.			

HCM Analysis Summary

5 Mile & HWY 312 Secondary Imps Highway 312/Five Mile Align Area Type: Non CBD R Marvin 12/01/2011 Analysis Duration: 15 mins. PM Design Hour Case: MARYAL~1

	M Design Hour Case: MARYAL~1								111113.							
	Lanes					Geo	metry: Mo	vements	Serviced b	y Lane ar	nd Lane W	/idths (1	reet)			
	Approach (Outboun	d	Lane	e 1	La	ne 2	La	ine 3	La	ne 4	La	ane 5	La	ne 6	
EB	3	2		L	12.0	Т	12.0	TR	12.0							
WB	3	2		L	12.0	Т	12.0	TR	12.0							
NB	2	1	I	LT	12.0	R	12.0									
SB	1	1	L	TR	12.0											
	East						West			North			South			
	Data			L	Т	R	L	Т	R	L	T	R	L	T	R	
Move	ement Volun	ne (vph)		5	470	20	150	300	5	30	5	210	5	5	5	
PHF			0	.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
% He	avy Vehicle	s		1	3	1	2	3	1	3	1	3	1	1	1	
Lane	Lane Groups			L	TR		L	TR			LT	R		LTR		
Arriv	al Type			3	3		3	3			3	3		3		
RTO	R Vol (vph)				0		0				100			0		
Peds/	Hour				0		0			0			0			
% Gr	ade				0			0			0			0		
Buses	s/Hour				0			0		0				0		
Parke	ers/Hour (Le	ft Right)														
Signa	nal Settings: Actuated Operational Analysis		ysis	Cycl	e Length:	60.0 Sec	2	Lost Tin	ne Per Cyc	ele: 11.0 S	ec					
Phase	:	1		2	2	3	4		5	6		7	8	Pe	d Only	
EB	LTP															
WB		LT	2													
NB				LT	ГР											
SB				L												
Greei		35.			1.0										0	
Yello	w All Red	4.0	2.0	3.5	1.5											

			Canad	city Analysis R	aculte				Approa	ch:
		_				,				
	Lane	Cap (vph)	v/s	g/C Ratio	Lane	v/c	Delay (sec/veh)	T 00	Delay	LOG
App	Group	(vpn)	Ratio	Ratio	Group	Ratio	(sec/ven)	LOS	(sec/veh)	LOS
EB	_									
	L	601	0.006	0.583	L	0.010	5.3	A	6.5	Α
	TR	2032	0.156	0.583	TR	0.268	6.5	A		
WB										
	* L	488	0.200	0.583	L	0.342	8.4	A	6.8	Α
	TR	2039	0.097	0.583	TR	0.166	5.9	A		
NB										
	LT	344	0.026	0.233	LT	0.113	18.2	В	19.0	В
	* R	366	0.078	0.233	R	0.333	19.3	В		
SB										
	LTR	391	0.011	0.233	LTR	0.046	17.8	В	17.8	В

Intersection: Delay = 8.4 sec/veh SIG/Cinema v3.08

Int. LOS=A $X_c = 0.34$

* Critical Lane Group

 \sum (v/s)Crit= 0.28

Page 1

NETSIM Summary Results

5 Mile & HWY 312 Secondary Imps R Marvin PM Design Hour Highway 312/Five Mile Align 12/01/2011 Case: MARYAL~1

App EB	Lane Group L	Queues Per Lane Avg/Max (veh) 0 / 0	Average Speed (mph) 31.5	Spillback in Worst Lane (% of Peak Period) 0.0	5 5 5 1 1 1 5
	IK	2/4	19.4	0.0	→ 300 → 150
	All		19.4	0.0	
WB	L	1 / 3	17.0	0.0	
	TR	2 / 2	20.4	0.0	
					5 -
	All		19.3	0.0	470
NB	LT	0 / 1	21.3	0.0	
	R	1 / 3	16.3	0.0	30 210
	All		18.7	0.0	
					1 2 !!!
SB	LTR	0 / 1	11.8	0.0	===
					35 4 2 13 4 2
	All		11.8	0.0	
	Inte	rsect.	19.1		

SIG/Cinema v3.08 Page 2

HCM Analysis Summary

Marvin Associates

R Marvin

2035 PM Design Hour

Mary Alignment/Mary Street

O2/24/2012

Analysis Duration: 15 mins.

Case: Mary Opt 1_2 Five Mile Signal 2035

	35 PM De	sign Ho	our			Case: Mary Opt 1_2 Five Mile Signal 2035										
	Lanes					Ge	ometry: Mo	ovements	Serviced 1	y Lane aı	nd Lane W	idths (f	eet)			
	Approach (Outbound	1	Lane	1	L	ane 2	L	Lane 3		ne 4	La	ane 5	La	ne 6	
EB	3	2]	L	12.0	Т	12.0	TR	12.0							
WB	3	2]	L	12.0	Т	12.0	TR	12.0							
NB	2	1]	L	12.0	TR	12.0									
SB	2	1]	L	12.0	TR	12.0									
	East					West			North			South				
	Data]	L	Т	R	L	Т	R	L	Т	R	L	Т	R	
Move	ement Volun	ne (vph)		5	450	5	20	700	230	5	50	20	170	10	5	
PHF			0.	.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
% He	% Heavy Vehicles			1	4	1	1	4	1	1	2	1	4	1	1	
Lane	Lane Groups]	L	TR		L	TR		L	TR		L	TR		
Arriv	al Type			3	3		3	3		3	3		3	3		
RTO	R Vol (vph)				0			40			5			0		
Peds/	Hour				5			5			5			5		
% Gr	ade				0		0			0			0			
Buses	s/Hour				0			0			0			0		
Parke	ers/Hour (Le	ft Right)														
Signa	gnal Settings: Actuated Operational Ana		onal Ana	lysis	Cyc	le Length:	60.0 Sec	c	Lost Tin	ne Per Cyc	le: 8.0 S	lec				
Phase	: :	1		2	2	3		ļ.	5	6		7	8	Pe	ed Only	
EB		LTP	•													
WB		LTP	•													
NB				LT	ТР											
SB				LT	ТР											
Gree	ı	30.0)	22	2.0										0	
Yello	w All Red	3.5	1.5	1.5	1.5											

Cap (vph) L 207 TR 1733	v/s Ratio 0.014 0.146	g/C Ratio 0.500 0.500	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Approa Delay (sec/veh)	LOS
coup (vph) L 207	0.014	0.500	Group	Ratio	(sec/veh)		Delay (sec/veh)	LOS
L 207	0.014	0.500			,		(sec/veh)	LOS
			L	0.029				
			L	0.029				
TR 1733	0.146	0.500		0.027	7.9	A	9.2	A
		0.500	TR	0.292	9.2	Α		
L 434	0.025	0.500	L	0.051	7.9	A	12.0	В
TR 1695	0.292	0.500	TR	0.583	12.1	В		
	0,2,2	0.000		0.000				
L 513	0.004	0.367	L	0.012	12.1	В	12.5	В
TR 659	0.041	0.367	TR	0.111	12.6	В		
L 473	0.146	0.367	L	0.400	14.3	В	14.1	В
TR 652	0.010	0.367	TR	0.026	12.2	В		
	L 513 FR 659 L 473	L 513 0.004 FR 659 0.041 L 473 0.146	CR 1695 0.292 0.500 L 513 0.004 0.367 CR 659 0.041 0.367 L 473 0.146 0.367	CR 1695 0.292 0.500 TR L 513 0.004 0.367 L CR 659 0.041 0.367 TR L 473 0.146 0.367 L	CR 1695 0.292 0.500 TR 0.583 L 513 0.004 0.367 L 0.012 CR 659 0.041 0.367 TR 0.111 L 473 0.146 0.367 L 0.400	TR 1695 0.292 0.500 TR 0.583 12.1 L 513 0.004 0.367 L 0.012 12.1 TR 659 0.041 0.367 TR 0.111 12.6 L 473 0.146 0.367 L 0.400 14.3	TR 1695 0.292 0.500 TR 0.583 12.1 B L 513 0.004 0.367 L 0.012 12.1 B TR 659 0.041 0.367 TR 0.111 12.6 B L 473 0.146 0.367 L 0.400 14.3 B	TR 1695 0.292 0.500 TR 0.583 12.1 B L 513 0.004 0.367 L 0.012 12.1 B 12.5 TR 659 0.041 0.367 TR 0.111 12.6 B L 473 0.146 0.367 L 0.400 14.3 B 14.1

Intersection: Delay = 11.5 sec/veh SIG/Cinema v3.08

Int. LOS=B

* Critical Lane Group

 \sum (v/s)Crit= 0.44

 $X_c = 0.51$ * Constant * Marvin & Associates

Page 1

NETSIM Summary Results

Marvin Associates R Marvin 2035 PM Design Hour Mary Alignment/Mary Street 02/24/2012

Case: Mary Opt 1_2 Five Mile Signal 2035

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	10 5 170
EB	L	0/0	27.4	0.0	↓
	TR	3 / 4	17.8	0.0	230 1
					↓ ↓ ↓ ↓ 20
	All		17.8	0.0	
WB	L	0 / 1	12.5	0.0	
	TR	5 / 6	15.2	0.0	
					5
	All		15.2	0.0	450 →
NB	L	0 / 1	6.5	0.0	5 —
	TR	1 / 1	18.1	0.0	
					5 20 50
	All		17.3	0.0	
SB	L	2/3	9.2	0.0	1 2 11
	TR	0 / 1	24.3	0.0	
					29 4 2 21
	All		13.8	0.0	
	Inte	rsect.	15.8		

HCM Analysis Summary

Mary Alignment Bitteroot Alt A

Mary Alignment/Bitteroot

R Marvin

Design Hour PM

Mary Alignment/Bitteroot

Area Type: Non CBD

11/29/2011

Analysis Duration: 15 mins.

Case: Mary Align & Bitteroot Alt A 2035 PM

	viarvin sign Hour	· PM			Case: Mary Align & Bitteroot Alt A 2035 PM										
	Lanes					Geor	metry: Mo	vements !	Serviced b	y Lane ar	nd Lane W	idths (fe	eet)		
	Approach	Outbound		Lane	e 1	La	Lane 2		ne 3	Laı	ne 4	Lane 5		Laı	ne 6
EB	3	2	I		12.0	Т	12.0	TR	12.0						
WB	3	2	I		12.0	Т	12.0	TR	12.0						
NB	2	1	I		12.0	TR	12.0								
SB	2	1	I		12.0	TR	12.0								
	East					West				North			South		
	Data		I		T	R	L	Т	R	L	T	R	L	Т	R
Move	ement Volur	ne (vph)	1	10	360	10	110	520	50	20	110	95	40	50	30
PHF			0.9	90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
% He	% Heavy Vehicles			1	4	0	0	4	1	0	1	0	0	1	0
Lane	Groups		L	-	TR		L	TR		L	TR		L	TR	
Arriv	al Type		3	3	3		3	3		3	3		3	3	
RTOI	R Vol (vph)				0		10				25			5	
Peds/	Hour				5		5			5			5		
% Gr	ade				0		0			0			0		
Buses	s/Hour				0		0			0				0	
Parke	rs/Hour (Le	ft Right)													
Signa	nal Settings: Actuated Operational Analysis		/sis	Cycle	e Length:	60.0 Sec	2	Lost Tim	e Per Cyc	le: 10.0 S	ec				
Phase	:	1		2	2	3	4		5	6		7	8	Pe	d Only
EB		LTP													
WB		LTP													
NB				LT	ГР										
SB				LT	ГР										
Greer	1	32.0			3.0										0
Yello	w All Red	3.5	1.5	3.5	1.5										

			Como	aitre Amalessia D	aau16a				A	ale.
	Lane	Cap (vph)	v/s	g/C Ratio	Lane	v/c	Delay (sec/veh)	1.00	Approa Delay	
App EB	Group	(vpn)	Ratio	Ratio	Group	Ratio	(sec/ven)	LOS	(sec/veh)	LOS
	L	401	0.015	0.533	L	0.027	6.8	A	7.7	A
	TR	1844	0.119	0.533	TR	0.223	7.7	Α		
WB										
	L	516	0.126	0.533	L	0.236	8.6	A	8.5	A
	* TR	1831	0.181	0.533	TR	0.340	8.5	A		
NB										
	L	399	0.017	0.300	L	0.055	15.0	В	16.6	В
	* TR	530	0.113	0.300	TR	0.377	16.7	В		
SB										
	L	354	0.037	0.300	L	0.124	15.3	В	15.4	В
	TR	535	0.047	0.300	TR	0.157	15.5	В		

Intersection: Delay = 10.0 sec/veh SIG/Cinema v3.08

Int. LOS=B

* Critical Lane Group

 \geq (v/s)Crit= 0.29

 $X_c = 0.35$ * Constant * Constant * Associates

Page 1

NETSIM Summary Results

Mary Alignment Bitteroot Alt A R Marvin Design Hour PM Mary Alignment/Bitteroot 11/29/2011

Case: Mary Align & Bitteroot Alt A 2035 PM

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	50 30 40
EB	L	0 / 0	28.9	0.0	
	TR	2 / 3	18.1	0.0	50 ← 520
					↓ 110
	All		18.2	0.0	
WB	L	1 / 2	14.4	0.0	
	TR	3 / 4	17.6	0.0	
					10 -
	All		17.4	0.0	360 →
NB	L	0 / 1	12.5	0.0	
	TR	2/3	17.7	0.0	
					20 95
	All		17.1	0.0	
SB	L	1 / 2	12.5	0.0	1 2 11
	TR	1 / 2	17.3	0.0	
					31 4 2 17
	All		15.1	0.0	
	Inte	rsect.	17.3		

HCM Analysis Summary

Year 2035 Mary Op1 Alt

N Frontage Rd/Johnson Lane

Area Type: Non CBD

R Marvin

10/20/11

Analysis Duration: 15 mins.

Peak PM

Case: N Ertg Johnson Mary Op1 2035 PM

Pea	ak PM							Case	e: N F	rtg Jo	ohnso	n Mary	Op1 20	35 PM	Dare		. 151	
	Lanes						Geom	etry: Mo	vement	s Serv	riced b	y Lane an	d Lane W	idths (f	eet)			
	Approach	Outbound]	Lane	: 1		Lane	e 2	I	Lane 3		Lar	ne 4	La	ne 5		Lar	ne 6
EB	2	1	L		12.0	Т	R	12.0										
WB	2	1	L		12.0	Т	R	12.0										
NB	3	2	L		12.0	7	Γ	12.0	TR	1	12.0							
SB	3	2	L		12.0	7	Γ	12.0	TR		12.0							
			East					West			North			South				
Data			L		Т	I	3	L	Т		R	L	Т	R	L		Т	R
Move	ement Volur	ne (vph)	155	5	25	2	10	25	20		5	190	930	30	5	5	700	100
PHF			0.92	2	0.92	0.9	92	0.92	0.92	(0.92	0.92	0.92	0.92	0.9	2	0.92	0.92
% Не	avy Vehicle	es	4		2		8	2	2		2	8	4	2	2	2	4	2
Lane Groups			L		TR			L	TR			L	TR		L		TR	
Arrival Type			3		3			3	3			3	3		3		3	
RTOR Vol (vph)			40				0			5			30					
Peds/Hour			0				5			5			0					
% Grade			0				0			0			0					
Buses/Hour					0				0		0					0	0	
Parkers/Hour (Left Right)			-															
Signa	Operational Analysis					Cyc	Cycle Length:			80.0 Sec Lost Ti			ne Per Cycle: 8.0 Sec					
Phase: 1			2	,	3		4	4		i	6		7		8		Ped Only	
EB		LTP																
WB		LTP																
NB				LT	'n	L.	ГР											
SB						L	ГР											
Green		24.0		12	0.0	36	5.0	ļ										0
Yello	w All Red	0.0	0.0	3.0	0.0	3.5	1.5											

				city Analysis R	. 1.					
	Approach:									
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay	
App	Group	(vpĥ)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB										
	L	389	0.130	0.300	L	0.432	22.8	C	22.9	C
	* TR	463	0.137	0.300	TR	0.458	23.0	C		
WB										
	L	241	0.034	0.300	L	0.112	20.4	С	20.1	C
	TR	543	0.015	0.300	TR	0.050	19.9	В		
NB	Lper	198	0.000	0.512					8.6	A
	* Lpro	251	0.124	0.150	L	0.461	10.5	В		
	TR	2204	0.300	0.637	TR	0.471	8.2	A		
SB										
	L	231	0.010	0.450	L	0.022	12.4	В	17.4	В
	* TR	1541	0.244	0.450	TR	0.543	17.4	В		

Intersection: Delay = 13.9 sec/veh SIG/Cinema v3.08

Int. LOS=B X

* Critical Lane Group

 \sum (v/s)Crit= 0.51

Marvin & Associates

Page 1

NETSIM Summary Results

Year 2035 Mary Op1 Alt R Marvin Peak PM N Frontage Rd/Johnson Lane 10/20/11 Case: N Frtg Johnson Mary Op1 2035 PM

App EB	Lane Group L TR	Queues Per Lane Avg/Max (veh) 4 / 6 2 / 4	Average Speed (mph) 6.3 20.8	Spillback in Worst Lane (% of Peak Period) 0.0	700 100 5 - 5
	All		13.2	0.0	$\begin{array}{c c} & & & & & & & & & & & & & & & & & & &$
WB	L	0 / 1	6.9	0.0	<u> </u>
	TR	1 / 1	15.1	0.0	
					$\begin{array}{c c} 155 & \longrightarrow \\ 25 & \longrightarrow \\ \end{array}$
	All		12.2	0.0	
NB	L	3 / 5	9.0	0.0	
	TR	5 / 7	17.4	0.0	
					190 30 930
	All		15.6	0.0	
SB	L	0 / 1	19.7	0.0	
	TR	5 / 7	14.2	0.0	
					24 0 0 12 3 0 35 4 2
	All		14.3	0.0	
	Inte	rsect.	14.6		

HCM Analysis Summary

Five Mile Align HWY 312 Highway 312/Five Mile Align Area Type: Non CBD R Marvin 12/01/2011 Analysis Duration: 15 mins. PM design Hour Case: Five Mile Align 312 PM 2035

PM	l design H	our	Case: Five Mile Align 312 PM 2035 Geometry: Movements Serviced by Lane and Lane Widths (feet)												
	Lanes					Geo	metry: Mo	vements	Serviced b	y Lane aı	nd Lane W	/idths (f	eet)		
	Approach (Outbour	ıd	Lane	1	La	ine 2	La	ane 3	La	ne 4	La	ane 5	La	ne 6
EB	3	2		L	12.0	Т	12.0	TR	12.0						
WB	3	2		L	12.0	Т	12.0	TR	12.0						
NB	3	1		L	12.0	Т	12.0	R	12.0						
SB	1	1	L	TR	12.0										
					East			West			North			South	
	Data			L	Т	R	L	Т	R	L	Т	R	L	Т	R
Move	ement Volun	ne (vph)		5	470	20	160	310	5	30	5	230	5	5	5
PHF			0	.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
% He	avy Vehicle	s		1	3	1	2	3	1	3	1	3	1	1	1
Lane	Groups			L	TR		L	TR		L	Т	R		LTR	
Arriv	al Type			3	3		3	3		3	3	3		3	
RTO	R Vol (vph)				0			0			100			0	
Peds/	Hour				0			0			0			0	
% Gr	ade				0			0			0			0	
Buses	s/Hour				0			0			0			0	
Parke	rs/Hour (Le	ft Right])												
Signa	l Settings: A	ctuated			Operati	onal Anal	ysis	Cycl	e Length:	60.0 Sec	2	Lost Tin	ne Per Cyc	le: 11.0 S	ec
Phase	»:	1		2	2	3	4		5	6		7	8	Pe	d Only
EB		LT	P												
WB		LT	P												
NB				LT	ТР										
SB				Lī	ТР										
Green	1	35.	.0	14	1.0										0
Yello	w All Red	4.0	2.0	3.5	1.5										

				·	1,					,
	1		Capac	city Analysis R	esults		ı		Approa	cn:
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay	
App	Group	(vpĥ)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB										
	L	595	0.006	0.583	L	0.010	5.3	A	6.5	A
	TR	2032	0.156	0.583	TR	0.268	6.5	Α		
WB										
	* L	488	0.213	0.583	L	0.365	8.7	A	6.9	A
	TR	2039	0.100	0.583	TR	0.172	6.0	A		
NB										
	L	321	0.024	0.233	L	0.103	18.1	В	19.3	В
	T	439	0.003	0.233	T	0.014	17.7	В		
	* R	366	0.092	0.233	R	0.393	19.7	В		
SB										
	LTR	393	0.011	0.233	LTR	0.046	17.8	В	17.8	В

Intersection: Delay = $8.7\,\mathrm{sec/veh}$ Int. LOS=A X_c = 0.37 * Critical Lane Group Σ (v/s)Crit= 0.30 SIG/Cinema v3.08 Marvin & Associates Page 1

NETSIM Summary Results

Five Mile Align HWY 312 R Marvin PM design Hour Highway 312/Five Mile Align 12/01/2011

Case: Five Mile Align 312 PM 2035

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	5 5 5
EB	L	0 / 0	31.5	0.0	-
	TR	2/3	19.6	0.0	
					160
	All		19.6	0.0	<u> </u>
WB	L	1 / 2	17.3	0.0	
	TR	2/3	19.7	0.0	
					5
	All		19.0	0.0	470 →
NB	L	0 / 1	8.1	0.0	20 —
	T	0 / 1	24.6	0.0	
	R	1 / 3	16.2	0.0	30 230
	All		18.2	0.0	
					1 2 1
SB	LTR	0 / 1	11.8	0.0	
					35 4 2 13
	All		11.8	0.0	
	Inte	rsect.	19.0		

HCM Analysis Summary

Five Mile Align & Mary Signal

R Marvin
2035 PM Design Hour

Case: Five Mile Align Area Type: Non CBD
Analysis Duration: 15 mins.

Case: Five Mile Align Mary Signal 2035

Case: Five Mile Align Mary Signal 2035

203	35 PM De	sign Ho	ur				Case	: Fiv	e M	ile Ali	gn Mar	y Sign	al 2	2035				
	Lanes					Geom	etry: Mo	vemer	nts Se	erviced b	y Lane a	nd Lane	Wio	dths (f	eet)			
	Approach	Outbound	La	ne 1		Lane	2		Lane	2 3	La	ne 4		La	ane 5		Lar	ne 6
EB	2	0	L	12.0	I	3	12.0											
WB	0	1																
NB	3	2	L	12.0	-	Γ	12.0	Т		12.0								
SB	2	2	T	12.0	Т	R	12.0											
				East				We	st			Nortl	ı				South	
	Data		L	T	I	3	L	Т		R	L	Т		R	I		T	R
Move	ement Volur	ne (vph)	30	0	3	30	0	0)	0	500	280		0		0	190	30
PHF			0.90	0.90	0.	90	0.90	0.9	0	0.90	0.90	0.90		0.90	0.9	90	0.90	0.90
% Не	avy Vehicle	es	2	2		4	2	2	2	2	4	2		2		2	2	4
Lane	Groups		L		I	3					L	Т					TR	
Arriv	al Type		3			3					3	3					3	
RTO	R Vol (vph)			150				C)			0					5	
Peds/	Hour			0				C)			5					5	
% Gr	ade			0				0)			0					0	
Buse	s/Hour			0				0				0					0	
Parke	ers/Hour (Le	ft Right)																
Signa	l Settings: A	Actuated		Opera	tional A	Analysi	is	Cy	ycle I	Length:	65.0 Se	С	L	ost Tin	ne Per	Cycle	: 14.0 S	ec
Phase	e:	1		2	(3	4			5	6		7	7	8	3	Pe	d Only
EB		LP																
WB																		
NB				LT	-	Γ												
SB					7	ТР												
Green	n	12.0		29.0	10	0.0	ļ.,								-			0
Yello	w All Red	3.5	1.5 4.0	0.0	3.5	1.5												

			Como	aites Amalesaia D) a a vilta				A	ale.
	1			city Analysis R		1	1		Approa	CII:
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay	
App	Group	(vph)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB										
	L	327	0.019	0.185	L	0.101	22.1	C	29.6	C
	* R	287	0.129	0.185	R	0.697	30.9	С		
NB										
	* L	775	0.320	0.446	L	0.717	17.4	В	12.7	В
	T	2341	0.088	0.662	Т	0.133	4.2	A		
SB										
	* TR	534	0.069	0.154	TR	0.448	27.7	С	27.7	С

Intersection: Delay = 18.3 sec/veh SIG/Cinema v3.08

Int. LOS=B X₀=

* Critical Lane Group

 \sum (v/s)Crit= 0.52

Marvin & Associates

NETSIM Summary Results

Five Mile Align & Mary Signal R Marvin 2035 PM Design Hour Mary Street/Five Mile Align 02/24/2012

Case: Five Mile Align Mary Signal 2035

App EB	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	190 30 1
	R	1 / 2	22.9	0.0	
	All		21.6	0.0	
					30 -
	All		14.7	0.0	330 —
NB	L	7/9	8.7	0.0	
	T	1 / 2	24.3	0.0	
					500
	All		12.3	0.0	
SB	TR	2/3	12.3	0.0	
					11 4 2 29 4 0 9 4 2
	Inte	rsect.	15.5		

HCM Analysis Summary

Five Mile Align 2035 Secondary Imp

R Mary Imp

R Mary Street/Bitteroot

12/19/2011

Analysis Duration: 15 mins.

Pm Design Hour

Case: FIVEMICA

Pm	Design I	lour					Case	: FIV	ÆΜ	I~1							
	Lanes					Geom	etry: Mo	vemen	ıts Se	rviced b	y Lane ar	nd Lane V	Vidths (1	feet)			
	Approach	Outbound	La	ne 1		Lan	e 2		Lane	3	La	ne 4	La	ane 5		Lan	e 6
EB	2	1	L	12.)	TR	12.0										
WB	2	1	L	12.)	TR	12.0										
NB	1	1	LTR	12.)												
SB	1	1	LTR	12.	0												
				Eas	t			Wes	st			North			Sc	outh	
	Data		L	Т		R	L	Т		R	L	Т	R	L		Т	R
Move	ment Volur	ne (vph)	20	31)	50	80	390	0	60	50	100	80	40		60	10
PHF			0.92	0.9	2 ().92	0.92	0.92	2	0.92	0.92	0.92	0.92	0.92	0.	.92	0.92
% He	avy Vehicle	es	0	4		0	0	4		0	0	1	0	0		1	0
Lane	Groups		L	TR			L	TR				LTR			L	TR	
Arriv	al Type		3	3			3	3				3				3	
RTO	R Vol (vph)			10)			10)			30				5	
Peds/	Hour			5				5	i			5				5	
% Gr	ade			0				0				0				0	
Buses	/Hour			0				0				0				0	
Parke	rs/Hour (Le	ft Right)							-						-		
Signa	1 Settings: A	Actuated		Oper	ational	Analys	is	Cy	cle L	ength:	60.0 Sec	С	Lost Tin	ne Per Cy	cle: 10	0.0 Se	ec
Phase	:	1		2		3	4			5	6		7	8		Ped	d Only
EB		LTP															
WB		LTP															
NB				LTP													
SB				LTP													
Green		33.0		17.0			1				ļ , , , , , , , , , , , , , , , , , , ,						0
Yello	w All Red	3.5	1.5 3.:	5 1.5	5												

			Capac	city Analysis R	esults				Approa	ch:
App EB	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
ED	L	437	0.028	0.550	L	0.050	6.5	A	8.7	A
	TR	997	0.210	0.550	TR	0.381	8.8	A		
WB										
	L	521	0.092	0.550	L	0.167	7.4	A	9.5	A
	* TR	997	0.264	0.550	TR	0.479	9.9	A		
NB										
	* LTR	465	0.132	0.283	LTR	0.467	18.0	В	18.0	В
SB										
				·	·					
	LTR	442	0.072	0.283	LTR	0.256	16.7	В	16.7	В

Intersection: Delay = 11.3 sec/veh SIG/Cinema v3.08

Int. LOS=B $X_c = 0.48$

* Critical Lane Group

 \sum (v/s)Crit= 0.40

Page 1

NETSIM Summary Results

Five Mile Align 2035 Secondary Imp R Marvin Pm Design Hour Mary Street/Bitteroot 12/19/2011 Case: FIVEMI~1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	60
EB	L	0 / 1	24.7	0.0	↓ ' ↓
	TR	4 / 5	16.7	0.0	1 ← 60
	All		17.0	0.0	80 _
WB	L	1 / 2	17.8	0.0	
	TR	5 / 6	17.2	0.0	<u>→</u>
					$310 \longrightarrow $
	All		17.2	0.0	50 —
NB	LTR	2/3	14.3	0.0	
					50 80
	All		14.3	0.0	
					1 2
SB	LTR	2 / 2	12.2	0.0	== 2 2=
					32 4 2 16 4 2
	All		12.2	0.0	
	Inte	rsect.	16.0		

SIG/Cinema v3.08 Page 2

HCM Analysis Summary

Year 2035 Five Mile Align

N Frontage Rd/Johnson Lane

Area Type: Non CBD

R Marvin

O2/24/12

Analysis Duration: 15 mins.

Peak PM

Case: Five Mile Align N Erts Signal 2035

	narvin ik PM								:4/12 e: Five	Mile A	lig	n N Frt	tg Signa	anaiysis d 2035	Duratio	n: 151	mins.
	Lanes						Geom	etry: Mo	ovements	Service	d by	Lane an	d Lane W	/idths (fe	eet)		
	Approach	Outbound	I	Lane	: 1		Lane	2	L	ane 3		Lar	ne 4	La	ne 5	La	ne 6
EB	2	1	L		12.0	Т	R	12.0									
WB	2	1	L		12.0	T	'n	12.0									
NB	3	2	L		12.0	-	Γ	12.0	TR	12.0)						
SB	3	2	L		12.0	-	Γ	12.0	TR	12.0)						
					East				West				North			South	
	Data		L		Т	I	R	L	Т	R		L	Т	R	L	T	R
Move	ment Volun	ne (vph)	135		25	2	15	25	20	5		190	785	30	5	600	90
PHF			0.92		0.92	0.	92	0.92	0.92	0.92	2	0.92	0.92	0.92	0.92	0.92	0.92
% He	avy Vehicle	es	4		2		8	2	2	2		8	4	2	2	4	2
Lane	Groups		L		TR			L	TR			L	TR		L	TR	
Arriv	al Type		3		3			3	3			3	3		3	3	
RTO	R Vol (vph)				40				0				5			20	
Peds/	Hour				0				5				5			0	
% Gr	ade				0				0				0			0	
Buses	/Hour				0				0				0			0	
Parke	rs/Hour (Le	ft Right)															
Signa	1 Settings: A	Actuated		(Operati	onal A	Analys	is	Cyc	le Lengtl	h: 8	80.0 Sec	;	Lost Tim	e Per Cyc	le: 8.0 S	lec
Phase	:	1		2	2		3	4		5		6		7	8	Pe	ed Only
EB		LTP															
WB		LTP															
NB				LT	'R	Ľ	ГР										
SB						Ľ	ΤР										
Greer	1	24.0			2.0		6.0										0
Yello	w All Red	0.0	0.0	3.0	0.0	3.5	1.5										

				'. A 1 ' D	1,					1
			Capac	city Analysis R	lesults		T		Approa	ch:
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay	
App	Group	(vpĥ)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB										
	L	389	0.113	0.300	L	0.378	22.3	C	22.8	C
	* TR	463	0.141	0.300	TR	0.469	23.1	C		
WB										
	L	237	0.034	0.300	L	0.114	20.4	С	20.1	C
	TR	543	0.015	0.300	TR	0.050	19.9	В		
NB	Lper	240	0.000	0.512					7.9	A
	* Lpro	251	0.124	0.150	L	0.422	9.1	A		
	TR	2203	0.255	0.637	TR	0.399	7.6	A		
SB										
	L	270	0.008	0.450	L	0.019	12.3	В	16.4	В
	* TR	1538	0.213	0.450	TR	0.473	16.4	В		

Intersection: Delay = 13.4 sec/veh SIG/Cinema v3.08

Int. LOS=B $X_c = 0.53$

* Critical Lane Group

 \sum (v/s)Crit= 0.48

Page 1

NETSIM Summary Results

Year 2035 Five Mile Align R Marvin Peak PM N Frontage Rd/Johnson Lane 02/24/12

Case: Five Mile Align N Frtg Signal 2035

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	600 90 5
EB	L	3 / 5	6.7	0.0	
	TR	3 / 5	18.2	0.0	
	All		13.4	0.0	
WB	L	0 / 1	6.7	0.0	
	TR	1 / 1	15.5	0.0	
					$\begin{array}{c c} 135 & \\ 25 & \\ \end{array}$
	All		12.3	0.0	215 —
NB	L	3 / 5	10.8	0.0	
	TR	3 / 7	20.3	0.0	
					190 30 785
	All		18.2	0.0	765
SB	L	0 / 1	11.6	0.0	1 2 3 11
	TR	4/6	14.4	0.0	
					24 0 0 12 7 3 0 35 7 4 2
	All		14.4	0.0	
	Inte	rsect.	15.7		

SIG/Cinema v3.08 Page 2

APPENDIX 4

Alternative Intersection Control Roundabout Capacity



er.			

Site: Mary Alignment Option 1 Intersection with Five Mile adn Mary Street

Mary Alignment Option 1 Intersection of Mary Alignment with Mary Street & Five Mile Road Roundabout

Lane Use and Performance																
	. [Deman	d Flows		HV	Can	Deg.	Lane	Average	Level of	95% Back		Lane	SL	Cap. I	
	L veh/h	Veh/h	R veh/h	Total veh/h	пv %	Cap.	Satn v/c	Util. %	Delay sec	Service	Vehicles veh	Distance ft	Length ft	Туре	Adj. E %	Block. %
South: Mary			VC11/11	V C 1 1/11	/0	VOII/II	V/ O	/0	300		VO11	- 10	- 10		70	/0
Lane 1	5	54	22	82	0.0	681	0.120	100	8.2	LOS A	0.5	12.0	1600		0.0	0.0
Approach	5	54	22	82	0.0		0.120		8.2	LOS A	0.5	12.0				
East: Mary	Alignmeı	nt WB														
Lane 1	22	460	0	482	3.8	1335	0.361	100	5.1	LOS A	2.6	67.0	1600	_	0.0	0.0
Lane 2	0	301	250	551	3.1	1528	0.361	100	5.3	LOS A	2.6	67.6	1600	_	0.0	0.0
Approach	22	761	250	1033	3.4		0.361		5.2	LOS A	2.6	67.6				
North: Five	Mile Roa	ad SB														
Lane 1	185	11	5	201	1.9	627	0.321	100	15.9	LOS B	1.4	35.0	1600		0.0	0.0
Approach	185	11	5	201	1.9		0.321		15.9	LOS B	1.4	35.0				
West: Mary	Alignme	nt EB														
Lane 1	5	220	0	226	3.9	1101	0.205	100	5.8	LOS A	1.2	31.5	1600	_	0.0	0.0
Lane 2	0	247	5	252	3.9	1231	0.205	100	5.4	LOS A	1.3	32.2	1600		0.0	0.0
Approach	5	467	5	478	3.9		0.205		5.6	LOS A	1.3	32.2				
Intersection				1793	3.2		0.361		6.6	LOS A	2.6	67.6				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Monday, December 19, 2011 11:58:46 AM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Traffic Study\Capacity\Calculations\Mary Street\Mary Opt 1\Mary Align Mary_5 Mile Opt1 PM 2035.sip 8001325, MARVIN & ASSOCIATES, SINGLE



Site: Mary Alignment Option 2 Intersection with Five Mile & Mary Street

Mary Alignment Option 2 Intersection of Mary Alignment with Mary Street & Five Mile Road Roundabout

Lane Use and Performance																
	. [Deman	d Flows		HV	Cap.	Deg.	Lane	Average	Level of	95% Back		Lane	SL	Cap. I	
	veh/h	veh/h	R veh/h	Total veh/h	%	veh/h	Satn v/c	Util. %	Delay sec	Service	Vehicles veh	Distance ft	Length ft	Туре	Adj. I %	Block. %
South: Mary																
Lane 1	5	54	22	82	0.0	676	0.121	100	8.2	LOS A	0.5	12.1	1600	_	0.0	0.0
Approach	5	54	22	82	0.0		0.121		8.2	LOS A	0.5	12.1				
East: Mary A	Alignmer	nt WB														
Lane 1	22	450	0	471	3.8	1335	0.353	100	5.1	LOS A	2.5	65.1	1600	_	0.0	0.0
Lane 2	0	289	250	539	3.1	1527	0.353	100	5.3	LOS A	2.6	65.7	1600		0.0	0.0
Approach	22	739	250	1011	3.4		0.353		5.2	LOS A	2.6	65.7				
North: Five I	Mile Roa	ad SB														
Lane 1	185	11	5	201	1.9	634	0.317	100	15.8	LOS B	1.4	34.3	1600		0.0	0.0
Approach	185	11	5	201	1.9		0.317		15.8	LOS B	1.4	34.3				
West: Mary	Alignme	nt EB														
Lane 1	5	225	0	231	3.9	1101	0.210	100	5.8	LOS A	1.3	32.3	1600	_	0.0	0.0
Lane 2	0	253	5	258	3.9	1232	0.210	100	5.4	LOS A	1.3	33.1	1600	_	0.0	0.0
Approach	5	478	5	489	3.9		0.210		5.6	LOS A	1.3	33.1				
Intersection				1783	3.2		0.353		6.6	LOS A	2.6	65.7				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Monday, December 19, 2011 2:35:40 PM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Traffic Study\Capacity\Calculations\Mary Street\Mary Opt 2\Mary Align Mary_5 Mile Opt2 PM 2035.sip 8001325, MARVIN & ASSOCIATES, SINGLE



Mary Street Alignment Bitteroot Alternative B Roundabout

Lane Use and Performance																
	C	eman	d Flows		LI\	Con	Deg.	Lane	Average	Level of	95% Back		Lane	SL	Cap. F	
	L veh/h	T veh/h	R veh/h	Total veh/h	HV %	Cap.	Satn v/c	Util. %	Delay sec	Service	Vehicles veh	Distance ft	Length ft	Type	Adj. E %	Block. %
South: Bitter		V 011/11	VO11/11	V 011/11	70	V 011/11	•,, 0	70	000		7011				70	,,,
Lane 1	22	120	103	245	0.0	778	0.314	100	4.7	LOS A	1.4	35.5	200		0.0	0.0
Approach	22	120	103	245	0.0		0.314		4.7	LOS A	1.4	35.5				
East: Mary A	Alignmer	nt WB														
Lane 1	120	234	0	353	2.6	1201	0.294	100	7.9	LOS A	1.9	48.5	1600	_	0.0	0.0
Lane 2	0	331	54	386	3.4	1311	0.294	100	5.3	LOS A	1.9	49.6	1600	_	0.0	0.0
Approach	120	565	54	739	3.1		0.294		6.6	LOS A	1.9	49.6				
North: Bitter	oot SB															
Lane 1	43	54	33	130	0.3	661	0.197	100	6.9	LOS A	0.8	19.8	1600	_	0.0	0.0
Approach	43	54	33	130	0.3		0.197		6.9	LOS A	8.0	19.8				
West: Mary	Alignme	nt EB														
Lane 1	11	184	0	195	3.8	1125	0.174	100	5.9	LOS A	0.9	24.5	1600	_	0.0	0.0
Lane 2	0	207	11	218	3.8	1255	0.174	100	5.4	LOS A	1.0	24.9	1600		0.0	0.0
Approach	11	391	11	413	3.8		0.174		5.7	LOS A	1.0	24.9				
Intersection				1527	2.5		0.314		6.0	LOS A	1.9	49.6				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Thursday, December 22, 2011 11:04:34 AM SIDRA INTERSECTION 5.1.8.2059 Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Traffic Study\Capacity\Calculations\Mary Street\Mary Bitteroot Design Opts\Mary Align Bitteroot Alt B 2035 PM.sip

8001325, MARVIN & ASSOCIATES, SINGLE



Site: North Frontage Road & Johnson Lane Year 2035 PM

N Frontage Johnson Lane Year 2035 PM Roundabout

Lane Use and Performance																
		Deman	d Flows		HV	Can	Deg.	Lane	Average	Level of	95% Back		Lane	SL	Cap. F	
	L veh/h	veh/h	R veh/h	Total veh/h	пv %	Cap.	Satn v/c	Util. %	Delay sec	Service	Vehicles veh	Distance ft	Length ft	Type	Adj. E %	Block. %
South: John		V 011/11	VO11//11	V 011/11	70	V 011/11	•,, 0	70	000		7011				70	70
Lane 1	207	385	0	591	4.3	1075	0.550	100	6.0	LOS A	4.8	124.2	1600	_	0.0	0.0
Lane 2	0	626	33	659	4.0	1198	0.550	100	3.6	LOS A	4.9	127.4	1600	_	0.0	0.0
Approach	207	1011	33	1250	4.1		0.550		4.7	LOS A	4.9	127.4				
East: N From	ntage W	B														
Lane 1	27	22	5	54	1.0	369	0.147	100	11.9	LOS B	0.6	15.5	1600		0.0	0.0
Approach	27	22	5	54	1.0		0.147		11.9	LOS B	0.6	15.5				
North: John	son SB															
Lane 1	5	411	0	417	4.0	1033	0.404	100	3.9	LOS A	2.8	72.3	1600	_	0.0	0.0
Lane 2	0	350	109	458	4.0	1135	0.404	100	3.9	LOS A	2.9	73.9	1600	_	0.0	0.0
Approach	5	761	109	875	4.0		0.404		3.9	LOS A	2.9	73.9				
West: N Fro	ntage E	В														
Lane 1	168	33	228	429	4.3	532	0.807	100	18.0	LOS B	7.0	180.6	1600	_	0.0	0.0
Approach	168	33	228	429	4.3		0.807		18.0	LOS B	7.0	180.6				
Intersection				2609	4.0		0.807		6.8	LOS A	7.0	180.6				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Monday, October 31, 2011 3:14:30 PM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Johnson & Mary Add Concepts July 2011\Johnson Lane\Capacity 102011\N Frtg Johnson 2035 PM.sip 8001325, MARVIN & ASSOCIATES, SINGLE



Site: Five Mile Road Alignment HWY 312 Intersection

Five Mile Road Alignment Highway 312 Intersection Year 2035 PM Design Hour Roundabout

Lane Use and Performance																
		Deman	d Flows				Deg.	Lane	Average	Level of	95% Back		Lane	SL	Cap.	
	L	Τ.	R	Total	HV	Cap.	Satn	Util.	Delay	Service	Vehicles	Distance	Length	Type		Block.
Cauth Fast		veh/h		veh/h	%	veh/h	v/c	%	sec		veh	ft	ft		%	%
South East:	-					400		225					4000			
Lane 1	33	5	0	38	3.6	480	0.079	28 ⁵	15.4	LOS B	0.3	7.3	1600	_	0.0	0.0
Lane 2	0	0	250	250	3.0	891	0.281	100	7.9	LOS A	1.2	31.8	1600		0.0	0.0
Approach	33	5	250	288	3.1		0.281		8.9	LOS A	1.2	31.8				
North East:	HWY 3	12 SW	3													
Lane 1	174	74	0	248	3.0	1335	0.186	100	10.2	LOS B	1.1	28.1	1600	_	0.0	0.0
Lane 2	0	263	5	268	3.0	1445	0.186	100	4.5	LOS A	1.1	28.4	1600	_	0.0	0.0
Approach	174	337	5	516	3.0		0.186		7.3	LOS A	1.1	28.4				
North West:	Access	Road	SEB													
Lane 1	5	5	5	16	1.0	753	0.022	100	8.1	LOS A	0.1	1.9	1600	_	0.0	0.0
Approach	5	5	5	16	1.0		0.022		8.1	LOS A	0.1	1.9				
South West	: HWY	312 NE	В													
Lane 1	5	249	0	254	3.0	1172	0.217	100	5.5	LOS A	1.2	31.0	1600	_	0.0	0.0
Lane 2	0	262	22	284	3.0	1310	0.217	100	5.3	LOS A	1.2	31.5	200	_	0.0	0.0
Approach	5	511	22	538	3.0		0.217		5.4	LOS A	1.2	31.5				
Intersection				1359	3.0		0.281		6.9	LOS A	1.2	31.8				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

5 Lane underutilisation determined by program

Processed: Thursday, December 01, 2011 1:02:56 PM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Traffic Study\Capacity\Calculations\Mary Street\Five Mile Align HWY 312 Int PM 2035.sip

8001325, MARVIN & ASSOCIATES, SINGLE



Site: Five Mile Road Alignment Mary Street Intersection

Five Mile Road Alignment Mary Street Intersection Year 2035 PM Design Hour Roundabout

Lane Use and Performance																
	. [Deman	d Flows		HV	Can	Deg.	Lane	Average	Level of	95% Back		Lane	SL	Cap. I	
	L veh/h	veh/h	R veh/h	Total veh/h	пv %	Cap.	Satn v/c	Util. %	Delay sec	Service	Vehicles veh	Distance ft	Length ft	Туре	Adj. I %	Block. %
South East:				VG11/11	/0	VG11/11	V/C	/0	366		VEII		- 1		/0	/0
Lane 1	543	0	0	543	4.0	1600	0.340	100	12.5	LOS B	2.4	61.6	1600	_	0.0	0.0
Lane 2	0	304	0	304	3.0	1320	0.231	68 ⁵	4.5	LOS A	1.4	36.0	1600	_	0.0	0.0
Approach	543	304	0	848	3.6		0.340		9.7	LOS A	2.4	61.6				
North West: Five Mile Align SEB																
Lane 1	0	109	0	109	2.0	853	0.128	100	7.5	LOS A	0.7	17.8	1600	_	0.0	0.0
Lane 2	0	98	33	130	1.7	1018	0.128	100	7.3	LOS A	0.7	18.7	1600	_	0.0	0.0
Approach	0	207	33	239	1.9		0.128		7.4	LOS A	0.7	18.7				
South West	: Mary S	treet N	IEB													
Lane 1	33	0	0	33	1.0	638	0.051	100	14.0	LOS B	0.2	5.1	200	_	0.0	0.0
Lane 2	0	0	359	359	3.0	1087	0.330	100	6.8	LOS A	1.8	46.1	200		0.0	0.0
Approach	33	0	359	391	2.8		0.330		7.4	LOS A	1.8	46.1				
Intersection				1478	3.1		0.340		8.7	LOS A	2.4	61.6				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

5 Lane underutilisation determined by program

Processed: Monday, December 19, 2011 3:01:47 PM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Traffic Study\Capacity\Calculations\Mary Street\Five Mile\Five Mile Align Mary Int PM 2035.sip 8001325, MARVIN & ASSOCIATES, SINGLE



Site: Five Mile Align Secondary Mary & Bitterroot

Five Mile Alignment Secondary Mary & Bitteroot 2035 Roundabout

Lane Use and Performance																
	L	Deman T veh/h	d Flows R veh/h	Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back Vehicles veh	of Queue Distance ft	Lane Length ft	SL Type	Cap. F Adj. E %	
South: Bitte	root NB															
Lane 1	54	109	87	250	0.0	763	0.328	100	6.1	LOS A	1.7	43.6	200	_	0.0	0.0
Approach	54	109	87	250	0.0		0.328		6.1	LOS A	1.7	43.6				
East: Mary	Street W	/B														
Lane 1	87	424	65	576	2.9	1023	0.563	100	6.1	LOS A	4.7	121.5	1600	_	0.0	0.0
Approach	87	424	65	576	2.9		0.563		6.1	LOS A	4.7	121.5				
North: Bitter	root SB															
Lane 1	43	65	11	120	0.4	641	0.187	100	7.6	LOS A	0.9	23.8	1600	_	0.0	0.0
Approach	43	65	11	120	0.4		0.187		7.6	LOS A	0.9	23.8				
West: Mary	Street E	В														
Lane 1	22	337	54	413	3.3	1016	0.407	100	5.2	LOS A	2.8	70.8	1600	_	0.0	0.0
Approach	22	337	54	413	3.3		0.407		5.2	LOS A	2.8	70.8				
Intersection	l			1359	2.3		0.563		6.0	LOS A	4.7	121.5				

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay per lane.

Intersection and Approach LOS values are based on average delay for all lanes.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Saturday, February 25, 2012 2:06:39 PM SIDRA INTERSECTION 5.1.8.2059

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Documents and Settings\Robert\My Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\Traffic Signal Warrant Study\Capacity Calcs\Five Mile Align Second Mary & Bitteroot 2035 PM.sip 8001325, MARVIN & ASSOCIATES, SINGLE



er.			



BILLINGS BYPASS EIS

NCPD 56(55)CN 4199

SECTION 4: Lighting Warrant Study Report

Billings Bypass
April, 2012







BILLINGS BYPASS EIS NCPD 56(55)CN 4199

Intentionally Blank Page.

LIGHTING WARRANTS

Specific empirical criteria for roads and streets other than freeways are not readily available in either the MDT "Traffic Engineering Manual – Chapter Thirteen- Highway Lighting Design" or in AASHTO's "An Informational Guide for Roadway Lighting". Inclusion of lighting on MDT facilities is normally considered when lighting is economically feasible and an agreement with local agencies can be reached to install and maintain lighting. The MDT "Traffic Engineering Manual" presents seven considerations in the assessment of lighting needs on streets and highways other than freeways.

- 1. Facilities With Raised Medians The proposed design section along the alternative alignments would not have raised medians throughout the length of the project, but would have curb & gutter at certain locations, specifically at roundabout intersection approaches and at intersections where raised medians or curb would be used to control access. There would also be curbed sections on secondary improvements to Mary Street associated with the Five Mile Road Alternative Alignment.
- 2. Major Urban Arterials The project's alternative alignments north of the Yellowstone River Bridge would be considered as Major Urban Arterials. Mary Street is currently classified as a Principal Arterial Street within the Billings Transportation Plan.
- 3. Intersections There are a number of intersections within the project alignments corridors. Due to multi-lane operation and relatively varying degrees of complexity at these intersections, lighting would enhance nighttime safety at all public street intersection locations. All roundabouts within curbed areas should have lighting, and consideration should be given to approach lighting at signalized intersections.
- 4. High Conflict Locations Conflicts within the project corridor are generally limited to areas near intersections. While there are no specific limits associated with "high conflict locations", anticipated potential for conflict within the Urban Arterial sections would be substantially higher than for the rural portions of the project.



Roadway illumination would be justified at public street intersections and at locations where there are pedestrian and/or bicycle crossings. Continuous lighting along Mary Street as a secondary improvement associated with the Five Mile alternative should be considered because bike lanes would exist along the roadway with numerous existing driveways.

- 5. Complex Roadway Geometry Geometric conditions within the majority of the project alignments would involve extended horizontal tangents and sweeping curves. The most complex geometries would occur at the interchange areas and at public street intersections, which would be illuminated as indicated above.
- 6. Night/Day Accident Ratio The nighttime accident rate is not expected to be substantially greater than the daytime rate on any of the alignments and the night/day accident rate would not be a consideration for lighting on any of the alignments.
- 7. Local Agency Needs The perceived benefits of lighting along this corridor do not provide an overwhelming justification for the inclusion of lighting throughout the entire corridor, yet some benefits could be realized by providing continuous lighting. Local governments and agencies still must be contacted and the needs and fiscal requirements of the lighting system must be agreed upon.



Johnson Lane Interchange

Warranting conditions for full and partial interchange lighting are detailed in both the AASHTO publication "An Informational Guide for Roadway Lighting" and the MDT "Traffic Engineering Manual". The existing interchange has continuous lighting on the crossroad (Johnson Lane) and standard gore area lighting (three luminaires) on Interstate 90. Continuous freeway lighting is generally not justified nor provided at MDT interchanges and the mainline traffic projections of 27,500 ADT west of Johnson Lane would not meet the 30,000 ADT criteria for continuous lighting. The following table presents the design year values for this interchange, which includes all proposed alternatives, and the minimum warranting values for partial interchange lighting:

Complete Interchange Lighting (Urban)

Criteria	Design Value	Warrant Min.	Met?
1 - Ramp Volume (2035 ADT)	8000	5000	Yes
2 - Crossroad Volume (2035 ADT)	22000	10000	Yes
3 - Land Development/ Lighting Condition	ons		Yes
4 - Night/Day Accident Ratio	na	na	No
5 - Local Agency Needs			?
6 - Continuous Freeway Lighting			
(2035 ADT)	27,500	30000	No

It can be seen that partial interchange lighting can be justified by virtue of the volume criteria and adjacent land development. Local needs will be considered to the extent of lighting that is desired at this location. Because of unique geometric conditions associated with some of the interchange design options, continuous lighting along the ramp sections should be considered, and all sections on the ramps and crossroads that have curb & gutter sections and/or raised medians should be illuminated.



LIGHTING DESIGN CRITERIA & RECOMMENDATIONS

Lighting criteria within the project will conform to AASHTO and MDT standards for roadway lighting. MDT standards require that "illuminance" criteria be used on state roadways. Figure 13.6B in the "Traffic Engineering Manual" indicates the appropriate lighting illuminance for sections of urban roadway. Where lighting is required, as previously noted, the roadway classification should be considered as Principal Urban Arterials. Residential areas would be along Mary Street as a secondary improvement associated with the Five Mile Road Alignment. Intersections on the Mary Street Alignment at US 87 would be considered Intermediate areas, and lighting along the Johnson Lane corridor would be considered Commercial areas.

Design criteria contained within the MDT Traffic Engineering manual shall be used to determine mounting height, pole spacing and luminaire type and distribution. With the recent advances in LEDs, use of LED luminaires should be considered as an option in final design. The design options should conform to MDT and AASHTO standards with regard to average foot-candles and uniformity ratios. Replacement of existing street lighting installation should be considered to match the light source and illumination levels of the new lighting system to provide a uniform appearance.





BILLINGS BYPASS EIS

NCPD 56(55)CN 4199

SECTION 5 FEIS Traffic Study Report

Billings Bypass

August 2013







BILLINGS BYPASS EIS NCPD 56(55)CN 4199

Intentionally Blank Page.

Table of Contents	Page
INTRODUCTION	1
PHASE 1 TRAFFIC PROJECTIONS	1
Phase 1 – Alignment Travel Times	1
Travel Time Analysis Methodology	2
Percent No-passing	3
HCS Two-Lane Travel Speed Results	3
Phase 1 Year 2035 Traffic Projections	4
Phase 1 and Phase 2 Traffic Projections Significance	12
PHASE 1 STREET SYSTEM IMPACTS	13
Year 2035 Alternative Alignments Vehicle Miles of Travel	13
Year 2035 Alternative Alignments Vehicle Hours of Travel	15
Year 2035 Alternative Capacity & LOS	15
Crash Projections	17
ALTERNATIVE PHASE 1 ALIGNMENT INTERSECTIONS	19
Johnson Lane Interchange	19
Johnson Lane/Coulson Road Intersections	21
Mary Street Alignment Intersections	21
Mary Option 1 & Five Mile Road	21
Mary Option 2 & Five Mile Road	21
Mary Street Alignment & Bitterroot Drive	25
Mary Options 1 & 2 & Hawthorne Lane	25
Five Mile Road Alignment & HWY 312	25
Five Mile Road Alignment & Dover Road	29
Five Mile Road & Mary Street	29
Mary Street Alignments – US87/Old HWY 312 Intersection	29
SUMMARY & CONCLUSIONS	32
APPENDIX A - Phase 1 Two Lane Corridor Capacity	
APPENDIX B - Phase 1 System Intersections Capacity	
APPENDIX C - Phase 1 Alignments Intersections Capacity	



List of Fig	jures	Page
Fig 4	Many Charat Ontion A Dhoor A Tour Lone Very 2005 ADT Velumes	0
Figure 1.	Mary Street Option 1 Phase 1 Two Lane Year 2035 ADT Volumes	6
Figure 2.	Mary Street Option 1 Phase 1 Two Lane Year 2035	_
	PM Design Hour Traffic	7
Figure 3.	Mary Street Option 2 Phase 2 Two Lane Year 2035 ADT Volumes	8
Figure 4.	Mary Street Option 2 Phase 2 Two Lane Year 2035	
	PM Design Hour Traffic	9
Figure 5.	Five Mile Road Phase 1 Two Lane Year 2035 ADT Volumes	10
Figure 6.	Five Mile Road Phase 1 Two Lane Year 2035 Design Hour Traffic	11
Figure 7.	Mary Street Option 2 Phase 1 Design Concept Johnson Lane	20
Figure 8.	Mary Street Opt 2 Johnson Lane –	
	Coulson Road Intersections Phase 1	22
Figure 9.	Mary Street Option 1 – Five Mile Road Intersection Phase 1	23
Figure 10.	Mary Alignment Option 2 - Five Mile Road Intersection Phase 1	24
Figure 11.	Mary Option 2 Alignments & Bitterroot Phase 1	26
Figure 12.	Mary Street 2 Alignment – Hawthorne Lane Phase 1	27
Figure 13.	Five Mile Road Alternative & Old Hwy 312 Phase 1	28
Figure 14.	Five Mile Road Alignment – Mary Street Phase 1	30
Figure 15.	Mary Street Alignments US 87 HWY 312 Bench Blvd.	
	Phase 1 Intersection	31
List of Ta	bles	Page
Table 1.	Travel Time Differences Between 4 Lane and 2 Lane	4
Table 2.	Phase 1 Trip Reductions Between Origins & Destinations	
	on Bypass Alignments	5
Table 3.	Vehicle Miles Travel Comparison Between Phase 1 & Phase 2	
	(Full Builout) Alternative Alignments	14
Table 4.	Existing Street System Capacity for Phase 1 Alignments	16
Table 5.	Annual Crash Projections on Existing Streets & Roads with Bypass	
	For Phase 1 & Full Buildout - Year 2035	18



INTRODUCTION

This report was prepared as a part of the Final Environmental Impact Statement (FEIS) and addresses traffic and transportation issues related to two-lane operations that would be associated with Phase 1 of the Billings Bypass Project NCPD 56(55) CN 4199. Traffic and transportation analysis addressed within this report are based upon operational differences between Phase 1 (two-lane) and the Full Buildout (aka Phase 2 or four-lane) alignments contained in the Draft Environmental Impact Study (DEIS) Traffic Report. Future design year (2035) traffic projections for Phase 1 alignment alternatives are presented along with traffic analysis results associated with existing and proposed alternative roadways and intersections.

This report is intended to supplement the data and analysis summarized in the Preliminary Traffic Study Report and is included as an extension of that report. Thus, this report does not include detailed descriptions of existing and future street systems, statistics, or analysis methods that have already been addressed in the DEIS Traffic Report.

All of the design alternatives presented within this report are based upon twolane traffic operations and would provide acceptable operating conditions until the end of the Phase 1 useful design life, in the year 2035. It has been assumed that, Full Buildout improvements would be planned and construction of the fourlane roadway sections would commence on or before the year 2035.

PHASE 1 TRAFFIC PROJECTIONS

Traffic projection methodology that was used for the Full Buildout alternative alignments was also used for the Phase 1 two-lane traffic projections. Within that methodology travel time is the primary variable that determines travel route choice. Vehicular trips are assigned to the route with the least travel time. Therefore, the difference in travel time between two-lane and four-lane operations is directly related to the difference in Bypass travel demand. Travel time differences were input directly to the traffic model and traffic projections related to Phase 1 alignments were calculated.

Phase 1 – Alignment Travel Times

The analysis of travel time calculations associated with Phase 1, two-lane operations, was performed for each of the three Bypass alignment alternatives detailed in the Draft EIS. The average two-lane travel speeds and travel times presented herein are based upon a number of qualified assumptions that are commensurate with the basic parameters used within the Draft EIS traffic model for four-lane facilities. The objective of this analysis was to determine differences in travel times that can be applied to the traffic model in an effort to predict traffic volumes for Phase1 impact assessment in the Final EIS.



The Bypass traffic model was based on bypass alignment travel times relative to existing system routes between various origins and destinations. Any change in the alignment travel times would result in traffic volume assignment changes on the alternative alignments. Since two and four lane roadways have distinct operational differences, it was assumed that travel speeds for the two lane phase would result in travel time changes. The difference in travel times for each alignment alternative was input to the model to determine the resultant traffic volumes that could be assigned to each of the Phase 1 alternative alignments.

Travel Time Analysis Methodology

Analysis of alternative bypass alignment travel times on two lane road segments was performed by using uninterrupted flow modules of the 2010 Highway Capacity Manual (HCM). Input data for two lane highway operations in the 2010 Highway Capacity Software (HCS) program consists of: highway alignment or description of the terrain; classification of roadway; traffic volumes by direction; peak hour factor; roadway cross section dimensions; roadway segment length; vehicle mix; percentage of no passing zones; access-point density; and baseline travel speeds or measured travel speed data. The alignments and typical sections of the alternative alignments are known along with the relative terrain and roadway classifications. The remaining inputs are subject to a number of assumptions regarding traffic volumes and operational characteristics that would exist commensurate with the traffic model for year 2035 projections. The following assumptions were made in an effort to determine two lane travel speeds that are consistent with the original traffic model's travel time estimates:

- Phere were two distinct segments associated with Mary Street Option 1 and 2 alternative alignments. The roadside environment along these two segments determined operational speeds in the year 2035. The first segment, between Johnson Lane and Mary Street, is in a rural environment with rolling terrain. The model's travel speed was assumed to be 60 mph in this segment. The second segment, between Mary Street and Hwy 312, is in an urban environment with level terrain. The model's travel speed on that segment was assumed to be 45 mph. Two segments in the Five Mile Road alternative both have rural characteristics, which would be conducive to 60 mph travel speeds.
- Although there are intersections (Mary Street and Bitterroot Drive) that would interrupt traffic flow on each alternative alignment, it was assumed that the two-lane HCM methods to estimate travel speeds would be appropriate to estimate the difference in travel speeds along the alignments. Overall travel time was then determined by adding average intersection delays in the same manner as for the original model projections for the four lane facilities.
- ➤ The difference in travel time for the two lane facilities was then estimated by dividing the roadway segment lengths by the travel speeds and comparing the results to the original traffic model travel times.
- Since average travel times are the objective of the analysis, the average hour of the day was used as input to the HCS rather than



the peak design hour traffic typically used to determine capacity of two-lane roadway facilities. By examining hourly traffic variations on Main Street, it was determined that the daytime average hourly traffic volume is approximately 6% of average daily traffic (ADT). In addition, the directional traffic split is approximately 50%/50% at that hour.

- ➤ It was assumed that the two lane section would not substantially reduce the year 2035 traffic projections since sufficient capacity would generally be provided. Thus, 6% of the original year 2035 ADT projections for each alternative alignment were used as vehicles per hour inputs to the HCS module.
- ➤ Rather than using the model speeds of 60 mph and 45 mph as baseline design travel speeds in HCS, travel speeds based upon observations on similar two-lane facilities in the Billings area were used. This would be commensurate with the original model estimates of 60 mph and 45 mph where the actual free-flow speeds would most likely be higher than the speed limits.
- ➤ It was assumed that the level of secondary roadway improvements associated with each alternative alignment would be the same. Thus, travel time differences would only impact traffic projections on the primary alignment.

Percent No-passing

Estimates of the percentage of roadway that would be "no passing" were made according to AASHTO and MUTCD guidelines. The estimated percentage of "no-passing" was calculated based upon each segment's length and the length of allowable passing distances. Measurements were made along each alignment to determine passing zone lengths. Tabular summaries of each alternative alignment's geometry including lengths of horizontal curves, tangents, significant vertical influences, and intersection locations were used to determine percent no-passing values used in the HCS two-lane highway analysis.

HCS Two-Lane Travel Speed Results

Appendix A contains capacity calculation summaries for each of the alternative alignment segments based upon the assumptions contained herein. Table 1 provides a summary of the travel speeds and travel time results in comparison to the traffic model's travel speeds and travel times.

The greatest difference in two-lane travel speeds would be associated with the Mary Option 1 alternative alignment between Johnson Lane Interchange and the Mary Street intersection, which would experience average travel speeds 3.8 mph slower than the four-lane section. The result is an average travel time increase of 0.22 minutes. The greatest difference in two-lane travel times along the entire length of the alternative alignments would be 0.32 minutes for the Mary Option 2 alignment. This increase in travel time, less than 20 seconds, is unlikely to appreciably decrease traffic projections for the alternative alignments.



Table 1. Travel Time Difference Between 4 Lane and 2 Lane

Alternative Roadway Segments	4 Lane	2 Lane	Differences							
Mary Street Option 1										
Johnson Inter Mary (3.2 miles)										
Travel Speed (mph)	60.00	56.20	-3.80							
Travel Time (min)	3.20	3.20 3.42								
Mary - Hwy 312 (1.7 miles)										
Travel Speed (mph)	45.00	43.20	-1.80							
Travel Time (min)	2.27	2.36	0.09							
Mary Street Option 1 Total Travel Times =	5.47	5.78	0.31							
Mary Street Option 2										
Johnson Inter Mary (3.0 miles)										
Travel Speed (mph)	60.00	56.40	-3.60							
Travel Time (min)	3.00	3.19	0.19							
Mary - Hwy 312 (2.2 miles)										
Travel Speed (mph)	45.00	43.10	-1.90							
Travel Time (min)	2.93	3.06	0.13							
Mary Street Option 2 Total Travel Times =	5.93	6.25	0.32							
Five Mile Road										
Johnson Inter Mary Street (3.0 miles)										
Travel Speed (mph)	60.00	57.30	-2.70							
Travel Time (min)	3.00	3.14	0.14							
Mary Street - Hwy 312 (1.4 miles)										
Travel Speed (mph)	60.00	57.60	-2.40							
Travel Time (min)	1.40	1.46	0.06							
Five Mile Road Total Travel Times =	4.40	4.60	0.20							

Phase 1 Year 2035 Traffic Projections

Previous DEIS traffic projection methodologies were utilized for each of the alternative alignments. The first level traffic projection analysis indicated that the additional travel time associated with the two-lane facility would have no effect on trips exchange between a number of traffic analysis zones while trip exchange between other traffic analysis zones would have a reduction in trips utilizing the Bypass alignments. Table 2 summarizes the reduction in trips exchange between traffic analysis zones on key street segments for each of the three bypass alignments. These projections indicate that both Mary Street Alignment



options would have the highest reduction in traffic demand which would amount to 360 less trips per day on the Bypass river crossing structure. Since secondary improvements would be made to Mary Street in conjunction with the Five Mile Road alignment, the total reduction in traffic demand for that alignment would only be 205 vehicles per day.

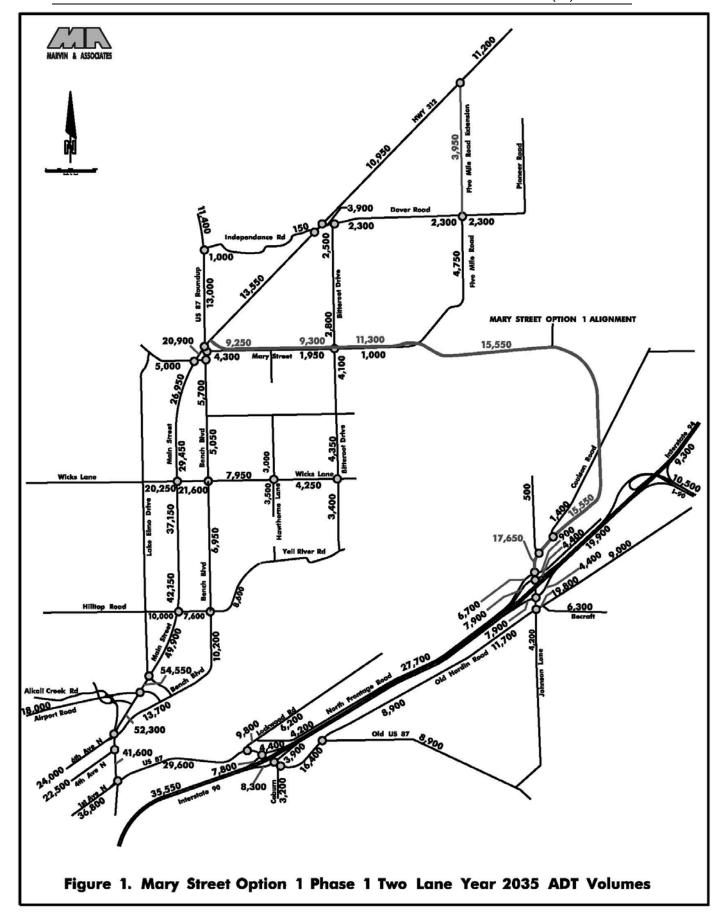
Table 2. Phase 1 Trip Reductions Between Origins & Destinations On Bypass Alignments

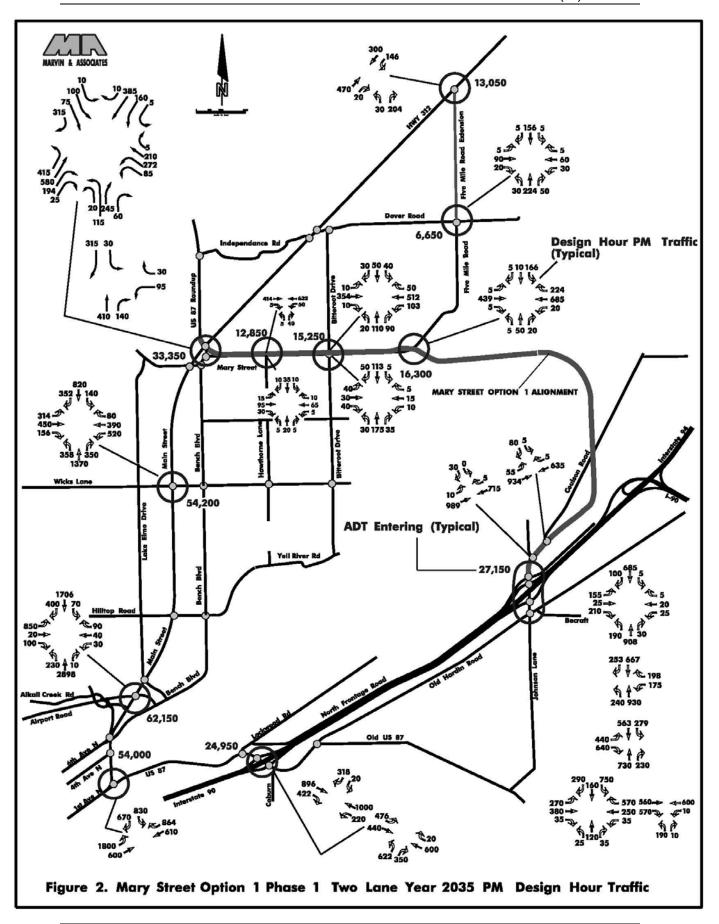
									Lockwood		
	Heights West				Heights East			Commercial	Redistribute		
	% Distribution to				% Distribution to			Traffic	Huntley		
Alternative Alignments	Lock East	Lock Wes	I-90 / I-94	Westend	Lock East	Lock West	I-90 / I-94	Westend	Redistribute	Interchange	Totals
Mary Alignment Option 1											
Traffic Distribution	-67	-27	-13	-19	-91	-5	-17	-4	-18	-104	-364
Mary Align	-67	-27	-13	-19	-91	-5	-17	-4	-18	0	-260
FiveMile S of HWY 312	0	0	0	0	0	0	0	0	0	-104	-104
Bitteroot N of Mary	0	0	0	0	0	0	0	0	0	0	0
Bypass to Johnson Lane	-67	-27	-13	-19	-91	-5	-17	-4	-18	-104	-364
Mary Alignment Option 2											
Traffic Distribution	-67	-27	-13	-19	-91	-5	-17	-4	-15	-105	-362
Mary Align	-67	-27	-13	-19	-91	-5	-17	-4	-15	0	-257
FiveMile S of HWY 312	0	0	0	0	0	0	0	0	0	-105	-105
Bitteroot N of Mary	0	0	0	0	0	0	0	0	0	0	0
Bypass to Johnson Lane	-67	-27	-13	-19	-91	-5	-17	-4	-15	-105	-362
Five Mile Road Alignmen	t										
Traffic Distribution	-29	0	-6	0	-25	-15	-5	-15	-5	-105	-205
Mary Existing Align	-29	0	-6	0	-25	-15	-5	-15	-5	0	-100
FiveMile S of HWY 312	0	0	0	0	0	0	0	0	0	-105	-105
Five Mile N of Mary	0	0	0	0	0	0	0	0	0	-105	-105
Five Mile/to Johnson Ln	-29	0	-6	0	-25	-15	-5	-15	-5	-105	-205

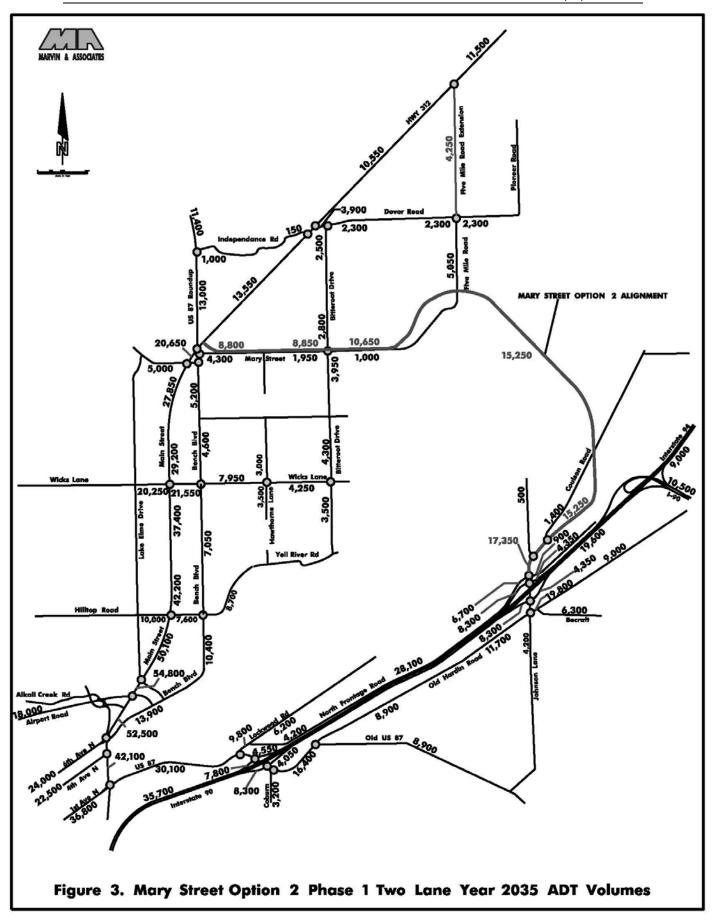
A second level of traffic projections was completed to determine average daily traffic (ADT) on the entire system of impacted streets and design hour volumes at key intersections. Figures 1 through 6, on the following pages, present a summary of year 2035 ADT and PM design hour traffic volumes on the existing system and at proposed intersections that would be associated with each of the Phase 1 alternative alignments. Comparisons between the ADT and design hour traffic projections in the DEIS Traffic Study and the Phase 1 traffic projections (Figures 11 thru 16) indicate that many of the streets would have minimal differences in traffic volumes. The most substantial changes would be on the Mary Street Alignments south of the river crossing (-360 ADT). On Main Street south of 6th Avenue N. and on US 87 east of Main Street, there would an increase of approximately 250 ADT associated with the Mary Street Alignments.

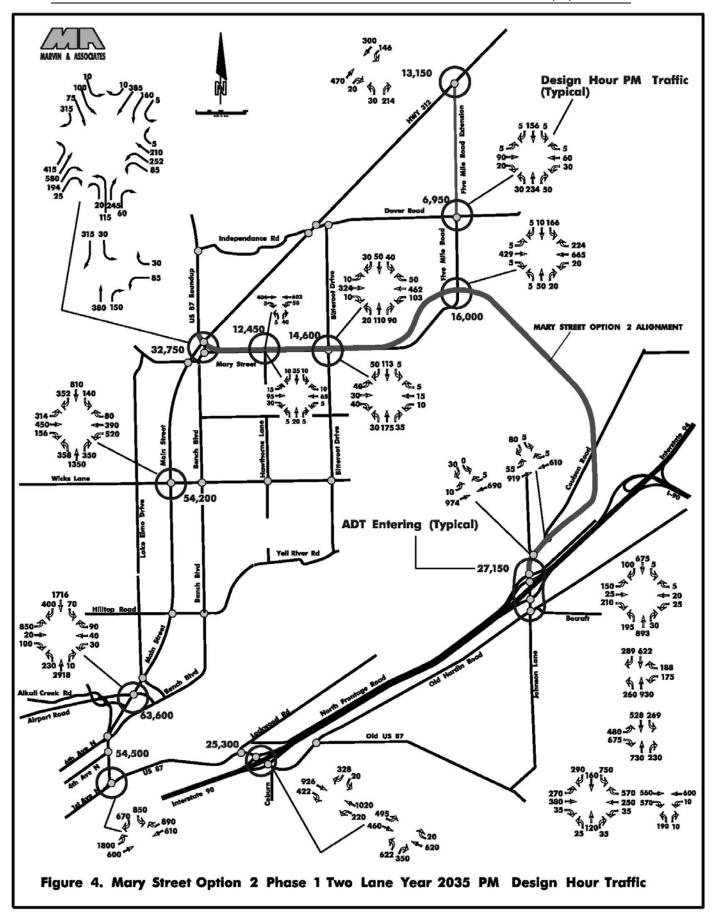
Since PM peak hour traffic volumes are considerably higher than the AM hour and operational measures of efficiency are worse during the PM hour, the PM peak hour volumes were used as design hour volumes. This is consistent with the DEIS traffic projections for the Full Buildout alternative alignments. Most of the alternative bypass intersections are considered to be operationally symmetrical and reversal of PM traffic flow patterns in the AM hour would result in the same or better (less traffic) levels of service during that time of the day.

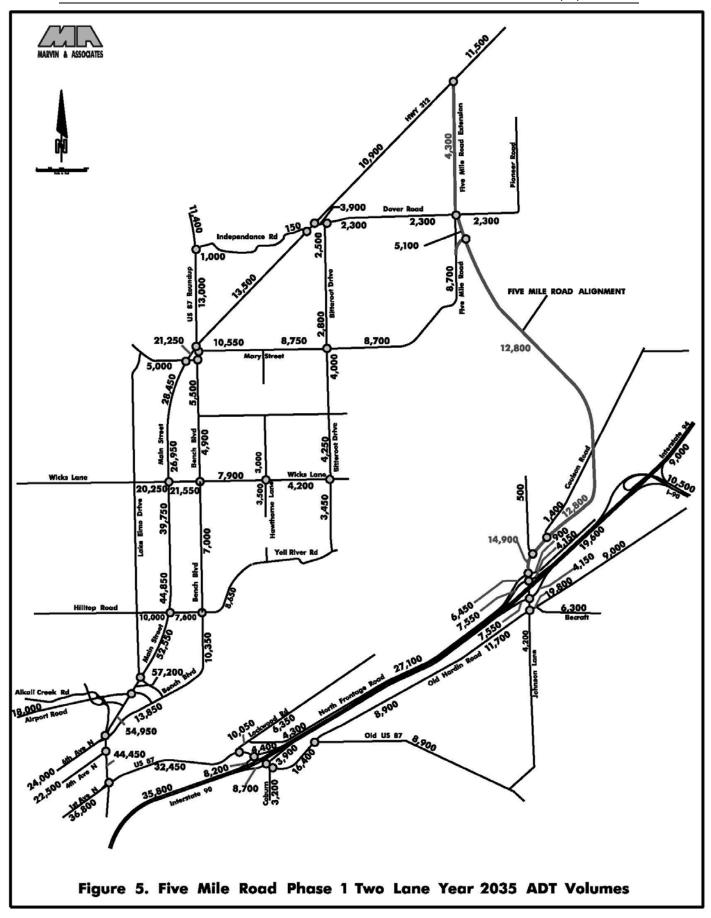


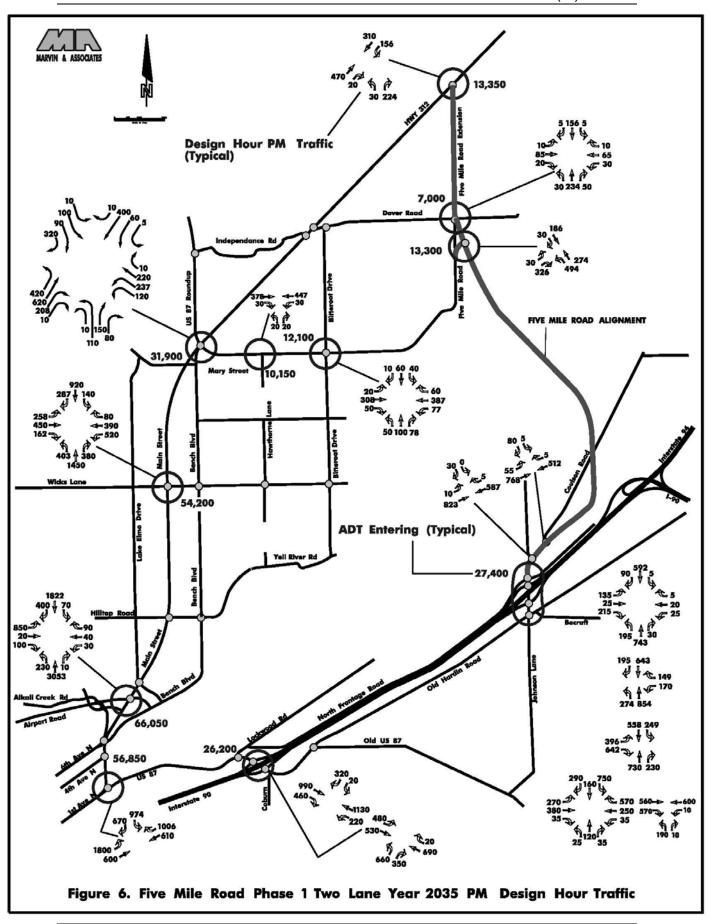












Phase 1 and Phase 2 Traffic Projections Significance

An analysis was performed to determine if the differences between Phase 1 (two lane facilities) traffic projections and Full Buildout (four lane facilities) traffic projections are statistically significant. To determine this, a statistical analysis using the "T" statistic was performed. The "T" statistical analysis compares two sample groups with normal distributions to determine whether there is a true difference in the average or median of the two groups. In order to provide relevant samples of traffic volumes, the Montana Department of Transportation Main Street permanent traffic count station data was used to replicate seasonal and daily traffic variations that would be associated with the Bypass alignment. Since there are 7 days in a week and 12 months in the year, a total of 84 (7x12) data points were used in the sample size for both two lane and four lane facilities. The analysis resulted in the following statistics for the Mary Street Option 2 Alignment (DEIS preliminary preferred alternative):

	<u> 4 Lane</u>	<u>2 Lane</u>
Median ADT	15,600	15,250
Standard Deviation	1,979	1,935

The calculated "T" statistic was 0.84, which is substantially less than the "T" Statistic Table value of 1.99 and therefore it was confirmed that there is no statistical difference between the four lane and two lane traffic projections.

The statistical analysis confirms what would be a logical conclusion when examining the range of daily traffic volumes that would typically occur on the Bypass alignments. Main Street daily traffic volumes have a range between 72% of ADT to 124% of ADT over the course of a year. Thus applied to the Mary Street Option 2 Alignment, the daily traffic could range between 11,200 and 19,300 vehicles per day. Even with accurate traffic count samples, it is difficult to estimate the annual average daily traffic (AADT) within 10% of the actual number. Since the difference between the two lane and the four lane projections is only 350 ADT, or 2.2%, that volume of traffic would be well within the normal range of accuracy.

Given the above data and narratives, it is evident that there would be no significant differences between traffic projections for the two lane and four lane alignment sections. Traffic impacts associated with each alternative alignment will therefore be the same or have only minimal differences as a worst case scenario.



PHASE 1 STREET SYSTEM IMPACTS

Year 2035 Alternative Alignments Vehicle Miles Travel

Table 3 presents a summary of vehicle miles of travel (VMT) on the impacted roadway system for each of the alternative alignments as reported in the DEIS, including the No-Build alternative. The DEIS four-lane alignments are labeled "Phase 2" and additional columns are labeled Phase 1 representing the two-lane alignments. VMTs are based on ADTs projected for each alternative route segment.

The VMT for all of the Bypass alternatives are higher than the No-Build alternative VMT total because the Bypass would provide shorter travel times despite the longer travel distance. The most pertinent data in Table 3 is the difference between Phase 1 and Full Buildout VMTs for each alternative alignment. It can be seen that Phase 1 improvements would produce between 115 (Mary Street Option 1) and 136 (Five Mile Road) fewer vehicle miles of travel than Full Buildout or substantially less than 1% of the total VMT for the average day in 2035. Mary Street Option (DEIS preferred alternative) would have 124 fewer VMT for Phase 1 than Full Buildout.

It is important to note that the Mary Street Option 1 Alignment would have the highest ADT along the Bypass at the Yellowstone River and MRL railroad crossing, but the total VMT for that alternative would be less than the Five Mile Road Alignment. The smallest increase in VMT would be for the Phase 1 and Full Buildout Mary Street Option 2 Alignments with approximately 3,359 and 3,483 more VMTs than the No-Build alternative, respectively.



Table 3. Vehicle Miles Travel Comparison Between Phase 1 & Phase 2 (Full Buildout) Alternative Alignments

	Li	ink	Existing	Length		Alt	ernative	s' Vehic	le Miles	Travel	
_ ,	_	_				Mary 1	Mary 1	Mary 2	Mary 2	5 Mile Rd	5 Mile Rd
Route	From	To Post I	ADT		No-Build		Phase 2		Phase 2		Phase 2
Highway 312	US 87	Dover Road	10900	1.32	21912	17886	17886	17886	17886	17820	17820
Tilgilway 312	Dover Road	Five Mile Road	8700	1.47	17346	16097	16097	15509	15509	16023	16023
110.07.1111	Five Mile Road	S-522 Huntley	6500	6.16	56056	64039	64680	65881	66528	65881	66528
US 87 North	Highway 312	Independence Lane	5900	0.96	12480	12480	12480	12480	12480	12480	12480
	1st Avenue N	4th/6th Avenues North	36100	0.32	17280	13310	13232	13470	13392	14222	14192
Main Street	4th/6th Avenues North	Airport Road	49200	0.40	24960	20916	20860	21016	20960	21998	21960
wam Street	Airport Road	Hilltop Road	42200	0.64	38400	31930	31840	32090	32000	33638	33600
	Hilltop Road	Wicks Lane	35200	1.02	50184	40434	40290	40638	40494	43156	43095
	Wicks Lane	US 87/312	19350	1.00	31300	28206	28350	28509	28650	27710	27750
	US 87	Wicks Lane	2900	1.03	5871	5511	5511	5047	5047	5356	5356
Bench Boulevard	Wicks Lane	Hilltop Road	4300	1.01	8585	7006	6969	7107	7070	7090	7070
	Hilltop Road	Main Street	na	1.36	19380	16255	16116	16527	16388	16470	16388
Bitterroot Drive	Dover Road	Mary Street	900	0.96	2400	2544	2544	2544	2544	2544	2544
	Mary Street	Wicks Lane	1800	1.00	3200	4133	4250	3983	4100	3995	4100
Mary Street	Bench Boulevard	Bitterroot Drive	1450	1.00	4000	3100	3100	3100	3100	9700	9700
•	Bitterroot Drive	5 Mile Road	500	1.15	1150	1150	1150	1150	1150	10120	10120
5 Mile Road	Mary Street	Dover Road	100	0.65	325	3085	3153	3279	3348	5652	5720
Dover Road	HWY 312	Bitterroot Drive	1600	0.08	304	312	312	312	312	312	312
	Bitterroot Drive	5 Mile Road	1000	1.00	2400	2300	2300	2300	2300	2300	2300
	Lake Elmo Road	Main Street	15500	0.24	4824	4860	4860	4860	4860	4860	4860
Wicks Lane	Main Street	Bench Boulevard	15300	0.24	5256	5184	5184	5172	5172	5172	5172
	Bench Boulevard	Bitteroot Drive	4100	1.00	6400	6087	6050	6087	6050	6070	6050
Hilltop Road	Lake Elmo Road	Main Street	8900	0.24	2400	2400	2400	2400	2400	2400	2400
Timtop Rodu	Main Street	Bench Boulevard	6400	0.24	1824	1824	1824	1824	1824	1824	1824
Johnson Lane	Old Hardin Road	Johnson Interchange	12500	0.17	3196	3196	3196	3196	3196	3196	3196
Johnson Lane	Johnson Interchange	Coulson Road	1400	0.29	609	5114	5220	5027	5133	4320	4379
US 87	Lockwood Interchange	Old Hardin Road	10900	0.58	9512	9512	9512	9512	9512	9512	9512
00 01	1st Avenue N/Main	Lockwood Interchange	28000	1.25	52500	36991	36688	37616	37313	40556	40438
I-94	Huntley Interchange	Pinehill Interchange	7100	6.21	65826	57778	57132	55915	55269	55921	55269
	S. 27th St. Interchange	Lockwood Interchange	24900	2.76	103224	98535	98118	98949	98532	98863	98808
1-90	Lockwood Interchange	Johnson Ln Interchange	21800	1.27	41529	35180	34989	35688	35497	34550	34417
	Johnson Ln Interchange	Pinehill Interchange	14100	2.45	51940	48765	48510	48030	47775	48032	47775
	Highway 312	Bitterroot Drive	0	0.97	0	8978	9118	0	0	0	0
Mary Street Option 1	Bitterroot Drive	Five Mile Road	0	0.65	0	7338	7508	0	0	0	0
	Five Mile Road	Johnson Lane	0	3.08	0	47848	48972	0	0	0	0
	Highway 312	Bitterroot Drive	0	0.97	0	0	0	8593	8730	0	0
Mary Street Option 2	Bitterroot Drive	Five Mile Road	0	1.18	0	0	0	12558	12862	0	0
	Five Mile Road	Johnson Lane	0	2.75	0	0	0	41902	42900	0	0
	Highway 312	Dover Road	0	0.93	0	0	0	0	0	3994	4092
Five Mile Road Align.	Dover Road	Five Mile/Mary	100		225	0	0	0	0	2293	2340
	Five Mile/Mary	Johnson Lane	0		0	0	0	0	0	36082	36660
	ADT = Average Daily Traffic	<u> </u>	Totals =		666798	670283	670398	670157	670281	674113	674250
		Differences b	etween	Phase 1	& 2 =	-1	15	-1	24	-1	36
		Differences	between	n No-Bui	ld =	3485	3600	3359	3483	7315	7452

MDT★

Year 2035 Alternative Alignments Vehicle Hours of Travel

It has been determined that the average travel time savings for all traffic that would use the alternative alignments ranges between 4 and 6 minutes. If an average travel time savings of 5 minutes was applied to year 2035 traffic projections for the alternative alignments, the approximate annual travel time savings for Phase 1 and Full Buildout alignments would be:

Mary Street Option 1 Phase 1 Alignment
Mary Street Option 1 Full Buildout Alignment
Mary Street Option 2 Phase 1 Alignment
Mary Street Option 2 Phase 1 Alignment
Mary Street Option 2 Full Buildout Alignment
Five Mile Road Phase 1 Alignment
Five Mile Road Full Buildout Alignment

473,000 VHT Savings
480,000 VHT Savings
475,000 VHT Savings
389,300 VHT Savings
395,000 VHT Savings

The differences between Phase 1 and Full Buildout alignment VHTs range between 5,700 hours for the Five Mile Road Alternative and 11,100 hours for the Mary Street Option 2 Alternative on an annual basis. The Phase 1 calculations assume that the same average travel time of 5 minutes would apply and the reductions in ADT for each of the Phase 1 alternatives account for the small differences in travel time along the Bypass. The differences in Phase 1 VHT savings range between 1.4% and 2.3% of the Full Buildout VHTs.

Year 2035 Alternative Alignment Capacity & LOS

Capacity calculations along existing roads and streets that have the most probable impacts were completed for the Full Buildout alternative alignments based upon year 2035 traffic at critical intersections in the DEIS. Similar capacity calculations were completed for Phase 1 of the DEIS preliminary alignments using traffic volumes illustrated in Figures 2, 4, and 6 of this report. The capacity analysis calculations for each intersection can be found in Appendix B of this report. Capacity calculations at intersections along the two-lane Bypass alignment are discussed in a later section.

Table 4 presents a summary of LOS and delay (sec/vehicle) for each of the seven existing street system intersections associated with the Phase 1 alternative alignments. In comparing these intersections to the same intersections in Tables 8, 9, and 10 of the DEIS Traffic Report for the four lane facility, it can be seen that Phase 1 capacity calculations are almost identical to the Full Buildout facility. Only minor changes in delay would be evident at most of the intersections since the differences in traffic volumes between Phase 1 and Full Buildout are very minor in comparison to total traffic demand. Since there would be no differences in traffic volumes at the intersections along Dover Road for any of the alternatives, the Full Buildout capacity calculations would also apply to Phase 1 operations. As noted in the DEIS Traffic Study report, the existing street system would benefit from traffic diversion to the new Bypass alignments.



Table 4. Existing Street System Capacity for Phase 1 Alignments

Mary Street Option 1			Inter	section	Approa	ach				
Alignment	NE	3	S	В	E	В	WB			
		Delay		Delay		Delay		Delay		
Intersection	LOS	(s/v)	LOS	(s/v)	LOS	(s/v)	LOS	(s/v)		
Highway 312 & Dover*	F	194					В	13		
Dover & Bitterroot*	В	12					Α	8		
Main & Wicks Lane	F	105	D	45	D	45	F	103		
Main & Airport Road	F	82	O	34	F	99	F	178		
Main/1st Ave N/US 87			С	26	С	29	D	48		
Lockwood US87/WB I-90 Ramps			С	30	С	30	В	16		
Lockwood US87/EB I-90 Ramps	D	54			D	45	Е	64		

^{*} Minimal Difference from No-Build Alt.

Mary Street Option 2			Inter	section	Approa	ach				
Alignment	NE	3	S	В	E	В	WB			
		Delay		Delay		Delay		Delay		
Intersection	LOS	(s/v)	LOS	(s/v)	LOS	(s/v)	LOS	(s/v)		
Highway 312 & Dover*	F	194					В	13		
Dover & Bitterroot*	В	12					Α	8		
Main & Wicks Lane	F	103	D	45	D	45	F	103		
Main & Airport Road	F	85	O	35	F	99	F	178		
Main/1st Ave N/US 87			С	28	С	29	D	49		
Lockwood US87/WB I-90 Ramps			С	31	С	31	В	17		
Lockwood US87/EB I-90 Ramps	D	50			D	51	Е	68		

^{*} Minimal Difference from No-Build Alt.

			Inter	section	Approa	ach				
Five Mile Road Alignment	NE	3	S	В	E	В	WB			
		Delay		Delay		Delay		Delay		
Intersection	LOS	(s/v)	LOS	(s/v)	LOS	(s/v)	LOS	(s/v)		
Highway 312 & Dover*	F	194					В	13		
Dover & Bitterroot*	В	12					Α	8		
Main & Wicks Lane	F	96	D	42	Е	57	F	104		
Main & Airport Road	F	111	С	33	F	99	F	178		
Main/1st Ave N/US 87			D	36	D	37	Е	58		
Lockwood US87/WB I-90 Ramps			С	33	С	35	В	17		
Lockwood US87/EB I-90 Ramps	F	80			D	43	Е	64		

^{*} Minimal Difference from No-Build Alt.





Crash Projections

Table 5 represents a projection of future crash statistics that would be associated with the No-Build alternative and Phase 1 and Full Buildout of the preliminary alternative alignments if current crash and severity rates were applicable in the design year 2035. Crash and severity rates on the new alignments were estimated based upon historic crash data on similar facilities that were constructed using current design standards, including Old Hwy 312 from US 87 to Five Mile Road and Airport Road. The crash rates on the Phase 1 alignments were increased by an approximate factor of 1.5 times the Full Buildout rates due to differences in operational characteristics. A number of research reports indicate that crash rates for two lane roadways range between 20% and 70% higher than four lane facilities generally due to passing maneuvers. Though there were a number of conflicting results between studies, it was felt that a 50% increase by the year 2035 would provide a conservative estimate of conditions on a facility that would be at the end of its useful design life.

In comparing Phase 1 and Full Buildout total system crashes in the year 2035, the preliminary preferred Mary Option 2 alignment Phase 1 alternative is projected to have 514 total crashes while the Full Buildout alternative is projected to have 502, or approximately 2% more crashes with the two lane roadway. In comparison to the No-Build alternative, which would have 551 crashes, the Phase 1 two-lane roadway would still provide a net benefit of 37 fewer crashes and 13 fewer injury crashes in the year 2035. The number of fatalities would remain below two under Phase 1 of the Mary Option 2 alternative in 2035. Similar results comparing the Phase 1 and Full Buildout calculations can be noted for the Mary Street Option 1 and Five Mile Road alternative alignments.



Table 5. Annual Crash Projections on Existing Streets & Roads with Bypass for Phase 1 & Full Buildout - Year 2035

									Mary Alignment Op			ent Option 1		Mary Alignment Option 2						Five Mile Road Alignment																		
EXIST	ING STREET LINK SE	GMENTS	1			ld Projec						e Roadw	-			ut 4 Lan		_		ase 1 - T					Buildou			•			Two Lan		-				e Roadwa	ay
ROUTE NAME	from	to	Length (miles)					No. Fatals			Injury Crash	No. Inury	No. Fatals	2035 ADT		Injury Crash		No. Fatals		No. Crash			No. Fatals	2035 ADT	No. Crash	Injury Crash	No. Inury	No. Fatals	2035 ADT		Injury Crash		No. Fatals	2035 ADT		Injury Crash	No. Inury F	No. Fatals
Interstate 94	Pinehill Interchange	Huntley Interchange	6.21	10600	23.6	5.4	6.9	0.0	9300	20.7	4.7	6.0	0.0	9200	20.5	4.7	6.0	0.0	9000	20.0	4.6	5.8	0.0	8900	19.8	4.5	5.8	0.0	9000	20.0	4.6	5.8	0.0	8900	19.8	4.5	5.8	0.0
Interstate 90	Johnson Lane	Lockwood	1.27	32700	22.2	6.0	9.6	0.0	27700	18.8	5.1	8.1	0.0	27550	18.7	5.1	8.1	0.0	28100	19.1	5.2	8.2	0.0	27950	19.0	5.1	8.2	0.0	27100	18.4	5.0	8.0	0.0	27100	18.4	5.0	8.0	0.0
Interstate 90	Pinehill Interchange	Johnson Lane	2.45	21200	2.1	0.3	0.3	0.0	19900	2.0	0.3	0.3	0.0	19800	2.0	0.3	0.3	0.0	19600	1.9	0.3	0.3	0.0	19500	1.9	0.3	0.3	0.0	19600	1.9	0.3	0.3	0.0	19500	1.9	0.3	0.3	0.0
Johnson Lane	I-90 Interchange	Coulson Road	0.29	6900	6.0	0.9	1.5	0.0	17650	15.3	2.3	3.8	0.0	18000	15.7	2.3	3.9	0.0	17350	15.1	2.3	3.8	0.0	17700	15.4	2.3	3.8	0.0	14900	13.0	1.9	3.2	0.0	15100	13.1	2.0	3.3	0.0
Johnson Lane	Old Hardin Road	I-90 Interchange	0.17	18000	3.0	0.6	1.5	0.0	18800	3.1	0.6	1.6	0.0	18800	3.1	0.6	1.6	0.0	18800	3.1	0.6	1.6	0.0	18800	3.1	0.6	1.6	0.0	18800	3.1	0.6	1.6	0.0	18800	3.1	0.6	1.6	0.0
(Old US 87)	Lockwood Interchang	Jct Old Hardin Road	0.58	16400	5.1	2.4	4.5	0.0	16400	5.1	2.4	4.5	0.0	16400	5.1	2.4	4.5	0.0	16400	5.1	2.4	4.5	0.0	16400	5.1	2.4	4.5	0.0	16400	5.1	2.4	4.5	0.0	16400	5.1	2.4	4.5	0.0
Highway 87	I-90 Lockwood Inter	1st Avenue N	1.25	42000	53.8	15.3	22.3	0.0	29600	37.9	10.8	15.7	0.0	29350	37.6	10.7	15.6	0.0	30100	38.5	10.9	16.0	0.0	29850	38.2	10.9	15.8	0.0	32450	41.5	11.8	17.2	0.0	32350	41.4	11.8	17.2	0.0
Main Street	1st Avenue N	6th Avenue N	0.35	54000	40.1	12.4	17.9	0.0	41600	30.9	9.5	13.8	0.0	41350	30.7	9.5	13.7	0.0	42100	31.3	9.6	13.9	0.0	41850	31.1	9.6	13.8	0.0	44450	33.0	10.2	14.7	0.0	44350	33.0	10.2	14.7	0.0
Main Street	6th Avenue N	Airport Road	0.37	62400	27.5	8.7	14.4	0.0	52300	23.1	7.3	12.1	0.0	52150	23.0	7.3	12.0	0.0	52500	23.2	7.4	12.1	0.0	52400	23.1	7.3	12.1	0.0	54950	24.2	7.7	12.7	0.0	54900	24.2	7.7	12.7	0.0
Main Street	Airport Road	Hilltop Road	0.64	62400	83.0	28.5	46.1	0.0	49900	66.3	22.8	36.8	0.0	49750	66.1	22.7	36.7	0.0	50100	66.6	22.9	37.0	0.0	50000	66.5	22.8	36.9	0.0	52550	69.9	24.0	38.8	0.0	52500	69.8	24.0	38.8	0.0
Main Street	Hilltop Road	Wicks Lane	1.02	49100	81.4	30.9	47.7	0.6	39650	65.7	24.9	38.5	0.5	39500	65.5	24.8	38.4	0.5	39800	66.0	25.0	38.7	0.5	39700	65.8	25.0	38.6	0.5	42300	70.1	26.6	41.1	0.5	42250	70.0	26.6	41.0	0.5
Main Street	Wicks Lane	HWY 312/Bench	1.00	30700	46.4	9.9	0.0	0.0	28200	42.7	9.1	0.0	0.0	28350	42.9	9.1	0.0	0.0	28500	43.1	9.2	0.0	0.0	28650	43.3	9.2	0.0	0.0	27700	41.9	8.9	0.0	0.0	27750	42.0	8.9	0.0	0.0
Highway 87	HWY 312/Bench	Independence Road	0.96	13000	15.7	3.6	5.8	0.0	13000	15.7	3.6	5.8	0.0	13000	15.7	3.6	5.8	0.0	13000	15.7	3.6	5.8	0.0	13000	15.7	3.6	5.8	0.0	13000	15.7	3.6	5.8	0.0	13000	15.7	3.6	5.8	0.0
Wicks Lane	Lake Elmo	Main Street	0.24	21000	5.3	1.1	1.1	0.0	20250	5.1	1.1	1.1	0.0	20250	5.1	1.1	1.1	0.0	20250	5.1	1.1	1.1	0.0	20250	5.1	1.1	1.1	0.0	20250	5.1	1.1	1.1	0.0	20250	5.1	1.1	1.1	0.0
Wicks Lane	Main Street	Bench Boulevard	0.24	21900	13.1	4.7	5.5	0.0	21600	13.0	4.6	5.5	0.0	21600	13.0	4.6	5.5	0.0	21550	12.9	4.6	5.5	0.0	21550	12.9	4.6	5.5	0.0	21550	12.9	4.6	5.5	0.0	21550	12.9	4.6	5.5	0.0
Wicks Lane	Bench Boulevard	Bitterroot Drive	1.00	6400	15.1	2.7	4.1	0.0	6100	14.4	2.6	3.9	0.0	6050	14.3	2.6	3.9	0.0	6000	14.1	2.6	3.9	0.0	6050	14.3	2.6	3.9	0.0	6050	14.3	2.6	3.9	0.0	6050	14.3	2.6	3.9	0.0
Mary Street	Bench Boulevard	Five Mile Road	1.67	4500	5.4	0.0	0.0	0.0	2050	2.5	0.0	0.0	0.0	2050	2.5	0.0	0.0	0.0	2050	2.5	0.0	0.0	0.0	2050	2.5	0.0	0.0	0.0	9200	11.0	0.0	0.0	0.0	9250	11.1	0.0	0.0	0.0
Highway 312	US 87 (N16)	Dover Road	1.32	16600	6.2	0.9	0.9	0.3	13550	5.1	0.8	0.8	0.3	13550	5.1	0.8	0.8	0.3	13550	5.1	0.8	0.8	0.3	13550	5.1	0.8	0.8	0.3	13500	5.0	0.8	0.8	0.3	13500	5.0	0.8	0.8	0.3
Highway 312	Dover Road	Pioneer Road	2.20	13600	19.5	8.0	11.9	0.4	10950	15.7	6.5	9.6	0.3	10950	15.7	6.5	9.6	0.3	10450	15.0	6.2	9.1	0.3	10550	15.2	6.2	9.2	0.3	10900	15.7	6.4	9.5	0.3	10900	15.7	6.4	9.5	0.3
Highway 312	Pioneer Road	S-522 Huntley	5.43	9000	28.8	11.4	18.9	0.3	10400	33.3	13.2	21.8	0.3	10500	33.6	13.3	22.1	0.4	10700	34.2	13.6	22.5	0.4	10800	34.6	13.7	22.7	0.4	10700	34.2	13.6	22.5	0.4	10800	34.6	13.7	22.7	0.4
Bench Bld	Wicks Lane U-1012	US 87 (N16)	1.03	5800	24.0	8.4	10.8	0.0	5350	22.1	7.7	10.0	0.0	5350	22.1	7.7	10.0	0.0	4900	20.3	7.1	9.1	0.0	4900	20.3	7.1	9.1	0.0	5200	21.5	7.5	9.7	0.0	5200	21.5	7.5	9.7	0.0
Dover Road	HWY 312 CO56788	Pioneer Road	1.56	2300	2.3	0.4	0.4	0.0	3100	3.1	0.5	0.5	0.0	3100	3.1	0.5	0.5	0.0	3100	3.1	0.5	0.5	0.0	3100	3.1	0.5	0.5	0.0	3100	3.1	0.5	0.5	0.0	3100	3.1	0.5	0.5	0.0
Bitterroot Drive	Wicks (U-1012)	Mary Street	1.00	4000	10.5	1.8	3.1	0.0	4150	10.9	1.9	3.2	0.0	4250	11.1	2.0	3.3	0.0	4000	10.5	1.8	3.1	0.0	4100	10.7	1.9	3.2	0.0	4100	10.7	1.9	3.2	0.0	4100	10.7	1.9	3.2	0.0
Bitterroot Drive	Mary Street	Dover Road	0.96	2500	0.0	0.0	0.0	0.0	2650	0.0	0.0	0.0	0.0	2650	0.0	0.0	0.0	0.0	2650	0.0	0.0	0.0	0.0	2650	0.0	0.0	0.0	0.0	2650	0.0	0.0	0.0	0.0	2650	0.0	0.0	0.0	0.0
5 Mile Road	Mary Street	Dover Road	0.65	500	0.7	0.7	0.7	0.0	4750	6.3	6.3	6.3	0.0	4850	3.2	3.2	3.2	0.0	5050	6.7	6.7	6.7	0.0	5150	3.4	3.4	3.4	0.0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0
Pioneer Road	Dover Road	HWY 312 CO56788	1.50	400	2.0	1.2	1.2	0.0	400	2.0	1.2	1.2	0.0	400	2.0	1.2	1.2	0.0	400	2.0	1.2	1.2	0.0	400	2.0	1.2	1.2	0.0	400	2.0	1.2	1.2	0.0	400	2.0	1.2	1.2	0.0
Huntley Main St	I-94 Huntley Inter	CO56788 (HWY 312)	2.37	5500	8.6	4.2	4.8	0.0	4700	7.4	3.6	4.1	0.0	4800	7.5	3.6	4.2	0.0	4300	6.7	3.3	3.7	0.0	4200	6.6	3.2	3.6	0.0	4300	6.7	3.3	3.7	0.0	4200	6.6	3.2	3.6	0.0
	Highway 312	Bitterroot Drive	0.97						9250	3.8	0.6	0.8	0.1	9400	2.6	0.4	0.5	0.1																				
Mary St Opt 1	Bitterroot Drive	Five Mile Road	0.65						11300	3.1	0.5	0.6	0.1	11550	2.1	0.3	0.4	0.0																				
	Five Mile Road	Johnson Lane	3.08						15550	20.3	3.1	4.1	0.4	15900	13.9	2.1	2.8	0.3																				
	Highway 312	Bitterroot Drive	0.97																8850	3.6	0.5	0.7	0.1	9000	2.5	0.4	0.5	0.0										
Mary St Opt 2	Bitterroot Drive	Five Mile Road	1.18																10650	5.3	0.8	1.1	0.1	10900	3.6	0.5	0.7	0.1										
	Five Mile Road	Johnson Lane	2.75																15250	17.8	2.7	3.6	0.4	15600	12.1	1.8	2.4	0.2										
	Highway 312	Dover Road	0.93																										4300	1.7	0.3	0.3	0.0	4400	1.2	0.2	0.2	0.0
5 Mile Rd Align	Dover Road	Five Mile/Mary	0.45																										5100	1.0	0.1	0.2	0.0	5200	0.7	0.1	0.1	0.0
	Five Mile/Mary	Johnson Lane	2.82																										12800	15.3	2.3	3.1	0.3	13000	10.4	1.6	2.1	0.2
	Totals =		51.53		551.3	170.3	241.8	1.6			157.4	220.4	1.9			152.9	215.4	1.7			157.3	220.2	1.9	16983		152.6	215.0	1.7			153.6	218.7	1.8			152.7	217.5	1.6
				Avg				L	Avg					Avg	J				Avg	j				Avg					Avg	1				Avg				

ALTERNATIVE PHASE 1 ALIGNMENT INTERSECTIONS

This section of the report deals with Phase 1 intersections located along each of the three alternative two lane roadway alignments. The intersection design concepts presented herein were developed specifically for the two lane roadway sections and represent the minimum geometric and traffic control devices necessary to provide acceptable operations based on year 2035 design hour traffic projections. In all cases the intersections would operate at level of service (LOS) "C" or better under the two lane alignment alternatives. In some cases, the LOS on individual movements would operate just below LOS "C" even though the approach leg would operate at LOS "C". This ideally would represent conditions that would typically occur at the end of the project's design life. It should also be understood that the intersections evaluated herein do not necessarily represent the final design configurations. Rather, the concepts serve to illustrate that acceptable intersection designs can be implemented within the project's defined right of way limits. All capacity calculations for the intersections presented in this section of the report can be found in Appendix C.

Johnson Lane Interchange

The existing Johnson Lane Interchange is a conventional diamond type interchange that was constructed to serve residential and commercial areas in the community of Lockwood. There are a number of geometric and land use conditions that limit substantial traffic growth. The DEIS Traffic Study details a number of interchange concept alternatives that would serve traffic demands beyond the year 2035. Phase 1 improvement concepts were based on a desire to use the existing overpass structures in-place. Columns beneath the I-90 structures are separated by a distance of approximately 40 feet which limits the Johnson Lane roadway section to three lanes. A number of configurations were conceived and tested prior to development of the concept illustrated in Figure 7.

The Phase 1 concept involves multiple approach lanes and traffic signal control at the interchange ramps and at the adjacent intersections. Use of roundabouts at the intersections was considered, but was found to not be feasible due the proximity of the intersections on the north side of the overpass structures. Johnson Lane, beneath the overpass, would have two northbound lanes and one southbound lane, which fits the unbalanced directional traffic flows during all hours of the day. Improvements at intersections along Old Hardin Road match those considered for Full Buildout because it was assumed that those improvements would be required prior to the year 2035 and would be completed either by the Phase 1 project or by local funding in subsequent years. Capacity calculations for the ramp and North Frontage Road intersections associated with this design option can be found in Appendix C of this report. All intersections would operate at LOS "C" and all movements would operate at LOS "C" or better. Note that the Phase 1 design option has the same turning movements at the Old Hardin Road and Becraft intersections as those in Full Buildout. Thus, capacity calculations contained in the DEIS Traffic Study also apply to Phase 1 at those intersections.





Johnson Lane/Coulson Road Intersections

Figure 8 Illustrates the proposed geometry associated with the intersections of Coulson Road and Johnson Lane with the Phase 1 alternatives' alignment. The Johnson Lane intersection with the new alignment would be a "T"-intersection on the outside of a curve. The Coulson Road intersection would have four approach legs. Both intersections would have stop control for approaches accessing the Bypass alignment. The Phase 1 concept is essentially the same as what was set forth in the DEIS Traffic Report except that the alignment would have three lanes at the intersections instead of five lanes.

Capacity calculations (Appendix C) indicate that all approaches at the Johnson Lane intersection would operate at LOS "B" or better in the year 2035, while the minor approach at the Coulson Road intersection would operate at LOS "C".

Mary Street Alignment Intersections

There are four intersections on the Mary Street Alignments that are detailed within this section of the report. Mary Street Options 1 & 2 Alignments intersect with Five Mile Road at two different locations, but both Mary Street Alignments intersect Bitterroot Drive and Hawthorne Lane at the same locations, and thus, both alignments are covered by the same concept designs.

Mary Option 1 & Five Mile Road

Figure 9 illustrates the proposed design geometry and operational controls for the intersection of Mary Street Option 1 Phase 1 Alignment and the existing Mary Street/Five Mile Road corridor. The same basic roundabout location and access controls are used for the Phase 1 concept except that there are only single lane approaches on the Bypass alignment and the roundabout only has single circulation lanes.

Capacity calculations (Appendix C) indicate that all approaches to this intersection would operate at a LOS "B" or better in the year 2035.

Mary Option 2 & Five Mile Road

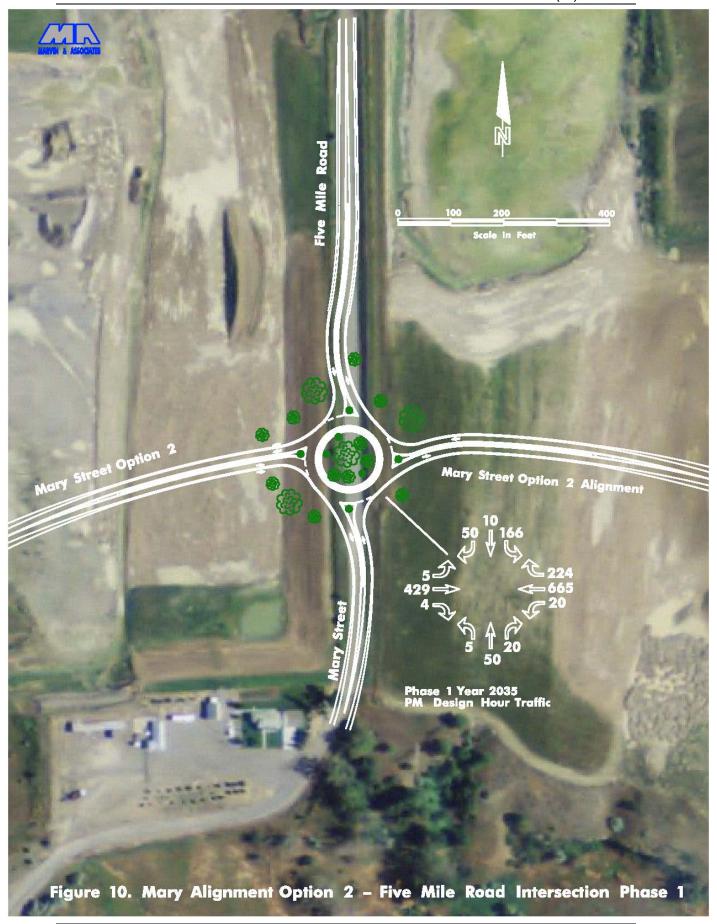
Figure 10 is similar to Mary Option 1 and Five Mile Road in that the Phase 1 roundabout would be at the same location and all approaches would have a single lane and there would be a single circulation lane. The Mary Street Option 2 Phase 1 Alignment intersection with Five Mile Road would provide the same safety benefits associated with the dual lane approaches detailed for the Full Buildout concept.

Capacity calculations (Appendix C) indicate that all approaches to this intersection would operate at a LOS "B" or better in the year 2035.









Mary Street Alignment & Bitterroot Drive

There were a number of alternative concepts presented for the Phase 2 Mary Street alignments that could be considered during design of the project. For purposes of the Phase 1 (two lane) alignment the roundabout option was evaluated to determine if the two lane alignment would operate efficiently. Figure 11 illustrates this Phase 1 concept intersection that was evaluated using single approach lanes and single circulation lanes within the roundabout. A two-way stop controlled intersection on Mary Street and Bitterroot Drive was used adjacent to the alignment intersection.

Capacity calculations (Appendix C) indicate that all approaches for the alignment intersection would operate at LOS "B" or better in the design year 2035. The two-way stop intersection of Mary Street and Bitterroot Drive would operate at LOS "C" for the eastbound approach and LOS "B" for the westbound approach.

Mary Options 1 & 2 & Hawthorne Lane

Figure 12 shows the Phase 1 concept that is the same as the Phase 2 concept discussed in the DEIS Traffic Study except that the Mary Street alignments would have three lanes instead of five. Capacity calculations (Appendix C) indicate that stop control on the northbound approach to the Mary Street alignment would operate at LOS "B". The intersection of Hawthorne Lane and existing Mary Street would have the same configuration and traffic volumes that were evaluated in the Phase 2 DEIS Traffic Study and both approaches would operate at LOS "B" or better in the year 2035.

Five Mile Road Alignment & Old Hwy 312

There were a number of design options and intersection locations investigated in the DEIS Traffic Study for the Five Mile Road alignment and Old Highway 312. For the purposes of the Phase 1 two lane alignment investigation it was assumed that a signalized intersection would be the most likely intersection control that would be implemented. Figure 13 shows the concept for Phase 1 construction. It incorporates a two lane section of the Five Mile Road Alignment with an auxiliary right-turn lane at its intersection with Hwy 312. It was also assumed that Hwy 312 at its intersection with Five Mile Road would be reconstructed to extend east beyond this intersection.

Capacity calculations (see Appendix C) for the Phase 1 concepts were completed for a stop controlled intersection that would likely exist prior to the year 2035. In that scenario the northbound left-turn lane would operate at LOS "E" and the southbound approach would operate at LOS "D". Thus, a traffic signal would likely be warranted prior to the year 2035.









Five Mile Road and Dover Road

Operations at the intersection of Five Mile Road and Dover Road for the Five Mile Road Alignment were investigated in the DEIS Traffic Study and capacity calculations indicated that stop control on the Dover Road approaches would result in LOS "C" in all cases. Even with one less travel lane in both directions on the Five Mile Road alignment, all of the approaches would still operate at LOS "C" or better in the year 2035 with stop control (see Appendix C).

Five Mile Road & Mary Street

Figure 14 shows the proposed design geometry and operational controls for the intersection of Five Mile Road Alignment and existing Mary Street. This intersection is basically the same as the Full Buildout roundabout except that instead of having two thru-lanes at each approach with two circulation lanes in the roundabout, there would only be one lane in each direction at each approach and a single circulation lane in the roundabout.

Capacity calculations (Appendix C) indicate that all approaches to this intersection would operate at a LOS "B" or better in the year 2035.

Mary Street Alignments & US 87/ Old Hwy 312 Intersection

The Phase 1 concept drawing for the intersection of US 87/Old Hwy 312 is contained in Figure 15. This concept is substantially different than the Full Buildout concepts discussed in the DEIS Traffic Study since it incorporates two adjacent signalized intersections. MDT is currently in the process of finalizing plans for reconstruction and signalization of the Main Street and Bench Boulevard intersection and the anticipated implementation date is within the next two years. One feature of that project involves construction of a raised median in Bench Boulevard which will change traffic operations at the intersection of Mary Street and Bench Boulevard so that access to Mary Street from Bench Boulevard will only accommodate right-in and right-out movements. That feature of the MDT project was approved by the City of Billings. Since it is anticipated that the Phase 1 alignment would be constructed a few years after the Main Street and Bench intersection is complete, it was decided that the Mary Street Alignment intersection with Hwy 312 could be designed to incorporate the majority of improvements that are associated with the Main Street and Bench Boulevard Thus, with that being the basis of the Phase 1 concept, it was determined that northbound and southbound traffic could be split so that southbound traffic on US 87 would enter Bench Boulevard, directly at the Main Street intersection, and would access the Mary Street Alignment, directly at the Hwy 312 intersection. Northbound US 87 traffic would originate from the Mary Street Alignment as a through movement at the Hwy 312 intersection and as a left-turn movement from Main Street. Travel distance for northbound US 87 traffic originating at Bench Boulevard would be approximately the same as with the Full Buildout roundabout concepts.







There is a possibility that the two signals could be controlled by the same controller or two controllers could be coordinated to provide desired operations. Capacity calculations (Appendix C) indicate that the Mary Street Alignment intersection would operate at LOS "C" and the US 87/Bench Boulevard intersection would operate at LOS "B" for year 2035 traffic volumes. However there would be a number of movements at the Mary Alignment and Hwy 312 intersection that would operate at LOS "D". This would indicate that this design concept has a limited design life and that the entire intersection would need to be reconfigured when Full Buildout improvements are constructed.

SUMMARY & CONCLUSIONS

Traffic projections for Phase 1 construction of alternative alignments with only two through traffic lanes instead of four are not significantly different for any of the alternative alignments. Analysis of existing street system impacts based upon Phase 1 traffic projections for the preliminary alignment alternatives were completed and it was determined that there would be no significant difference in operations between Phase 1 and Full Buildout for any of the three alternatives. In addition, the differences in VMT and VHT between Phase 1 and Full Buildout conditions would be minimal. Analysis of crash impacts provided the greatest differences simply due to a theoretical variance between two lane and four lane operations on the alternative alignments. Even so, the difference in the number of crashes on the impacted street system would only be approximately 2% for each alternative alignment. The Phase 1 Alignments would still provide safety benefits by reducing traffic on existing streets and diverting traffic to a newer, safer facility.

This study evaluated concept intersections that could be considered in design along each of the alternative alignments. These intersections are all on the primary alignments, since it was assumed that secondary improvements associated with Phase 1 would be identical to those presented in the DEIS Traffic Study. It was determined that acceptable Phase 1 intersection designs would be possible for all of the alternative alignments within the right-of-way limits established in the DEIS. The intersection concepts presented herein were developed as minimal improvements that could easily be expanded at such time when Full Buildout construction is considered necessary, but the concepts do not necessarily commit Phase 1 designers to replicate their features in final design considerations.



APPENDIX A

Phase 1

Two Lane Corridor Capacity

DIRECTION	AL TWO-LANE HIGHWA	AY SEGMENT WORK	(SHEET
General Information		Site Information	
Agency or Company Date Performed	R Marvin Marvin Associates 4/24/2013 Average Daytime Hour	Highway / Direction of Travel From/To Jurisdiction Analysis Year	Mary Option 1 Johnson Lane to Mary Street MDT 2035
Project Description: Billings Bypass	Average Daytime Hour	Allalysis i cai	2000
Input Data			
	-a		
- *	Shoulder width ft Lane width tt		_
*	Lane width It		highway Class II
*	Shoulder widthtt	highway 🗹	Class III highway
-		Terrain	Level Rolling
Segment length,	L _t mi	Grade Lengt Peak-hour fa No-passing z	ictor, PHF 0.95
Analysis direction vol., V _d 475ve	h/h	Show North Arrow % Trucks an	d Buses , P _T 4 %
Opposing direction vol., V ₀ 475ve	h/h	% Recreation	nal vehicles, P _R 2%
Shoulder width ft 10.0		Access point	s <i>mi</i> 1/mi
Lane Width ft 12.0 Segment Length mi 3.2			
Average Travel Speed		•	
		Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T	(Exhibit 15-11 or 15-12)	1.8	1.8
Passenger-car equivalents for RVs, E_R (E	Exhibit 15-11 or 15-13)	1.1	1.1
Heavy-vehicle adjustment factor, f _{HV,ATS}	=1/ (1+ $P_T(E_T-1)+P_R(E_R-1)$)	0.967	0.967
Grade adjustment factor ¹ , f _{g,ATS} (Exhibit		0.95	0.95
Demand flow rate 2 , $v_i^{}$ (pc/h) $v_i^{}{=}V_i^{}$ / (PHF*	$f_{g,ATS} * f_{HV,ATS}$)	544	544
Free-Flow Speed fron	n Field Measurement	Estimated Fr	ee-Flow Speed
		Base free-flow speed ⁴ , BFFS	mi/h
Mean speed of sample ³ , S _{FM}	60	Adj. for lane and shoulder width,	⁴ f _{LS} (Exhibit 15-7) <i>mi/h</i>
Total demand flow rate, both directions, <i>v</i>		Adj. for access points ⁴ , f _A (Exhib	oit 15-8) mi/h
Free-flow speed, FFS=S _{FM} +0.00776(v/ f _F		Free-flow speed, FFS (FSS=BF	FS-f _{LS} -f _A) 66.3 <i>mi/h</i>
Adj. for no-passing zones, f _{np,ATS} (Exhibi		Average travel speed, ATS _d =FF	S-0.00776(v _{d,ATS} + 56.2 <i>mi/h</i>
		v _{o,ATS}) - f _{np,ATS} Percent free flow speed, PFFS	84.8 %
Percent Time-Spent-Following		Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E _T (Exhibit 15-18 or 15-19)	1.4	1.4
Passenger-car equivalents for RVs, E_R (E	Exhibit 15-18 or 15-19)	1.0	1.0
Heavy-vehicle adjustment factor, f _{HV} =1/ (1+ P _T (E _T -1)+P _R (E _R -1))	0.984	0.984
Grade adjustment factor ¹ , f _{g,PTSF} (Exhibi	t 15-16 or Ex 15-17)	0.96	0.96
Directional flow rate ² , v_i (pc/h) v_i = V_i /(PHF ²	f _{HV,PTSF} * f _{g,PTSF})	529	529
Base percent time-spent-following ⁴ , BPTS	SF _d (%)=100(1-e ^{av} d ^b)	,	53.5
Adj. for no-passing zone, f _{np,PTSF} (Exhibi	t 15-21)	,	31.9
Percent time-spent-following, PTSF _d (%)=	$BPTSF_d^+f_np,PTSF^*(v_{d,PTSF}^/v_{d,PTSF}^+$		69.4
v _{o,PTSF}) Level of Service and Other Performand	en Massuras		
Level of Service and Other Performant Level of service, LOS (Exhibit 15-3)	.c mcasures		В
Volume to capacity ratio, <i>v/c</i>		1	0.32

Capacity, C _{d,ATS} (Equation 15-12) pc/h	1578
Capacity, C _{d,PTSF} (Equation 15-13) pc/h	1619
Percent Free-Flow Speed PFFS _d (Equation 15-11 - Class III only)	84.8
Bicycle Level of Service	
Directional demand flow rate in outside lane, $v_{ m OL}$ (Eq. 15-24) veh/h	500.0
Effective width, Wv (Eq. 15-29) ft	32.00
Effective speed factor, S_t (Eq. 15-30)	4.94
Bicycle level of service score, BLOS (Eq. 15-31)	0.85
Bicycle level of service (Exhibit 15-4)	Α
Notes	

^{1.} Note that the adjustment factor for level terrain is 1.00,as level terrain is one of the base conditions. For the purpose of grade adjustment, specific downgrade segments are treated as level terrain.

Copyright © 2012 University of Florida, All Rights Reserved

HCS 2010TM Version 6.41

Generated: 4/25/2013 4:21 PM

^{2.} If v_i(v_d or v_o) >=1,700 pc/h, terminate analysis--the LOS is F.

^{3.} For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only
5. Exhibit 15-20 provides coefficients a and b for Equation 15-10.
6. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

DIRECTIONAL T	WO-LANE HIGHW	AY SEGMENT WORK	SHEET
General Information		Site Information	
Date Performed 4/24/201	ssociates 3	Highway / Direction of Travel From/To Jurisdiction	Mary Option 1 Mary St - HWY 312 MDT
Analysis Time Period Average Project Description: Billings Bypass	Daytime Hour	Analysis Year	2035
Input Data			
	der widthft	_	_
			nighway Class II
	der widthft	highway 🔽	Class III highway
		Terrain	Level Rolling
Segment length, L _t	mi	Grade Length Peak-hour far No-passing z	ctor, PHF 0.95
Analysis direction vol., V _d 315veh/h		Show North Arrow % Trucks and	•
Opposing direction vol., V ₀ 315veh/h Shoulder width ft 10.0		% Recreation Access points	nal vehicles, P _R 2% s <i>mi</i> 1/mi
Lane Width ft 12.0 Segment Length mi 1.7		7.00000 politic	7
Average Travel Speed			
		Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T (Exhibit	15-11 or 15-12)	1.4	1.4
Passenger-car equivalents for RVs, E_R (Exhibit 19	5-11 or 15-13)	1.0	1.0
Heavy-vehicle adjustment factor, f _{HV,ATS} =1/ (1+ F	$P_T(E_T-1)+P_R(E_R-1)$)	0.984	0.984
Grade adjustment factor ¹ , f _{g,ATS} (Exhibit 15-9)		1.00	1.00
Demand flow rate ² , v_i (pc/h) v_i = V_i / (PHF* $f_{g,ATS}$ *	f _{HV,ATS})	337	337
Free-Flow Speed from Field N	Measurement		ee-Flow Speed
		Base free-flow speed ⁴ , BFFS	mi∕h
Mean speed of sample ³ , S _{FM}	45	Adj. for lane and shoulder width, ⁴	20
Total demand flow rate, both directions, <i>v</i>		Adj. for access points ⁴ , f _A (Exhibit	it 15-8) <i>mi/h</i>
Free-flow speed, FFS=S _{FM} +0.00776(v/ f _{HV,ATS})		Free-flow speed, FFS (FSS=BFF	S-f _{LS} -f _A) 49.7 mi/h
Adj. for no-passing zones, f _{np,ATS} (Exhibit 15-15)	1.3 mi/h	Average travel speed, ATS _d =FFS	S-0.00776(v _{d,ATS} + 43.2 <i>mi/h</i>
		v _{o,ATS}) - f _{np,ATS} Percent free flow speed, PFFS	87.0 %
Percent Time-Spent-Following		Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E _T (Exhibit 1	15-18 or 15-19)	1.1	1.1
Passenger-car equivalents for RVs, E _R (Exhibit 19	5-18 or 15-19)	1.0	1.0
Heavy-vehicle adjustment factor, f _{HV} =1/ (1+ P _T (E	_T -1)+P _R (E _R -1))	0.996	0.996
Grade adjustment factor ¹ , f _{g,PTSF} (Exhibit 15-16 c		1.00	1.00
Directional flow rate ² , v_i (pc/h) v_i = V_i /(PHF* $f_{HV,PTSI}$		333	333
Base percent time-spent-following ⁴ , BPTSF _d (%)=	100(1-e ^{av} d ^b)	3	86.0
Adj. for no-passing zone, f _{np,PTSF} (Exhibit 15-21)		3	88.9
Percent time-spent-following, PTSF _d (%)=BPTSF _d	$^{+f}$ np,PTSF * (V d,PTSF $^{/}$ V d,PTSF $^{+}$	5	55.5
v _{o,PTSF}) Level of Service and Other Performance Meas	uros		
Level of Service and Other Performance Measi Level of Service, LOS (Exhibit 15-3)	ui es		В
Volume to capacity ratio, <i>v/c</i>		†	0.20

Capacity, C _{d,ATS} (Equation 15-12) pc/h	1673
Capacity, C _{d,PTSF} (Equation 15-13) pc/h	1693
Percent Free-Flow Speed PFFS _d (Equation 15-11 - Class III only)	87.0
Bicycle Level of Service	
Directional demand flow rate in outside lane, v _{OL} (Eq. 15-24) veh/h	331.6
Effective width, Wv (Eq. 15-29) ft	32.00
Effective speed factor, S_t (Eq. 15-30)	4.42
Bicycle level of service score, BLOS (Eq. 15-31)	0.43
Bicycle level of service (Exhibit 15-4)	Α
Notes	

^{1.} Note that the adjustment factor for level terrain is 1.00,as level terrain is one of the base conditions. For the purpose of grade adjustment, specific downgrade segments are treated as level terrain.

Copyright © 2012 University of Florida, All Rights Reserved

HCS 2010TM Version 6.41

Generated: 4/25/2013 4:23 PM

^{2.} If $v_i(v_d \text{ or } v_o) >= 1,700 \text{ pc/h}$, terminate analysis--the LOS is F.

^{3.} For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only
5. Exhibit 15-20 provides coefficients a and b for Equation 15-10.
6. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

DIRECTION	AL TWO-LANE HIGHWA	AY SEGMENT WORK	KSHEET
General Information		Site Information	
Agency or Company Date Performed	R Marvin Marvin Associates 4/24/2013 Average Daytime Hour	Highway / Direction of Travel From/To Jurisdiction Analysis Year	Mary Option 2 Johnson Lane to Mary Street MDT 2035
Project Description: Billings Bypass	Average Daytime Hour	Alialysis Teal	2033
Input Data			
+	-=		
<u> </u>	Shoulder widthtt Lane width tt	_	_
 *	Lane width tt		highway Class II
1	Shoulder widthtt	highway 🗹	Class III highway
		/ Terrain	Level Rolling
Segment length,	L _L mi	Grade Lengt Peak-hour fa No-passing 2	actor, PHF 0.95
Analysis direction vol., V _d 470ve	h/h	Show North Arrow % Trucks an	d Buses , P _T 4 %
Opposing direction vol., V ₀ 470ve	h/h	% Recreation	nal vehicles, P _R 2%
Shoulder width ft 10.0		Access point	ts <i>mi</i> 1/mi
Lane Width ft 12.0 Segment Length mi 3.0			
Average Travel Speed		•	
		Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T	(Exhibit 15-11 or 15-12)	1.8	1.8
Passenger-car equivalents for RVs, E_R (E	Exhibit 15-11 or 15-13)	1.1	1.1
Heavy-vehicle adjustment factor, f _{HV,ATS}	=1/ (1+ P _T (E _T -1)+P _R (E _R -1))	0.967	0.967
Grade adjustment factor ¹ , f _{g,ATS} (Exhibit		0.95	0.95
Demand flow rate ² , v_i (pc/h) v_i = V_i / (PHF*	$f_{g,ATS} * f_{HV,ATS}$	539	539
Free-Flow Speed fron	n Field Measurement	Estimated Fr	ree-Flow Speed
		Base free-flow speed ⁴ , BFFS	mi/h
Mean speed of sample ³ , S _{FM}	60	Adj. for lane and shoulder width,	⁴ f _{LS} (Exhibit 15-7) mi/h
Total demand flow rate, both directions, <i>v</i>		Adj. for access points ⁴ , f _A (Exhib	oit 15-8) <i>mi/h</i>
Free-flow speed, FFS=S _{FM} +0.00776(<i>v</i> / f _F		Free-flow speed, FFS (FSS=BF	FS-f _{LS} -f _A) 66.3 mi/h
Adj. for no-passing zones, f _{np,ATS} (Exhibi		Average travel speed, ATS _d =FF	S-0.00776(v _{d,ATS} + 56.4 mi/h
		v _{o,ATS}) - f _{np,ATS} Percent free flow speed, PFFS	85.1 %
Percent Time-Spent-Following		Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_{T}	Exhibit 15-18 or 15-19)	Analysis Direction (d)	1.4
Passenger-car equivalents for RVs, E_R (E		1.0	1.0
Heavy-vehicle adjustment factor, f _{HV} =1/ (0.984	0.984
Grade adjustment factor ¹ , f _{g,PTSF} (Exhibi		0.96	0.96
Directional flow rate ² , v _i (pc/h) v _i =V _i /(PHF	f _{HV,PTSF} * f _{g,PTSF})	524	524
Base percent time-spent-following ⁴ , BPTS	,		53.4
Adj. for no-passing zone, f _{np,PTSF} (Exhibi	t 15-21)		29.2
Percent time-spent-following, PTSF _d (%)=	BPTSF _d +f _{np,PTSF} *(v _{d,PTSF} / v _{d,PTSF} +		68.0
v _{o,PTSF})			
Level of Service and Other Performand Level of service, LOS (Exhibit 15-3)	e Measures		В
LUVUI UI SUIVIUU, LUU (EXHIDIL 13-3)		i	u

Capacity, C _{d,ATS} (Equation 15-12) pc/h	1562
Capacity, C _{d,PTSF} (Equation 15-13) pc/h	1619
Percent Free-Flow Speed PFFS _d (Equation 15-11 - Class III only)	85.1
Bicycle Level of Service	
Directional demand flow rate in outside lane, v _{OL} (Eq. 15-24) veh/h	494.7
Effective width, Wv (Eq. 15-29) ft	32.00
Effective speed factor, S_t (Eq. 15-30)	4.94
Bicycle level of service score, BLOS (Eq. 15-31)	0.85
Bicycle level of service (Exhibit 15-4)	А
Notes	

^{1.} Note that the adjustment factor for level terrain is 1.00,as level terrain is one of the base conditions. For the purpose of grade adjustment, specific downgrade segments are treated as level terrain.

Copyright © 2012 University of Florida, All Rights Reserved

HCS 2010TM Version 6.41

Generated: 4/25/2013 4:25 PM

^{2.} If v_i(v_d or v_o) >=1,700 pc/h, terminate analysis--the LOS is F.

^{3.} For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only
5. Exhibit 15-20 provides coefficients a and b for Equation 15-10.
6. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

DIRECTION	AL TWO-LANE HIGHW	AY SEGMENT WORK	SHEET	
General Information		Site Information		
Agency or Company <i>N</i> Date Performed 4	Marvin farvin Associates /21/2013 verage Daytime Hour	From/To Jurisdiction	Mary Option 2 Mary St - HWY 312 MDT 2035	
Project Description: Billings Bypass	verage Daytime Hour	Allalysis Teal	2033	
Input Data				
<u> </u>				
<u> </u>	Shoulder widthtt	_	_	
 _	Lane width tt		Class I highway Class II	
Lane width tt		highway Class III highway		
		1 1 1	✓ Level ☐ Rolling	
Segment length, L _t mi		Grade Length mi Up/down Peak-hour factor, PHF 0.92 No-passing zone 32%		
Analysis direction vol., V _d 300veh	/h	Show North Arrow % Trucks and Buses , P _T 4 %		
Opposing direction vol., V _o 300veh	/h	% Recreation	% Recreational vehicles, P _R 2%	
Shoulder width ft 10.0		Access points <i>mi</i> 1/mi		
Lane Width ft 12.0 Segment Length mi 2.2				
Average Travel Speed				
		Analysis Direction (d)	Opposing Direction (o)	
Passenger-car equivalents for trucks, E_T (Exhibit 15-11 or 15-12)	1.4	1.4	
Passenger-car equivalents for RVs, E_R (E.	xhibit 15-11 or 15-13)	1.0	1.0	
Heavy-vehicle adjustment factor, f _{HV,ATS} =	1/ (1+ P _T (E _T -1)+P _R (E _R -1))	0.984	0.984	
Grade adjustment factor ¹ , f _{g,ATS} (Exhibit		1.00	1.00	
Demand flow rate ² , v_i (pc/h) v_i = V_i / (PHF* t	g,ATS * f _{HV,ATS})	331	331	
Free-Flow Speed from Field Measurement		Estimated Free-Flow Speed		
		Base free-flow speed ⁴ , BFFS	mi/h	
Mean speed of sample ³ , S _{FM}	45	Adj. for lane and shoulder width, ⁴	f _{LS} (Exhibit 15-7) mi/h	
Total demand flow rate, both directions, <i>v</i>	.0	Adj. for access points ⁴ , f _A (Exhibit	: 15-8) <i>mi/h</i>	
Free-flow speed, FFS=S $_{FM}$ +0.00776(v / f $_{H'}$	VATS)	Free-flow speed, FFS (FSS=BFF	S-f _{LS} -f _A) 49.7 mi/h	
Adj. for no-passing zones, f _{np,ATS} (Exhibit		Average travel speed, ATS _d =FFS-0.00776(v _{d,ATS} + 43.1 mi/h		
		v _{o,ATS}) - f _{np,ATS} Percent free flow speed, PFFS	86.7 %	
Percent Time-Spent-Following		Analysis Direction (d)	Opposing Direction (o)	
Passenger-car equivalents for trucks, E _T (E	Exhibit 15-18 or 15-19)	1.1	1.1	
Passenger-car equivalents for RVs, E _R (E.	xhibit 15-18 or 15-19)	1.0	1.0	
Heavy-vehicle adjustment factor, f _{HV} =1/ (1	+ P _T (E _T -1)+P _R (E _R -1))	0.996	0.996	
Grade adjustment factor ¹ , f _{g,PTSF} (Exhibit 15-16 or Ex 15-17)		1.00	1.00	
Directional flow rate ² , $v_i(pc/h)$ $v_i=V_i/(PHF^*f_{HV,PTSF}^*f_{g,PTSF})$		327	327	
Base percent time-spent-following ⁴ , BPTSF _d (%)=100(1-e ^{av} d ^b)		35.7		
Adj. for no-passing zone, f _{np,PTSF} (Exhibit 15-21)		42.3		
Percent time-spent-following, PTSF $_{\rm d}$ (%)=BPTSF $_{\rm d}$ +f $_{\rm np,PTSF}$ *(v $_{\rm d,PTSF}$ / v $_{\rm d,PTSF}$ +		5	6.8	
V _{o,PTSF})	Managemen			
Level of Service and Other Performance Level of service, LOS (Exhibit 15-3)	e Measures		В	
LCVCI OI SCIVICE, LOS (EXIIDIL 13-3)		i	U	

Capacity, C _{d,ATS} (Equation 15-12) pc/h	1673		
Capacity, C _{d,PTSF} (Equation 15-13) pc/h	1693		
Percent Free-Flow Speed PFFS _d (Equation 15-11 - Class III only)	86.7		
Bicycle Level of Service			
Directional demand flow rate in outside lane, v _{OL} (Eq. 15-24) veh/h	326.1		
Effective width, Wv (Eq. 15-29) ft	32.00		
Effective speed factor, S_t (Eq. 15-30)	4.42		
Bicycle level of service score, BLOS (Eq. 15-31)	0.42		
Bicycle level of service (Exhibit 15-4)	Α		
Notes			

^{1.} Note that the adjustment factor for level terrain is 1.00,as level terrain is one of the base conditions. For the purpose of grade adjustment, specific downgrade segments are treated as level terrain.

Copyright © 2012 University of Florida, All Rights Reserved

HCS 2010TM Version 6.41

Generated: 4/24/2013 1:04 PM

^{2.} If v_i(v_d or v_o) >=1,700 pc/h, terminate analysis--the LOS is F.

^{3.} For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only
5. Exhibit 15-20 provides coefficients a and b for Equation 15-10.
6. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

DIRECTION	AL TWO-LANE HIGHWA	AY SEGMENT WORK	SHEET
General Information		Site Information	
Agency or Company Date Performed	R Marvin Marvin Associates 4/24/2013 Average Daytime Hour	Highway / Direction of Travel From/To Jurisdiction Analysis Year	Five Mile Rd Alt Johnson Lane to Mary MDT 2035
Project Description: Billings Bypass	Average Daylime Hour	Allalysis i cai	2000
Input Data			
	Shoulder widthft Lane widthft	Class I highway Class II	
Lane width tt Shoulder width tt Segment length, L _t mi		highway Class III highway Terrain Level Rolling Grade Length mi Up/down Peak-hour factor, PHF 0.92 No-passing zone 14% Show North Arrow % Trucks and Puese P 4 %	
Analysis direction vol., V _d 390ve	h/h	% Trucks and Buses , P _T 4 %	
Opposing direction vol., V _o 390veh/h Shoulder width ft 10.0 Lane Width ft 12.0 Segment Length mi 3.0		% Recreational vehicles, P _R 2% Access points <i>mi</i> 1/mi	
Average Travel Speed		Analysis Direction (d)	Opposing Direction (a)
December our organization for trucks. E	(Eyhibit 15 11 or 15 12)	Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E_T Passenger-car equivalents for RVs, E_R (E		2.0	2.0
Heavy-vehicle adjustment factor, f _{HV,ATS}		0.960	0.960
Grade adjustment factor ¹ , f _{q,ATS} (Exhibit 15-9)		0.91	0.91
Demand flow rate ² , v_i (pc/h) v_i = V_i / (PHF*	f _{g,ATS} * f _{HV,ATS})	485	485
Free-Flow Speed from	n Field Measurement	Estimated Free-Flow Speed	
		Base free-flow speed ⁴ , BFFS	mi/h
Mean speed of sample ³ , S _{FM}	60	Adj. for lane and shoulder width, ⁴	f _{LS} (Exhibit 15-7) mi/h
Total demand flow rate, both directions, v		Adj. for access points ⁴ , f _A (Exhibi	t 15-8) mi/h
Free-flow speed, FFS=S _{FM} +0.00776(v/ f _F	AV ATS)	Free-flow speed, FFS (FSS=BFF	-S-f _{LS} -f _A) 66.3 mi/h
Adj. for no-passing zones, f _{np,ATS} (Exhibit 15-15) 1.5 mi/h		Average travel speed, ATS _d =FFS-0.00776(v _{d,ATS} + 57.3 mi/	
		v _{o,ATS}) - f _{np,ATS} Percent free flow speed, PFFS	86.4 %
Percent Time-Spent-Following		Analysis Direction (d)	Opposing Direction (o)
Passenger-car equivalents for trucks, E _T (Exhibit 15-18 or 15-19)	1.4	1.4
Passenger-car equivalents for RVs, E_R (E	Exhibit 15-18 or 15-19)	1.0	1.0
Heavy-vehicle adjustment factor, f _{HV} =1/ (1+ P _T (E _T -1)+P _R (E _R -1))	0.984	0.984
Grade adjustment factor ¹ , f _{g,PTSF} (Exhibit 15-16 or Ex 15-17)		0.91	0.91
Directional flow rate ² , $v_i(pc/h)$ $v_i=V_i/(PHF^*f_{HV,PTSF}^*f_{g,PTSF})$		473	473
Base percent time-spent-following ⁴ , $BPTSF_d(\%)=100(1-e^{av_d^b})$		49.4	
Adj. for no-passing zone, f _{np,PTSF} (Exhibit 15-21)		25.8	
Percent time-spent-following, PTSF $_{\rm d}$ (%)=BPTSF $_{\rm d}$ +f $_{\rm np,PTSF}$ * (v $_{\rm d,PTSF}$ / v $_{\rm d,PTSF}$ +		6	2.3
V _{o,PTSF})	o Manaura		
Level of Service and Other Performand Level of service, LOS (Exhibit 15-3)	e weasures		В
Volume to capacity ratio, <i>v/c</i>			.29

Capacity, C _{d,ATS} (Equation 15-12) pc/h	1539		
Capacity, C _{d,PTSF} (Equation 15-13) pc/h	1573		
Percent Free-Flow Speed PFFS _d (Equation 15-11 - Class III only)	86.4		
Bicycle Level of Service			
Directional demand flow rate in outside lane, v _{OL} (Eq. 15-24) veh/h	423.9		
Effective width, Wv (Eq. 15-29) ft	32.00		
Effective speed factor, S_t (Eq. 15-30)	4.94		
Bicycle level of service score, BLOS (Eq. 15-31)	0.77		
Bicycle level of service (Exhibit 15-4)	А		
Notes			

^{1.} Note that the adjustment factor for level terrain is 1.00,as level terrain is one of the base conditions. For the purpose of grade adjustment, specific downgrade segments are treated as level terrain.

Copyright © 2012 University of Florida, All Rights Reserved

HCS 2010TM Version 6.41

Generated: 4/25/2013 4:29 PM

^{2.} If v_i(v_d or v_o) >=1,700 pc/h, terminate analysis--the LOS is F.

^{3.} For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only
5. Exhibit 15-20 provides coefficients a and b for Equation 15-10.
6. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

DIRECTION	AL TWO-LANE HIGHWA	AY SEGMENT WORK	SHEET	
General Information		Site Information		
Agency or Company Date Performed	R Marvin Marvin Associates 4/24/2013 Average Daytime Hour	From/To Jurisdiction	Five Mile Rd Alt Mary to HWY 312 MDT 2035	
Project Description: Billings Bypass	Average Dayline Hour	Analysis Teal	2000	
Input Data				
l	Shoulder widthft Lane width ft	_	_	
 	Lane width It		Class I highway Class II	
*	Shoulder widthtt	highway Class III highway		
		1 1 1	Level Rolling	
Segment length, L _t mi		Grade Length mi Up/down Peak-hour factor, PHF 0.92 No-passing zone 41%		
Analysis direction vol., V _d 145ve	h/h	Show North Arrow % Trucks and Buses , P _T 4 %		
Opposing direction vol., V ₀ 145veh/h		% Recreational vehicles, P _R 2%		
Shoulder width ft 10.0		Access points	Access points <i>mi</i> 1/mi	
Lane Width ft 12.0 Segment Length mi 3.0				
Average Travel Speed		•		
		Analysis Direction (d)	Opposing Direction (o)	
Passenger-car equivalents for trucks, E_T	(Exhibit 15-11 or 15-12)	1.7	1.7	
Passenger-car equivalents for RVs, E_R (E	Exhibit 15-11 or 15-13)	1.0	1.0	
Heavy-vehicle adjustment factor, $f_{HV,ATS}=1/(1+P_T(E_T-1)+P_R(E_R-1))$		0.973	0.973	
Grade adjustment factor ¹ , f _{g,ATS} (Exhibit		1.00	1.00	
Demand flow rate ² , v_i (pc/h) v_i = V_i / (PHF*	f _{g,ATS} * f _{HV,ATS})	162	162	
Free-Flow Speed from	n Field Measurement	Estimated Free-Flow Speed		
		Base free-flow speed ⁴ , BFFS	mi/h	
Mean speed of sample ³ , S _{FM}	60	Adj. for lane and shoulder width, ⁴	f _{LS} (Exhibit 15-7) mi/h	
Total demand flow rate, both directions, <i>v</i>		Adj. for access points ⁴ , f _A (Exhibit	t 15-8) mi/h	
Free-flow speed, FFS=S _{FM} +0.00776(<i>v</i> / f _F		Free-flow speed, FFS (FSS=BFF	S-f _{LS} -f _A) 62.8 mi/h	
Adj. for no-passing zones, f _{np,ATS} (Exhibi		Average travel speed, ATS _d =FFS	-0.00776(v _{d,ATS} + 57.6 mi/h	
		v _{o,ATS}) - f _{np,ATS} Percent free flow speed, PFFS	91.7 %	
Percent Time-Spent-Following		Analysis Direction (d)	Opposing Direction (a)	
Passenger-car equivalents for trucks, E_{T}	(Exhibit 15-18 or 15-19)	Analysis Direction (d) 1.1	Opposing Direction (o) 1.1	
Passenger-car equivalents for RVs, E_R (E		1.0	1.0	
Heavy-vehicle adjustment factor, f _{HV} =1/ (0.996	0.996	
Grade adjustment factor ¹ , f _{g,PTSF} (Exhibi		1.00	1.00	
Directional flow rate ² , v_i (pc/h) v_i = V_i (PHF* $f_{HV,PTSF}$ * $f_{g,PTSF}$)		158	158	
Base percent time-spent-following ⁴ , BPTSF _d (%)=100(1-e ^{av} d ^b)		17.5		
Adj. for no-passing zone, f _{np,PTSF} (Exhibit 15-21)		50.0		
Percent time-spent-following, PTSF _d (%)=BPTSF _d +f _{np,PTSF} *(v _{d,PTSF} / v _{d,PTSF} +		4	2.5	
v _{o,PTSF})	Managemen		-	
Level of Service and Other Performand Level of service, LOS (Exhibit 15-3)	ce measures	T	R	
Volume to capacity ratio, <i>v/c</i>		B 0.10		

Directional Page 2 of 2

Capacity, C _{d,ATS} (Equation 15-12) pc/h	1654
Capacity, C _{d,PTSF} (Equation 15-13) pc/h	1693
Percent Free-Flow Speed PFFS _d (Equation 15-11 - Class III only)	91.7
Bicycle Level of Service	•
Directional demand flow rate in outside lane, $v_{ m OL}$ (Eq. 15-24) veh/h	157.6
Effective width, Wv (Eq. 15-29) ft	38.05
Effective speed factor, S_t (Eq. 15-30)	4.94
Bicycle level of service score, BLOS (Eq. 15-31)	-1.85
Bicycle level of service (Exhibit 15-4)	A
Notes	

^{1.} Note that the adjustment factor for level terrain is 1.00,as level terrain is one of the base conditions. For the purpose of grade adjustment, specific downgrade segments are treated as level terrain.

Copyright © 2012 University of Florida, All Rights Reserved

HCS 2010TM Version 6.41

Generated: 5/3/2013 12:42 PM

^{2.} If v_i(v_d or v_o) >=1,700 pc/h, terminate analysis--the LOS is F.

^{3.} For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only
5. Exhibit 15-20 provides coefficients a and b for Equation 15-10.
6. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

APPENDIX B

Phase 1

System Intersections Capacity

Mary Option 1 Alt 2035 Phase 1 Wicks Lane/Main Street Area Type: Non CBD

R Marvin 8/15/13 Analysis Duration: 15 mins.

PM								Case	e: Wic	ks N	Main N	Aary Op	1 2035	PM					
	Lanes						Geom	etry: Mo	ovemen	ts Sei	rviced b	y Lane an	d Lane W	idths (f	eet)				
	Approach (Outboun	ıd	Lane	e 1		Lane	2]	Lane	3	Lar	ne 4	La	ine 5	La	ne 6		
EB	3	2		L	12.0	7	Γ	12.0	TR		12.0								
WB	3	2		L	12.0	L	Т	12.0	TR		12.0								
NB	5	3		L	12.0	I	_	12.0	Т		12.0	Т	12.0	TR	12.0				
SB	4	3		L	12.0]	Γ	12.0	Т		12.0	TR	12.0						
					East				Wes	t			North			South			
	Data			L	T	F	2	L	Т		R	L	Т	R	L	T	R		
Move	ement Volun	ne (vph)	3	314	450	1:	56	520	390)	80	358	1370	350	140	820	352		
PHF			0	.92	0.92	0.9	92	0.92	0.92	2	0.92	0.92	0.92	0.92	0.92	0.92	0.92		
% Не	avy Vehicle	s		0	0		0	0	0		0	0	2	1	0	2	0		
Lane	Groups			L	TR			L	LTR	١ ا		L	TR		L	TR			
Arriv	al Type			5	5			3	3			5	5		4	4			
RTO	R Vol (vph)				80				30	1			100			120			
Peds/	Hour				0				5				5			5			
% Gr	ade				0				0				0			0			
Buse	s/Hour				0				0				0			0			
Parke	ers/Hour (Le	ft Right))							-									
Signa	ıl Settings: A	Actuated		(Operati	ional A	nalys	is	Су	cle L	ength: 1	25.0 Sec	;	Lost Tin	ne Per Cyc	le: 18.0 S	ec		
Phase	:	1		2	2	3	3	4	-		5	6		7	8	Pe	d Only		
EB								LT	'n										
WB						LT	ГР												
NB		L		T	P														
SB		L		T	P														
Green	1	16.			3.0		1.0	29									0		
Yello	w All Red	3.0	0.0	3.5	1.5	3.5	1.5	3.5	1.5										

			C	.' A	14 -				A	-1
	I		Capac	ity Analysis R	esuits		I		Approa	cn:
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay	
App	Group	(vph)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB										
	* L	419	0.189	0.232	L	0.814	52.1	D	44.5	D
	TR	819	0.162	0.232	TR	0.698	40.0	D		
WB										
	* L	347	0.224	0.192	L	1.164	151.4	F	102.8	F
	LTR	675	0.182	0.192	LTR	0.947	72.1	Е		
NB										
	* L	448	0.111	0.128	L	0.868	68.1	Е	105.3	F
	* TR	1509	0.355	0.304	TR	1.167	113.5	F		
SB										
	L	231	0.084	0.128	L	0.658	65.7	Е	45.0	D
	TR	1508	0.230	0.304	TR	0.758	42.3	D		

Intersection: Delay = 80.1 sec/veh SIG/Cinema v3.08

Int. LOS=F

1.03 * Critical Lane Group

 $\sum (v/s)$ Crit= 0.88

Marvin & Associates

Mary Option 1 Alt 2035 Phase 1 R Marvin PM Wicks Lane/Main Street

8/15/13

Case: Wicks Main Mary Op1 2035 PM

App EB	Lane Group L TR	Queues Per Lane Avg/Max (veh) 9 / 14 3 / 5	Average Speed (mph) 4.8 13.5	Spillback in Worst Lane (% of Peak Period) 0.0 0.0	820 352 140
WB	L	11 / 13	4.1	0.0	
WD	LTR	11 / 13	5.9	0.0	→
	DIK	11/11	3.7	0.0	
	All		5.4	0.0	$\begin{array}{c c} 314 & \longrightarrow \\ 450 & \longrightarrow \\ \end{array}$
NB	L	7/9	3.9	0.0	156 —
	TR	16 / 29	4.5	4.1	
					358 350
	All		4.3	4.1	1370
SB	L	8 / 10	3.2	0.0	
	TR	9 / 13	7.3	0.0	
					16 3 0 37 4 2 23 4 2 28 4
	All		6.4	0.0	
	Inte	rsect.	5.5		

Mary Opt 1 Alt 2035 Phase 1 Airport Road/Main Street Area Type: Non CBD

R Marvin 8/15/13 Analysis Duration: 15 mins.

PM Design Hours Opt 2035 PM

	I Design I	Hour						Case		port l	Main 1	Mary C	p1 2035	inarysis 5 PM	Duratio	Juration: 13 mins.			
	Lanes					Ge	eome	etry: Mo	vemer	nts Ser	viced b	y Lane aı	nd Lane W	Vidths (f	eet)				
	Approach	Outbound		Lane	1	I	Lane	2		Lane :	3	La	ne 4	La	ne 5	Laı	ne 6		
EB	3	1	L	,	12.0	LT		12.0	R		12.0								
WB	2	2	LT	Г	12.0	R		12.0											
NB	4	3	L		12.0	Т		12.0	Т		12.0	TR	12.0						
SB	4	3	L	,	12.0	Т		12.0	Т		12.0	TR	12.0						
					East				We	st			North			South			
	Data	-	L	,	Т	R		L	Т		R	L	Т	R	L	Т	R		
Move	ement Volur	ne (vph)	85	50	20	100		30	40)	90	230	2898	10	70	1706	400		
PHF			0.9	95	0.95	0.95		0.95	0.9	5	0.95	0.95	0.95	0.95	0.95	0.95	0.95		
% Не	eavy Vehicle	es	2	2	0	4		1	1		1	2	2	0	0	2	1		
Lane	Groups		L	,	LT	R			LT		R	L	TR		L	TR			
Arriv	al Type		3		3	3			3		3	5	5		5	5			
RTO	R Vol (vph)				20				30)			0			100			
Peds/	Hour				5				C)			5			5			
% Gr	ade				0				0	ı			0			0			
Buse	s/Hour				0				0				0			0			
Parke	ers/Hour (Le	ft Right)									-								
Signa	al Settings: A	Actuated		(Operati	onal An	alysi	s	Cy	ycle Le	ength: 1	50.0 Sec	2	Lost Tim	e Per Cyc	le: 20.0 S	ec		
Phase	e:	1		2	2	3		4		;	5	6		7	8	Pe	d Only		
EB		LTP				R													
WB				LT	ГР														
NB						LTP		T											
SB								T]			ΓR								
Green		39.0			0.0	20.0		56			5.0	ļ,					0		
Yello	w All Red	3.5 1	.5	3.5	1.5	3.0	0.0	3.5	1.5	3.5	1.5								

App Group (vph) Ratio Ratio Group R EB * L 460 0.292 0.260 L 1 LT 462 0.225 0.260 LT 0	Approach: V/c
EB * L 460 0.292 0.260 L 1 LT 462 0.225 0.260 LT 0	tatio (sec/veh) LOS (sec/veh) LOS .122 135.1 F 99.3 F
EB * L 460 0.292 0.260 L 1 LT 462 0.225 0.260 LT 0	.122 135.1 F 99.3 F
* L 460 0.292 0.260 L 1 LT 462 0.225 0.260 LT 0	
LT 462 0.225 0.260 LT 0	
	966 69.1 E
R 639 0.054 0.413 R 0	.866 68.1 E
307 3001 31120 31	.131 27.3 C
WB	
* LT 74 0.040 0.040 LT 1	.000 176.6 F 177.5 F
R 64 0.039 0.040 R 0	.984 178.5 F
NB NB	
L 236 0.137 0.133 L 1	.025 123.7 F 82.1 F
* TR 2677 0.603 0.527 TR 1	.144 78.8 E
SB	
* L 72 0.041 0.040 L 1	.028 184.0 F 34.4 C
TR 2219 0.425 0.447 TR 0	.952 29.2 C

Intersection: Delay = 70.9 sec/veh SIG/Cinema v3.08

Int. LOS=E $X_c = 1.13$

* Critical Lane Group

 $\sum (v/s)$ Crit= 0.98

Marvin & Associates

Mary Opt 1 Alt 2035 Phase 1 R Marvin PM Design Hour Airport Road/Main Street

8/15/13

Case: Airport Main Mary Op1 2035 PM

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	1706 400 70
EB	L	18 / 18	4.2	0.0	4 ' 4
	LT	17 / 17	5.7	0.0	90 ← 40
	R	2/3	17.3	0.0	- 30
	All		5.3	0.0	<u> </u>
WB	LT	3/3	5.1	0.0	
	R	3 / 4	9.6	0.0	850 -
	All		7.4	0.0	20
NB	L	13 / 16	2.9	0.0	100 —
	TR	28 / 30	6.2	21.7	
					$oxed{ \begin{array}{c cccccccccccccccccccccccccccccccccc$
	All		5.8	21.7	
SB	L	4 / 7	4.7	0.0	1 2 3 4 1
	TR	11 / 17	9.8	0.0	
					38 4 2 5 4 2 20 1 3 0 55 4 4
	All		9.5	0.0	5 4
	Inte	rsect.	6.6		5 4 2

Mary Option 1 Alt 2035 Phase 1

R Marvin

R Marvin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Maryin

R Ma

PM	I design H	Iour				Case: US 87 MAIN FIRST Mary Op1 2035 PM											
	Lanes					Geo	met	ry: Mo	vements	Serviced b	y Lane ar	nd Lane W	idths (fe	eet)			
	Approach	Outbound		Lane	e 1	La	ine 2	2	La	ne 3	Laı	ne 4	La	ne 5		Lar	ne 6
EB	4	2	L		12.0	L		12.0	L	12.0	Т	12.0					
WB	3	2	Т	,	12.0	T		12.0	R	12.0							
NB	0	3															
SB	4	0	L	,	12.0	L		12.0	R	12.0	R	12.0					
				•	East		West				North			So	outh		
	Data		L	,	T	R		L	T	R	L	T	R	L		Т	R
Move	ement Volur	ne (vph)	180	00	600	0		0	610	864	0	0	0	830		0	670
PHF			0.9	95	0.95	0.90		0.90	0.95	0.95	0.90	0.90	0.90	0.95	0.	.90	0.95
% He	avy Vehicle	es	2	2	2	2		2	2	4	2	2	2	4		2	2
Lane	Groups		L		T				Т	R				L			R
Arriv	al Type		5	;	5				3	3				5			5
RTO	R Vol (vph)				0				250			0				0	
Peds/	Hour				5				0			0				0	
% Gr	ade				0				0			0				0	
Buses	s/Hour				0				0			0				0	
Parke	ers/Hour (Le	ft Right)													-		
Signa	al Settings: A	Actuated			Operati	onal Anal	ysis		Cycle	Length:	130.0 Sec	:	Lost Tim	ne Per Cy	cle: 15	5.0 S	ec
Phase	e:	1		2	2	3		4		5	6		7	8		Pe	d Only
EB		LT															
WB				Т	ТР	R											
NB																	
SB		R				LP	_										
Greei		52.0			5.0	37.0											0
Yello	w All Red	3.5	1.5	3.5	1.5	3.5 1	.5										

			C	-: A1:- D)1 <i>t</i> -				A	-1
		I	Capac	city Analysis R	esuits	1	1		Approa	cn:
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay	
App	Group	(vph)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB										
	* L	2060	0.368	0.400	L	0.920	28.7	C	29.4	C
	T	745	0.339	0.400	T	0.848	31.2	С		
WB										
	* T	708	0.181	0.200	Т	0.907	65.9	Е	48.1	D
	R	812	0.416	0.523	R	0.796	30.4	С		
SB										
	* L	958	0.260	0.285	L	0.912	47.3	D	26.4	C
	R	2015	0.253	0.723	R	0.350	0.5	A		

Intersection: Delay = 33.0 sec/veh SIG/Cinema v3.08

Int. LOS=C X

* Critical Lane Group

 $\sum (v/s)$ Crit= 0.81

Marvin & Associates

Mary Option 1 Alt 2035 Phase 1 R Marvin PM design Hour 1st Ave N/ 8/15/13

Case: US 87 MAIN FIRST Mary Op1 2035 PM

App EB	Lane Group L T	Queues Per Lane Avg/Max (veh) 18 / 26 12 / 17	Average Speed (mph) 4.5 6.8	Spillback in Worst Lane (% of Peak Period) 1.2 0.2	670 830
	All		5.0	1.2	
WB	Т	11 / 13	6.0	0.0	 -
	R	17 / 26	7.0	2.4	<u></u>
	All		6.6	2.4	1800 - 600 →
					600
	A 11			0.0	
	All		6.5	0.0	
SB	L	16 / 18	4.0	0.0	
	D	1 / 2	21.7	0.0	
	R	1 / 2	21.7	0.0	51 4 2 25 4 2 36 4 2
	Inte	rsect.	5.8		

Mary Opt 1 2035 Phase 1

Old US 87/I90 EB Off Ramp

Area Type: Non CBD

R Marvin

PM Design Hour

Old US 87/I90 EB Off Ramp

Analysis Duration: 15 mins.

Case: EB Ramps US 87 Op1 2035 PM

PM	I Design I	Hour						Case: EB Ramps US 87 Op1 2035 PM										
	Lanes						Geom	etry: Mo	vements	Serviced b	y Lane ar	nd Lane W	idths (1	feet)				
	Approach (Outbound	d	Lane	e 1		Lane	2	La	nne 3	Laı	ne 4	La	ane 5	La	ne 6		
EB	3	2		L	12.0	7	Γ	12.0	Т	12.0								
WB	2	2		Т	12.0	Т	R	12.0										
NB	2	1		L	12.0	Т	R	12.0										
SB	0	0																
					East				West			North			South			
	Data			L	Т	I	۲ .	L	Т	R	L	T	R	L	Т	R		
Move	ement Volun	ne (vph)	4	176	440		0	0	600	20	622	350	350	0	0	0		
PHF			0.	.92	0.92	0.9	90	0.90	0.92	0.92	0.92	0.92	0.92	0.90	0.90	0.90		
% He	avy Vehicle	es		4	1		2	2	2	2	5	0	2	2	2	2		
Lane	Groups			L	T				TR		L	TR						
Arriv	al Type			3	3				3		3	3						
RTO	R Vol (vph)				0				5			100			0			
Peds/	Hour				5				0			0			5			
% Gr	ade				0				0			0			0			
Buses	s/Hour				0				0			0			0			
Parke	ers/Hour (Le	ft Right)																
Signa	ıl Settings: A	Actuated			Operat	onal A	analysi	is	Cycl	e Length:	120.0 Sec	2	Lost Tin	ne Per Cyc	le: 9.0 S	ec		
Phase	:	1		2	2	3	3	4		5	6		7	8	Pe	d Only		
EB		LT		L	Γ													
WB				T	R													
NB						L.	ГР											
SB																		
Greei	1	32.0			5.0		9.0	ļ			ļ ,					0		
Yello	w All Red	4.0	0.0	3.5	1.5	3.5	1.5											

	Capacity Analysis Results													
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS				
EB	* Lper	61	0.221	0.250	_				45.0	D				
	* Lpro	463	0.267	0.267	L	0.987	70.8	Е						
	T	1817	0.134	0.508	Т	0.263	17.1	В						
WB														
	TR	735	0.189	0.208	TR	0.909	63.6	Е	63.6	Е				
NB														
	* L	699	0.395	0.408	L	0.967	60.6	Е	54.4	D				
	TR	720	0.370	0.408	TR	0.906	48.0	D						

Intersection: Delay = 53.3 sec/veh SIG/Cinema v3.08

Int. LOS=D

 $X_c = 0.95$ * Critical Lane Group

 $\sum (v/s)$ Crit= 0.88

Marvin & Associates

Mary Opt 1 2035 Phase 1 R Marvin PM Design Hour Old US 87/I90 EB Off Ramp 8/15/13

Case: EB Ramps US 87 Op1 2035 PM

Арр	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	
EB	L	23 / 28	2.5	44.1	
	Т	5 / 8	9.2	3.4	 -
	All		5.4	44.1	√
WB	TR	9 / 11	6.8	0.0	
					476 -
	All		6.8	0.0	440
NB	L	24 / 27	4.3	2.3	
	TR	26 / 29	4.1	4.7] 1 1 1 1
					622 350
	All		4.2	4.7	
					1 2 3
					32 4 0 24 4 2 48
	Inte	rsect.	5.0		

Mary Op1 Alt 2035 Phase 1 Old US 87/I90 WB On Ramp Area Type: Non CBD R Marvin 8/15/13 Analysis Duration: 15 mins.
PM Design Hour Case: WB Ramps US 87 Mary Op1 2035 PM

	Aarvin Design F	Hour						8/15/ Case		Ramps U	JS 87 M			Duratio PM	n: 15 r	nins.
	Lanes							try: Mo	vements	Serviced b	y Lane ar	nd Lane W	/idths (fe	eet)		
	Approach (Outbound]	Lane 1	1	L	ane	2	La	ne 3	Laı	ne 4	La	ne 5	Laı	ne 6
EB	2	2	Т		12.0	TR		12.0								
WB	3	2	L		12.0	T		12.0	Т	12.0						
NB	0	0														
SB	1	1	LTF	2	12.0											
					East				West			North			South	
	Data		L		Т	R		L	Т	R	L	Т	R	L	Т	R
Move	ment Volun	ne (vph)	0)	896	422		220	1000	0	0	0	0	20	1	318
PHF			0.90	0.90 0.92 0. 2 5		0.92		0.92	0.92	0.90	0.90	0.90	0.90	0.92	0.92	0.92
% He	avy Vehicle	es	2					1	5	2	2	2	2	1	0	5
Lane	Groups				TR			L	Т						LTR	
Arriva	al Type				2			2	2						3	
RTOI	R Vol (vph)				150				0			0			100	
Peds/	Hour				0				5			0			0	
% Gra	ade				0				0			0			0	
Buses	/Hour				0				0			0			0	
Parke	rs/Hour (Le	ft Right)	-													
Signa	1 Settings: A	Actuated		O	peratio	onal Ana	lysi	s	Cycle	e Length:	80.0 Sec	2	Lost Tim	e Per Cyc	le: 14.0 S	ec
Phase	:	1		2		3		4		5	6		7	8	Pe	d Only
EB				TR	:											
WB		LT		LT												
NB																
SB			LTR													
Green		10.0	36.0 20.0												0	
Yello	w All Red	4.0	0.0	3.5	1.5	3.5	1.5									

									Approa	,			
	Capacity Analysis Results Lane Cap v/s g/C Lane v/c Delay												
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS			
EB													
	* TR	1493	0.383	0.450	TR	0.851	29.5	С	29.5	С			
WB	Lper	94	0.087	0.512					16.4	В			
	* Lpro	223	0.125	0.125	L	0.754	33.3	С					
	T	2149	0.316	0.625	Т	0.506	12.7	В					
SB													
	* LTR	395	0.165	0.250	LTR	0.658	30.1	С	30.1	С			

Intersection: Delay = 23.5 sec/veh SIG/Cinema v3.08

Int. LOS=C

 $X_c = 0.81$ * Critical Lane Group

 \sum (v/s)Crit= 0.67

Marvin & Associates

Mary Op1 Alt 2035 Phase 1 R Marvin PM Design Hour Old US 87/I90 WB On Ramp

8/15/13

Case: WB Ramps US 87 Mary Op1 2035 PM

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	318 20
ЕВ	TR	10 / 13	12.3	0.0	→—1000 ——220
	All		12.3	0.0	
WB	L	5 / 6	4.9	0.0	
	Т	4 / 6	17.6	0.0	
	All		14.2	0.0	896 → 422 →
	All		12.5	0.0	
					1 2 3 1
SB	LTR	4 / 7	12.5	0.0	
					$\begin{array}{cccccccccccccccccccccccccccccccccccc$
	Inte	rsect.	13.0		

Mary Option 2 Alt 2035 Wicks Lane/Main Street Area Type: Non CBD

R Marvin 10/12/2011 Analysis Duration: 15 mins.

Phase 1 PM Case: WICKS MAIN MARY OP2 2035 PHASE 1

	ase 1 PM							Case	2/201 e: WIC	CKS I	MAII	N MAR	Y OP2	2035 PF	HASE 1	11: 131	mns.
	Lanes					(Geom	etry: Mo	ovemen	ts Serv	iced b	y Lane ar	nd Lane W	idths (fe	eet)		
	Approach	Outbound	J	Lane	1		Lane	2	J	Lane 3		Laı	ne 4	La	ne 5	Laı	ne 6
EB	3	2	L		12.0	Г	7	12.0	TR	1	12.0						
WB	3	2	L		12.0	L	Т	12.0	TR	1	12.0						
NB	5	3	L		12.0	L	.	12.0	Т	1	12.0	Т	12.0	TR	12.0		
SB	4	3	L		12.0	Г		12.0	Т	1	12.0	TR	12.0				
				•	East				Wes	t			North			South	
	Data		L		T	F	2	L	Т		R	L	Т	R	L	Т	R
Move	ment Volur	ne (vph)	314	ı	450	15	56	520	390)	80	358	1350	350	140	810	352
PHF			0.92	2	0.92	0.9	92	0.92	0.92	2 ().92	0.92	0.92	0.92	0.92	0.92	0.92
% He	avy Vehicle	es	0		0		0	0	0		0	0	2	1	0	2	0
Lane	Groups		L		TR			L	LTR	١ ا		L	TR		L	TR	
Arriva	al Type		5		5			3	3			5	5		4	4	
RTOI	R Vol (vph)				80				30	1			100			120	
Peds/	Hour				0				5				5			5	
% Gra	ade				0				0				0			0	
Buses	s/Hour				0				0				0			0	
Parke	rs/Hour (Le	ft Right)	-								-						
Signa	l Settings: A	Actuated		C	Operati	onal A	nalys	is	Су	cle Le	ngth: 1	125.0 Sec		Lost Tim	e Per Cycl	le: 18.0 S	ec
Phase	:	1		2		3	3	4		5	i	6		7	8	Pe	d Only
EB								LT	R								
WB						LT	ГР										
NB		L		TI													
SB		L		TI													
Green	1	16.0		38.			1.0		0.0								0
Yello	w All Red	3.0	0.0	3.5	1.5	3.5	1.5	3.5	1.5								

			Approa	ch:						
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
EB					_					
	* L	419	0.189	0.232	L	0.814	52.1	D	44.5	D
	TR	819	0.162	0.232	TR	0.698	40.0	D		
WB										
	* L	347	0.224	0.192	L	1.164	151.4	F	102.8	F
	LTR	675	0.182	0.192	LTR	0.947	72.1	Е		
NB										
	* L	448	0.111	0.128	L	0.868	68.1	Е	100.5	F
	* TR	1508	0.350	0.304	TR	1.153	107.8	F		
SB										
	L	231	0.084	0.128	L	0.658	65.7	Е	44.8	D
	TR	1508	0.228	0.304	TR	0.751	42.0	D		

Intersection: Delay = 78.1 sec/veh Int. LOS=E $X_c = 1.02$ * Critical Lane Group SIG/Cinema v3.08 Marvin & Associates

 \geq (v/s)Crit= 0.87

Mary Option 2 Alt 2035 R Marvin Phase 1 PM Wicks Lane/Main Street 10/12/2011

Case: WICKS MAIN MARY OP2 2035 PHASE 1

App EB	Lane Group L TR	Queues Per Lane Avg/Max (veh) 9 / 14 3 / 8	Average Speed (mph) 4.6 12.9	Spillback in Worst Lane (% of Peak Period) 0.0 0.0	810 352 140 1 - 80 - 390 - 520
	All		8.8	0.0	
WB	L	12 / 13	3.8	0.0	—
	LTR	12 / 13	5.6	0.0	
					314 -
	All		5.0	0.0	450 →
NB	L	7 / 9	3.7	0.0	
	TR	13 / 23	5.5	0.4	
					358 350
	All		5.1	0.4	
SB	L	8 / 10	3.2	0.0	1 2 1 3 4
	TR	9 / 14	7.9	0.0	
					16 3 0 37 4 2 23 4 2 28 4
	All		6.8	0.0	
	Inte	rsect.	5.9		

Mary Opt 2 Phase 1 Alt 2035

R Marvin

10/12/2011

Analysis Duration: 15 mins.

PM Design Hour

Case: Airport Main Mary Op.2 Phase 1 2035 PM

PM	I Design I	Hour						Case	e: Air	port	Main	Mary C	p2 Phas	e 1 203	S5 PM	15 1	
	Lanes						Geome	etry: Mo	oveme	nts Sei	viced b	y Lane a	nd Lane W	idths (f	eet)		
	Approach	Outboun	d	Lane	e 1		Lane	2		Lane	3	La	ne 4	La	ine 5	Laı	ne 6
EB	3	1		L	12.0	L	Т	12.0	R		12.0						
WB	2	2	I	LT	12.0	F	2	12.0									
NB	4	3		L	12.0	7	Γ	12.0	Т		12.0	TR	12.0				
SB	4	3		L	12.0	7	Γ	12.0	Т		12.0	TR	12.0				
					East				We	st			North			South	
	Data			L	T	F	2	L	Т		R	L	Т	R	L	Т	R
Move	ement Volur	ne (vph)	8	350	20	10	00	30	40	0	90	230	2918	10	70	1714	400
PHF			0	.95	0.95	0.9	95	0.95	0.9	5	0.95	0.95	0.95	0.95	0.95	0.95	0.95
% He	avy Vehicle	es		2	0		4	1	1	l l	1	2	2	0	0	2	1
Lane	Groups			L	LT	F	١ .		LT	7	R	L	TR		L	TR	
Arriv	al Type			3	3	3	3		3		3	5	5		5	5	
RTO	R Vol (vph)				20				30	0			0			100	
Peds/	Hour				5				()			5			5	
% Gr	ade				0				C)			0			0	
Buses	s/Hour				0				0				0			0	
Parke	ers/Hour (Le	ft Right)								-							
Signa	al Settings: A	Actuated			Operati	onal A	nalysi	is	C	ycle L	ength: 1	150.0 Se	с	Lost Tin	ne Per Cyc	le: 20.0 S	ec
Phase	e:	1		2	2	3	3	4	-		5	6		7	8	Pe	d Only
EB		LTI	2]	R										
WB				LT	ГР												
NB						L	ГР	Т	P								
SB								Т	P		TR						
Greei		39.0			5.0		0.0	56			6.0				0		
Yello	w All Red	3.5	1.5	3.5	1.5	3.0	0.0	3.5	1.5	3.5	1.5						

	nne Cap oup (vph)	v/s						Approa	CII.						
App Gr	nne Cap oup (vph)		Capacity Analysis Results Lane Cap v/s g/C Lane v/c Delay												
App Gr	oup (vph)		g/C			Delay		Delay							
EB		Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS						
*]	L 460	0.292	0.260	L	1.122	135.1	F	99.3	F						
L	T 462	0.225	0.260	LT	0.866	68.1	Е								
R	639	0.054	0.413	R	0.131	27.3	С								
WB															
* L	T 74	0.040	0.040	LT	1.000	176.6	F	177.5	F						
R	. 64	0.039	0.040	R	0.984	178.5	F								
NB															
]	L 236	0.137	0.133	L	1.025	123.7	F	85.2	F						
* T	R 2677	0.607	0.527	TR	1.152	82.2	F								
SB															
*]	L 72	0.041	0.040	L	1.028	184.0	F	34.9	С						
Т	R 2219	0.427	0.447	TR	0.955	29.7	С								

Intersection: Delay = 72.6 sec/veh SIG/Cinema v3.08

Int. LOS=E $X_c = 1.13$

* Critical Lane Group

 $\sum (v/s)$ Crit= 0.98

Marvin & Associates

Mary Opt 2 Phase 1 Alt 2035 R Marvin PM Design Hour Airport Road/Main Street 10/12/2011

Case: Airport Main Mary Op2 Phase 1 2035 PM

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	1714 400 70
EB	L	18 / 19	4.0	0.0	4 14 1 1 1 1
	LT	17 / 19	5.3	0.0	90 ← 40
	R	1 / 2	17.9	0.0	
	All		5.0	0.0	
					<u> </u>
WB	LT	3/3	5.1	0.0	
	R	3 / 4	9.5	0.0	850 -
	All		7.4	0.0	20
NB	L	13 / 16	2.9	0.0	100 —
	TR	25 / 30	7.0	12.9	
					230 10 2918
	All		6.4	12.9	
SB	L	4 / 6	7.2	0.0	1 2 3 4 1
	TR	11 / 18	10.0	0.0	
					$\begin{bmatrix} 38 & 4 & 2 & 5 & & 4 & 2 & 20 & & & & & & & & & & & & & & & $
	All		9.8	0.0	5 4
	Inte	rsect.	6.9		5 4 2

Mary Option 2 Alt 2035 Phase 1 1st Ave N/ Area Type: Non CBD R Marvin 10/12/2011 Analysis Duration: 15 mins. PM design Hour Case: US 87 MAIN FIRST Mary Op2 2035 PM Phase 1

PM	design F	Iour				Case	e: US 87	7 MAIN	FIRST	Mary O	p2 203:	5 PM Ph	ase 1	
	Lanes				Geo	metry: Mo	vements	Serviced b	y Lane ar	nd Lane W	idths (f	eet)		
	Approach	Outbound	La	ne 1	La	ne 2	La	ne 3	Laı	ne 4	La	ne 5	La	ne 6
EB	4	2	L	12.0	L	12.0	L	12.0	T	12.0				
WB	3	2	T	12.0	Т	12.0	R	12.0						
NB	0	3												
SB	4	0	L	12.0	L	12.0	R	12.0	R	12.0				
				East			West			North			South	
	Data		L	Т	R	L	T	R	L	T	R	L	T	R
Move	ment Volur	ne (vph)	1800	600	0	0	610	890	0	0	0	850	0	670
PHF			0.95	0.95	0.90	0.90	0.95	0.95	0.90	0.90	0.90	0.95	0.90	0.95
% He	avy Vehicle				2	2	2	4	2	2	2	4	2	2
Lane	Groups		L T				Т	R				L		R
Arriva	al Type		5	5			3	3				5		5
RTOF	R Vol (vph)			0			250			0			0	
Peds/l	Hour			5			0			0			0	
% Gra	ade			0			0			0		0		
Buses	/Hour			0			0			0			0	
Parke	rs/Hour (Le	ft Right)												
Signa	l Settings: A	Actuated		Operat	ional Analy	ysis	Cycle	e Length:	130.0 Sec	;	Lost Tim	e Per Cyc	le: 15.0 S	ec
Phase	:	1		2	3	4		5	6		7	8	Pe	d Only
EB		LT												
WB				TP	R									
NB														
SB		R		LP										
Green	1	52.0	.0 26.0 37.0											0
Yello	w All Red	3.5	1.5 3.:	1.5	3.5 1.	5								

			Canac	city Analysis R	esults				Approa	ch·
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
EB	* L	2060	0.368	0.400	L	0.920	28.7	С	29.4	C
	T	745	0.339	0.400	Т	0.848	31.2	С		
WB										
	* T	708	0.181	0.200	T	0.907	65.9	Е	49.0	D
	R	812	0.434	0.523	R	0.830	33.0	С		
SB										
	* L	958	0.266	0.285	L	0.934	50.3	D	28.3	С
	R	2015	0.253	0.723	R	0.350	0.5	A		

Intersection: Delay = 33.8 sec/veh SIG/Cinema v3.08

Int. LOS=C

 $X_c = 0.92$ * Critical Lane Group

 \sum (v/s)Crit= 0.82

Marvin & Associates

Mary Option 2 Alt 2035 Phase 1 R Marvin PM design Hour 1st Ave N/ 10/12/2011

Case: US 87 MAIN FIRST Mary Op2 2035 PM Phase

App EB	Lane Group L T	Queues Per Lane Avg/Max (veh) 18 / 27 12 / 17	Average Speed (mph) 4.5 6.8	Spillback in Worst Lane (% of Peak Period) 3.0 0.2	670 850
	All		4.9	3.0	<u> </u>
WB	Т	11 / 13	5.7	0.0	 -
	R	22 / 28	5.4	3.4	
	All		5.5	3.4	1800 —
					600
	All		6.7	0.0	
SB	L	16 / 18	4.1	0.0	
	R	1 / 1	22.3	0.0	51 4 2 25 4 2 36 4 2
	Inte	rsect.	5.5		

Mary Opt 2 2035 Phase 1 Old US 87/I90 EB Off Ramp Area Type: Non CBD

R Marvin 10/13/2011 Analysis Duration: 15 mins.

PM Design Hour. Case: EB Papper US 87 Opt 2035 PM Phase 1

	I Design I	Hour		Case: EB Ramps US 87 Op2 2035 PM Phase 1 Geometry: Movements Serviced by Lane and Lane Widths (feet)											111113.
	Lanes					Geon	netry: Mo	vements	Serviced b	y Lane ar	nd Lane W	/idths (fe	eet)		
	Approach	Outbound	I	Lane 1		Lan	e 2	Laı	ne 3	La	ne 4	La	ne 5	Laı	ne 6
EB	3	2	L	12.0)	Т	12.0	Т	12.0						
WB	2	2	Т	12.0) 7	ΓR	12.0								
NB	2	1	L	12.0) 7	ΓR	12.0								
SB	0	0													
	•			East	 :			West			North			South	
	Data		L	Т		R	L	Т	R	L	Т	R	L	Т	R
Move	ement Volun	ne (vph)	495	460)	0	0	620	20	622	5	350	0	0	0
PHF			0.92	0.92	2 0	.90	0.90	0.92	0.92	0.92	0.92	0.92	0.90	0.90	0.90
% He	avy Vehicle	es	4	1		2	2	2	2	5	0	2	2	2	2
Lane	Lane Groups		L	Т				TR		L	TR				
Arriv	al Type		3	3				3		3	3				
RTO	R Vol (vph)			0				5			100			0	
Peds/	Hour			5				0			0		5		
% Gr	ade			0				0		0			0		
Buses	s/Hour			0				0		0				0	
Parke	ers/Hour (Le	ft Right)													
Signa	al Settings: A	Actuated		Opera	tional	Analys	sis	Cycle	Length:	120.0 Sec	2	Lost Tim	e Per Cyc	le: 9.0 S	ec
Phase	e:	1		2		3	4		5	6		7	8	Pe	d Only
EB		LT		LT											
WB			TR												
NB					I	TP									
SB															
Greei		32.0		25.0		19.0	ļ.,								0
Yello	w All Red	4.0	0.0	3.5 1.5	3.5	1.5	:		1						

			Canad	city Analysis R	eculte				Approa	ch:
	Long									
App	Lane Group	LOS	Delay (sec/veh)	LOS						
EB	* Lper	(vph) 61	Ratio 0.307	g/C Ratio 0.250	Group	Ratio	Delay (sec/veh)	LOD	50.5	D
	* Lpro	463	0.267	0.267	L	1.027	81.3	F		
	T	1817	0.140	0.508	Т	0.275	17.2	В		
WB										
	TR	735	0.196	0.208	TR	0.939	68.0	Е	68.0	Е
NB										
	* L	699	0.395	0.408	L	0.967	60.6	Е	50.4	D
	TR	648	0.174	0.408	TR	0.427	25.6	С		
				_			_			

Intersection: Delay = 55.0 sec/veh Int. LOS=D SIG/Cinema v3.08

X = 1.0

* Critical Lane Group

 $\sum (v/s)$ Crit= 0.97

Marvin & Associates

Mary Opt 2 2035 Phase 1 R Marvin PM Design Hour Old US 87/I90 EB Off Ramp 10/13/2011

Case: EB Ramps US 87 Op2 2035 PM Phase 1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)				
EB	L	26 / 29	2.7	53.8				
	Т	6 / 11	6.6	14.8				
	All		4.7	53.8				←
						-		
WB	TR	9 / 11	6.8	0.0			 → 	
					495 —	-		•
	All		6.8	0.0	460 →			
NB	L	17 / 24	6.2	0.8				
	TR	4 / 8	15.0	0.0				↑
								622 35
	All		7.9	0.8				
					1	2	3	
					\rightarrow	<u></u>	=	⇔ ∱.>
					32 4	0 24	4 2 48	1 4 2
	Inte	rsect.	6.1					

Mary Op2 Alt 2035 Phase 1 Old US 87/I90 WB On Ramp Area Type: Non CBD

R Marvin 10/13/2011 Analysis Duration: 15 mins.

PM Design Hour Case: WB Ramps US 87 Mary OP2 2035 PM Phase 1

	narvın Design I	Hour							3/2011 e: WB I	Ramps U	S 87 M	ary OP2	anaiysis 2 2035	PM Phas	n: 15 i se 1	nins.
	Lanes						Geom	etry: Mo	vements	Serviced b	y Lane ar	nd Lane W	Vidths (f	eet)		
	Approach	Outboun	ıd	Lane	e 1		Lane	e 2	La	ne 3	La	ne 4	La	ine 5	Laı	ne 6
EB	2	2		Т	12.0	Т	R	12.0								
WB	3	2		L	12.0	-	Γ	12.0	Т	12.0						
NB	0	0														
SB	1	1	L	TR	12.0											
					East				West			North			South	
	Data			L	Т	I	3	L	Т	R	L	Т	R	L	Т	R
Move	ment Volur	ne (vph)		0	926	4	22	220	1020	0	0	0	0	20	1	328
PHF			0	.90	0.92	0.	92	0.92	0.92	0.90	0.90	0.90	0.90	0.92	0.92	0.92
% He	avy Vehicle	es		2	5		5	1	5	2	2	2	2	1	0	5
Lane	Lane Groups				TR			L	Т						LTR	
Arriv	al Type				2			2	2						3	
RTOI	R Vol (vph)				150				0			0			100	
Peds/	Hour				0				5			0			0	
% Gr	ade				0				0		0			0		
Buses	/Hour				0				0		0				0	
Parke	rs/Hour (Le	ft Right)													
Signa	1 Settings: A	Actuated			Operat	ional A	Analys	is	Cycl	e Length:	80.0 Sec	2	Lost Tin	ne Per Cyc	le: 14.0 S	ec
Phase	:	1		2	2		3	4		5	6		7	8	Pe	d Only
EB	TR															
WB		LT	` _	Ľ	Г											
NB																
SB						L	ΓR									
Greer	1	10.	.0		5.0		0.0	ļ .								0
Yello	w All Red	4.0	0.0	3.5	1.5	3.5	1.5									

	Capacity Analysis Results Approach: Delay Delay Delay													
	1			ch:										
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS				
EB	Group	(VpII)	Ratio	Ratio	Group	Ratio	(SCC/VCII)	LOS	(SCC/VCII)	LOS				
LD														
	* TR	1494	0.392	0.450	TR	0.872	30.9	С	30.9	С				
WB	Lper		16.5	В										
	* Lpro	C												
	T	2149	0.323	0.625	T	0.516	12.9	В						
SB														
	* LTR	395	0.172	0.250	LTR	0.686	31.2	C	31.2	C				

Mary Op2 Alt 2035 Phase 1 R Marvin PM Design Hour Old US 87/I90 WB On Ramp

10/13/2011

Case: WB Ramps US 87 Mary OP2 2035 PM Phase

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	1 328 20 ,
ЕВ	TR	10 / 13	11.9	0.0	→1020 →220
	All		11.9	0.0	
WB	L	5 / 6	4.6	0.0	
	Т	4 / 5	18.2	0.0	
	All		14.5	0.0	926 → 422 →
	All		13.4	0.0	
					1 2 3 1
SB	LTR	4 / 7	13.4	0.0	
					$\begin{bmatrix} 10 & \downarrow & \downarrow & \downarrow \\ 4 & 0 & 35 & 4 & 2 & 19 & 4 & 2 \end{bmatrix}$
	Inte	rsect.	13.0		

Five Mile Alt 2035 Phase 2 Wicks Lane/Main Street Area Type: Non CBD

R Marvin 8/15/13 Analysis Duration: 15 mins.

PM Case: Wicks Main Five Mile 2035 PM

PM	[Case: Wicks Main Five Mile 2035 PM Geometry: Movements Serviced by Lane and Lane Widths									PM Î				
	Lanes				G	eom	etry: Mo	vement	s Service	d by	y Lane an	d Lane W	idths (f	eet)		
	Approach (Outbound	I	Lane 1		Lane	2	L	ane 3		Lar	ne 4	La	ne 5	Laı	ne 6
EB	3	2	L	12.0	Т		12.0	TR	12.0)						
WB	3	2	L	12.0	LT	·	12.0	TR	12.0)						
NB	5	3	L	12.0	L		12.0	T	12.0)	T	12.0	TR	12.0		
SB	4	3	L	12.0	Т		12.0	T	12.0)	TR	12.0				
				East				West				North			South	
	Data		L	Т	R		L	Т	R		L	Т	R	L	Т	R
Move	ement Volun	ne (vph)	258	450	162	2	520	390	80)	403	1450	380	140	920	287
PHF			0.92	0.92	0.92	2	0.92	0.92	0.92	2	0.92	0.92	0.92	0.92	0.92	0.92
% He	avy Vehicle	s	0	0	0		0	0	0		0	2	1	0	2	0
Lane	Lane Groups		L	TR			L	LTR			L	TR		L	TR	
Arriv	al Type		5 5			3		3			5	5		4	4	
RTO	R Vol (vph)			80				30				100			100	
Peds/	Hour			0				5				5			5	
% Gr	ade			0				0				0		0		
Buses	s/Hour			0				0		_		0			0	
Parke	ers/Hour (Le	ft Right)														
Signa	ll Settings: A	Actuated		Opera	ional Ar	alysi	is	Cyc	le Lengt	h: 1	30.0 Sec	;	Lost Tim	ne Per Cyc	le: 18.0 S	ec
Phase	:	1		2	3		4		5		6		7	8	Pe	d Only
EB							LT	R								
WB					LTI	2										
NB		L		TP												
SB		L		TP												
Green	ı	19.0		43.0	25.		25									0
Yello	w All Red	3.0	0.0 3	3.5 1.5	3.5	1.5	3.5	1.5								

			Capac	ity Analysis R	esults				Approa	ch:
App EB	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
	L	347	0.155	0.192	L	0.807	60.2	Е	57.0	Е
	* TR	678	0.164	0.192	TR	0.853	55.5	Е		
WB										
	* L	347	0.223	0.192	L	1.159	151.2	F	104.0	F
	LTR	676	0.182	0.192	LTR	0.948	74.3	Е		
NB										
	* L	512	0.125	0.146	L	0.855	64.6	Е	95.5	F
	* TR	1640	0.379	0.331	TR	1.146	102.7	F		
SB										
	L	264	0.084	0.146	L	0.576	60.6	Е	42.2	D
	TR	1638	0.243	0.331	TR	0.734	39.9	D		

Intersection: Delay = 78.2 sec/veh SIG/Cinema v3.08

Int. LOS=E

 $X_c = 1.03$ * Critical Lane Group

 $\sum (v/s)$ Crit= 0.89

Marvin & Associates

Five Mile Alt 2035 Phase 2 R Marvin PM Wicks Lane/Main Street 8/15/13

Case: Wicks Main Five Mile 2035 PM

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	920 287 140
EB	L	10 / 14	3.9	0.1	
	TR	3 / 6	11.7	0.0	
					520
	All		7.8	0.1	<u></u>
WB	L	12 / 14	3.7	0.0	
	LTR	12 / 13	5.9	0.0	
					258 -
	All		5.1	0.0	450 →
NB	L	8/9	3.9	0.0	162 —
	TR	13 / 28	5.2	4.2	
					403 380 1450
	All		4.9	4.2	
SB	L	9 / 11	3.3	0.0	1 2 1 3 4
	TR	9 / 13	7.3	0.0	
					19 3 0 42 4 2 24 4 2 24 4
	All		6.5	0.0	
	Inte	rsect.	5.7		

Five Mile Alt 2035 Phase 1 Airport Road/Main Street Area Type: Non CBD

R Marvin 8/15/13 Analysis Duration: 15 mins.

PM	I Design I	Hour		Case: Airport Main Fiv Geometry: Movements Serviced by L								Five M			Darane	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	1111151
	Lanes						Geom	etry: Mo	oveme	nts Sei	viced b	y Lane a	nd Lane W	idths (f	eet)		
	Approach	Outboun	d	Lane	e 1		Lane	2		Lane	3	La	ne 4	La	ine 5	La	ne 6
EB	3	1		L	12.0	L	Т	12.0	R		12.0						
WB	2	2	I	LT	12.0	F	۲ .	12.0									
NB	4	3		L	12.0	7	Γ	12.0	Т		12.0	TR	12.0				
SB	4	3		L	12.0	1	Γ	12.0	Т		12.0	TR	12.0				
	•				East				We	st			North			South	
	Data			L	Т	F	2	L	Т		R	L	Т	R	L	Т	R
Move	ement Volur	ne (vph)	8	350	20	10	00	30	40	0	90	230	3053	10	70	1822	400
PHF			0	.95	0.95	0.9	95	0.95	0.9	5	0.95	0.95	0.95	0.95	0.95	0.95	0.95
% He	avy Vehicle	es		2	0		4	1	1	1	1	2	2	0	0	2	1
Lane	Lane Groups			L	LT	F	2		LT	Γ	R	L	TR		L	TR	
Arriv	al Type			3	3	3	3		3		3	5	5		5	5	
RTO	R Vol (vph)							30	0			0			100		
Peds/	Hour				5				()			5			5	
% Gr	ade				0				0		0			0			
Buses	s/Hour				0				0			0				0	
Parke	ers/Hour (Le	ft Right)								-							
Signa	al Settings: A	Actuated			Operati	onal A	nalysi	is	C	ycle L	ength: 1	50.0 Se	с	Lost Tin	ne Per Cyc	le: 20.0 S	ec
Phase	e:	1		2	2	3	3	4	-		5	6		7	8	Pe	d Only
EB		LTF)]	R										
WB				L	ГР												
NB						L	ГР	Т									
SB								Т	P		TR						
Greei		39.0			5.0		7.0	59			6.0						0
Yello	w All Red	3.5	1.5	3.5	1.5	3.0	0.0	3.5	1.5	3.5	1.5						

	Capacity Analysis Results Approach: Lane Cap v/s g/C Lane v/c Delay Delay													
	1	I	Approa	ch:										
	Lane		Delay											
App	Group	(vph)	Ratio	g/C Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS				
EB														
	* L	460	0.292	0.260	L	1.122	135.1	F	99.4	F				
	LT	462	0.225	0.260	LT	0.866	68.1	Е						
	R	608	0.054	0.393	R	0.138	29.2	C						
WB														
	* LT	74	0.040	0.040	LT	1.000	176.6	F	177.5	F				
	R	64	0.039	0.040	R	0.984	178.5	F						
NB														
	L	201	0.137	0.113	L	1.204	190.1	F	111.0	F				
	* TR	2677	0.634	0.527	TR	1.205	105.1	F						
SB														
	* L	72	0.041	0.040	L	1.028	184.0	F	32.8	С				
	TR	2322	0.449	0.467	TR	0.962	27.8	С						

Intersection: Delay = 84.5 sec/veh SIG/Cinema v3.08

Int. LOS=F

 $X_c = 1.16$ * Critical Lane Group

 \geq (v/s)Crit= 1.01

Marvin & Associates

Five Mile Alt 2035 Phase 1 R Marvin PM Design Hour Airport Road/Main Street

8/15/13

Case: Airport Main Five Mile 2035 PM

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	1822
EB	L	17 / 18	4.3	0.0	→
	LT	16 / 17	5.8	0.0	— 90 ← 40
	R	1 / 2	17.9	0.0	30
	All		5.4	0.0	<u> </u>
					<u> </u>
WB	LT	3/3	5.1	0.0	
	R	3 / 4	9.4	0.0	850 -
	All		7.4	0.0	20
NB	L	17 / 20	1.7	0.0	100 —
	TR	28 / 30	6.0	28.3	
					230 10 3053
	All		5.2	28.3	3033
SB	L	6/9	2.8	0.0	1 2 3 4
	TR	11 / 17	10.5	0.0	
					38 4 2 5 4 2 17 3 0 58 4 2
	All		9.6	0.0	5 1
	Inte	rsect.	6.3		5 4 2

Mary Five Mile Alt 2035 Phase 1 1st Ave N/ Area Type: Non CBD

R Marvin 8/15/13 Analysis Duration: 15 mins.

PM design Hour Case: US 87 MAIN FIRST Five Mile 2035 PM

PM	I design H	Iour						Case	e: US 8	7 MAIN	FIRST	Five Mi	ile 2035	5 PM	11. 151	
	Lanes						Geom	etry: Mo	ovements	Serviced b	y Lane ar	nd Lane W	/idths (f	eet)		
	Approach (Outbound	i	Lane	1		Lane	e 2	La	nne 3	La	ne 4	La	ane 5	La	ne 6
EB	4	2	I	L	12.0	I		12.0	L	12.0	Т	12.0				
WB	3	2	-	Γ	12.0	7	Γ	12.0	R	12.0						
NB	0	3														
SB	4	0	I	L	12.0	I		12.0	R	12.0	R	12.0				
	•				East				West			North			South	
	Data		I	L	T	F	۲ .	L	Т	R	L	Т	R	L	Т	R
Move	ement Volun	ne (vph)	18	800	600		0	0	610	1006	0	0	0	974	0	670
PHF			0.	95	0.95	0.9	90	0.90	0.95	0.95	0.90	0.90	0.90	0.95	0.90	0.95
% Не	% Heavy Vehicles			2	2		2	2	2	4	2	2	2	4	2	2
Lane	Lane Groups		I	L	T				Т	R				L		R
Arriv	al Type			5	5				3	3				5		5
RTO	R Vol (vph)			0					250			0			0	
Peds/	Hour				5				0			0			0	
% Gr	ade				0				0	0		0		0		
Buse	s/Hour				0				0		0				0	
Parke	ers/Hour (Le	ft Right)														
Signa	al Settings: A	Actuated		(Operat	ional A	analys	is	Cycl	e Length:	140.0 Sec	2	Lost Tin	ne Per Cyc	le: 10.0 S	ec
Phase	e:	1		2	2	3	3	4		5	6		7	8	Pe	d Only
EB	LT															
WB	TP R		R													
NB																
SB		R					P									
Green		54.0	1.5		3.0		3.0									0
Yello				3.5	1.5	3.5	1.5									

	Capacity Analysis Results Approach: Lane Cap y/s g/C Lane y/c Delay Delay													
	Lane Cap v/s g/C Lane v/c Delay													
		Cap		g/C			Delay	1.00	Delay	1.00				
App	Group	(vpn)	Ratio	Ratio	Group	Ratio	(sec/ven)	LOS	(sec/veh)	LOS				
EB	_		_											
	* L	1986	0.368	0.386	L	0.954	36.2	D	36.6	D				
	T	719	0.339	0.386	T	0.879	37.6	D						
WB														
	T	708	0.181	0.200	Т	0.907	69.8	Е	58.1	Е				
	* R	843	0.513	0.543	R	0.944	48.6	D						
SB														
	L	1034	0.304	0.307	L	0.991	60.0	Е	35.7	D				
	R	2031	0.253	0.729	R	0.347	0.5	A						
							•							

Intersection: Delay = 41.8 sec/veh SIG/Cinema v3.08

Int. LOS=D

 $X_c = 0.95$ * Critical Lane Group

 \sum (v/s)Crit= 0.88

Marvin & Associates

Mary Five Mile Alt 2035 Phase 1 R Marvin PM design Hour 1st Ave N/ 8/15/13

Case: US 87 MAIN FIRST Five Mile 2035 PM

App EB	Lane Group L T	Queues Per Lane Avg/Max (veh) 21 / 29 13 / 21	Average Speed (mph) 4.3 6.5	Spillback in Worst Lane (% of Peak Period) 8.7 0.0	670 974
	All		4.7	8.7	
WB	T	11 / 13	5.9	0.0	 -
	R	28 / 30	4.2	24.6	
	All		4.8	24.6	1800 - 600 →
					600
	A 11		5.0	0.0	
GD.	All	10 / 21	5.9	0.0	
SB	L	19 / 21	3.7	0.0	
	R	1 / 2	22.6	0.0	53 4 2 27 4 2 42 4 2
	IX	1 / 2	22.0	0.0	
	Inte	rsect.	5.0		

Five Mile Alt 2035 Old US 87/I90 EB Off Ramp Area Type: Non CBD R Marvin 8/15/13 Analysis Duration: 15 mins. PM Design Hour Phase 1 Case: EB RAMPS US 87 Five Mile Alt 2035 PM

PIVI	Design i	Hour Pha	ase 1	L				Case	3: EB 1	KAMPS	ted by Lane and Lane Widths (feet)					
	Lanes						Geom	etry: Mo	ovement	s Serviced	by Lane a	nd Lane V	Vidths (f	eet)		
	Approach	Outbound		Lane	: 1		Lan	e 2	L	ane 3	La	ne 4	La	ine 5	L	ane 6
EB	3	2	L		12.0	7	Γ	12.0	Т	12.0						
WB	2	2	Т		12.0	Т	R	12.0								
NB	2	1	L	,	12.0	Т	R	12.0								
SB	0	0														
					East				West			North			South	
	Data		L	,	T	I	2	L	Т	R	L	Т	R	L	Т	R
Move	ment Volur	ne (vph)	48	30	530		0	0	690	20	660	5	350	0	0	0
PHF			0.9	92	0.92	0.	90	0.90	0.92	0.92	0.92	0.92	0.92	0.90	0.90	0.90
% He	% Heavy Vehicles Lane Groups		4	4	1		2	2	2	2	5	0	2	2	2	2
Lane	Lane Groups		L	,	T				TR		L	TR				
Arriv	Arrival Type		3	<u> </u>	3				3		3	3				
RTOI	RTOR Vol (vph)			0					5			100			0	
Peds/	Hour			5					0			0			5	
% Gr	ade				0				0			0			0	
Buses	s/Hour				0				0			0			0	
Parke	rs/Hour (Le	ft Right)														
Signa	l Settings: A	Actuated		(Operat	onal A	Analys	sis	Сус	le Length	: 120.0 Se	С	Lost Tin	ne Per Cyc	cle: 9.0	Sec
Phase	:	1		2	!	3	3	4	1	5	6		7	8	F	ed Only
EB		LT		LT	Γ											
WB		T	R													
NB	NB			L	ГР											
SB																
Greer		32.0		28			6.0	<u> </u>								0
Yello	w All Red	4.0	0.0	3.5	1.5	3.5	1.5									

	Capacity Analysis Results Approach: Lane Cap v/s g/C Lane v/c Delay Delay Oroup Group (vph) Ratio Ratio Group Ratio (sec/veh) LOS (sec/veh) LOS												
	_			CII.									
	Lane	1.00	Delay	1.00									
App	* I per	(vph)	(sec/veh)	LOS	(sec/veh)	LOS							
EB	Eper	61			43.4	D							
	* Lpro	463	0.267	0.267	L	0.996	73.7	Е					
	T	1906	0.161	0.533	T	0.302	16.0	В					
WB													
	TR	823	0.217	0.233	TR	0.931	63.5	Е	63.5	Е			
NB													
	* L	656	0.419	0.383	L	1.093	100.2	F	80.0	F			
	TR	609	0.174	0.383	TR	0.455	27.8	С					

Intersection: Delay = 61.5 sec/veh SIG/Cinema v3.08

Int. LOS=E

= 1.03 * Critical Lane Group

 \geq (v/s)Crit= 0.95

Marvin & Associates

Five Mile Alt 2035 R Marvin PM Design Hour Phase 1 Old US 87/I90 EB Off Ramp 8/15/13

Case: EB RAMPS US 87 Five Mile Alt 2035 PM

App EB	Lane Group L	Queues Per Lane Avg/Max (veh) 26 / 29 5 / 8	Average Speed (mph) 2.3 8.3	Spillback in Worst Lane (% of Peak Period) 49.6 7.3	<u>↑</u> 20 ↓ 690
	All		5.2	49.6	
WB	TR	10 / 12	7.0	0.0	480 -
	All		7.0	0.0	$\begin{bmatrix} 480 \\ 530 \end{bmatrix} \longrightarrow \begin{bmatrix} 480 \\ 1 \end{bmatrix}$
NB	L	25 / 29	4.1	23.6	
	TR	5 / 10	14.1	0.0	
					660 350
	All		5.4	23.6	
					1 2 3
					32 4 0 27 4 2 45
	Inte	rsect.	5.7		

Five Mile Alt 2035 Phase 1 Old US 87/I90 WB On Ramp Area Type: Non CBD

R Marvin 8/15/13 Analysis Duration: 15 mins.

PM Design Hour Case: WB RAMPS US 87 Five Mile 2035 PM

PM	I Design I	Hour						Case	e: WB 1	RAMPS	US 87 I	Five Mil	e 2035	PM	15 1	
	Lanes						Geom	etry: Mo	vements	Serviced 1	y Lane ar	nd Lane W	/idths (f	eet)		
	Approach (Outboun	d	Lane	e 1		Lan	e 2	La	ane 3	La	ne 4	La	ane 5	La	ne 6
EB	2	2		Т	12.0	Т	R	12.0								
WB	3	2		L	12.0	7	Γ	12.0	Т	12.0						
NB	0	0														
SB	1	1	L	TR	12.0											
					East				West			North			South	
	Data			L	Т	I	۲ .	L	Т	R	L	Т	R	L	T	R
Move	ement Volun	ne (vph)		0	990	4	60	220	1130	0	0	0	0	20	1	320
PHF			0	.90	0.92	0.	92	0.92	0.92	0.90	0.90	0.90	0.90	0.92	0.92	0.92
% He	% Heavy Vehicles			2	5		5	1	5	2	2	2	2	1	0	5
Lane	Lane Groups				TR			L	Т						LTR	
Arriv	al Type				2			2	2						3	
RTO	R Vol (vph)			150					0			0			100	
Peds/	Hour				0				5			0			0	
% Gr	ade				0				0			0		0		
Buses	s/Hour				0				0			0			0	
Parke	ers/Hour (Le	ft Right)														
Signa	al Settings: A	Actuated			Operat	ional A	analys	is	Cycl	e Length:	80.0 Sec	2	Lost Tin	ne Per Cyc	le: 14.0 S	ec
Phase	e:	1		2	2	3	3	4		5	6		7	8	Pe	d Only
EB				T	R											
WB	B LT LT															
NB																
SB						L	ΓR									
Greei		10.0			7.0		9.0	ļ .								0
Yello	Yellow All Red 4.0			3.5	1.5	3.5	1.5									

	Capacity Analysis Results Approach: Lane Cap v/s g/C Lane v/c Delay Delay Group Group (vph) Ratio Ratio Group Ratio (sec/veh) LOS (sec/veh) LOS												
App	Lane Group	LOS	Delay (sec/veh)	LOS									
EB	Огоцр	(1011)	Ratio	Tutto	Group	Ratio	(Bee/ Veil)	LOD	(Bee/ Veil)	Los			
	* TR	1533	0.426	0.463	TR	0.922	34.7	C	34.7	C			
WB	Lper	94	0.089	0.525					16.5	В			
	* Lpro	223	0.125	0.125	L	0.754	34.3	C					
	T	2192	0.357	0.637	Т	0.560	13.1	В					
SB													
	* LTR	375	0.166	0.237	LTR	0.699	32.7	C	32.7	C			

Intersection: Delay = 26.1 sec/veh SIG/Cinema v3.08

Int. LOS=C

0.87 * Critical Lane Group

 \geq (v/s)Crit= 0.72

Marvin & Associates

Five Mile Alt 2035 Phase 1 R Marvin PM Design Hour Old US 87/I90 WB On Ramp 8/15/13

Case: WB RAMPS US 87 Five Mile 2035 PM

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	1 320 20
ЕВ	TR	10 / 14	12.5	0.0	→1130 →220
	All		12.5	0.0	
WB	L	5 / 7	4.8	0.0	
	Т	6 / 7	17.5	0.0	
	All		14.3	0.0	990
					460 —
	All		12.0	0.0	
SB	LTR	4 / 7	12.0	0.0	
					10 4 0 36 4 2 18 4 2
	Inte	rsect.	13.1		

APPENDIX C

Phase 1 Alignments Intersections Capacity

Mary Op 2 Phase 1 Signals

I90 EB Off Ramp/Johnson Lane Area Type: Non CBD

R Marvin

06/08/2013

Analysis Duration: 15 mins.

2035 PM

Case: 190 EB Ramp Johnson MAry Op 2 Phase 1

	35 PM						e: I90 E	B Ramp	Johnso	n MAry	Op 2 P	hase 1	11. 131	111115.
	Lanes				Geor	metry: Mo	vements	Serviced b	y Lane ar	nd Lane W	/idths (fe	eet)		
	Approach	Outbound	La	ne 1	La	ne 2	La	ne 3	La	ne 4	La	ne 5	La	ne 6
EB	3	1	L	12.0	LT	12.0	R	12.0						
WB	0	0												
NB	3	2	T	12.0	T	12.0	R	12.0						
SB	2	2	L	12.0	Т	12.0								
				East			West			North			South	
	Data		L	T	R	L	Т	R	L	Т	R	L	Т	R
Move	ement Volui	me (vph)	480	1	675	0	0	0	0	730	230	269	528	0
PHF			0.95	0.95	0.95	0.90	0.90	0.90	0.90	0.95	0.95	0.95	0.95	0.90
% He	% Heavy Vehicles		4	0	8	2	2	2	2	4	8	8	4	2
Lane	Lane Groups		L	LT	R					T	R	L	T	
Arriv	al Type		3	3	3					3	3	3	3	
RTO	R Vol (vph)		300				0			80			0	
Peds/	Hour			5			0			5			5	
% Gr	ade			0			0		0			0		
Buses	s/Hour			0		0				0			0	
Parke	ers/Hour (Le	eft Right)												
Signa	d Settings: A	Actuated		Operat	ional Analy	ysis	Cycle	e Length:	90.0 Sec	2	Lost Tim	e Per Cyc	le: 10.0 S	lec
Phase	:	1		2	3	4	-	5	6		7	8	Pe	ed Only
EB					LTR									
WB														
NB				TP										
SB		LT		LT										
Gree		15.0		30.0	35.0									0
Yello	w All Red	0.0	0.0 3.5	5 1.5	3.5 1.	5								

			Capac	city Analysis R	esults				Approa	ch:
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
EB	L	675	0.145	0.200	т.	0.272	10.0	D	22.2	<u> </u>
	LT	675 677	0.145 0.146	0.389	L LT	0.373 0.375	19.8 19.8	B B	22.3	С
	* R	581	0.140	0.389	R	0.575	25.5	C		
	- 10	301	0.201	0.505	- 10	0.000	25.5			
NB										
	* T	1157	0.221	0.333	T	0.664	26.8	C	26.1	C
	R	495	0.106	0.333	R	0.319	22.5	C		
SB	Lper	124	0.013	0.389					17.5	В
	* Lpro	279	0.167	0.167	L	0.702	18.3	В		
	T	914	0.304	0.500	T	0.608	17.0	В		

Intersection: Delay = 22.1 sec/veh SIG/Cinema v3.08

Int. LOS=C

= 0.73 * Critical Lane Group

 \geq (v/s)Crit= 0.65

Marvin & Associates

Mary Op 2 Phase 1 Signals R Marvin 2035 PM I90 EB Off Ramp/Johnson Lane

06/08/2013

Case: I90 EB Ramp Johnson MAry Op 2 Phase 1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	528
ЕВ	L	5 / 6	10.7	0.0	→
	LT	3 / 4	14.6	0.0	
	R	3 / 5	18.5	0.0	
	All		15.2	0.0	
	All		11.1	0.0	480 -
					675 —
NB	Т	8 / 9	10.7	0.0	
	R	2 / 4	16.3	0.0	
	All		10.4	0.0	
SB	L	8 / 10	4.1	0.0	
	Т	7 / 8	16.1	0.0	$\begin{vmatrix} 1 & \downarrow \downarrow \\ & \downarrow \end{vmatrix}$, $\begin{vmatrix} 2 & \downarrow \downarrow \\ & \downarrow \end{vmatrix}$, $\begin{vmatrix} 3 & \downarrow \\ & \downarrow \end{vmatrix}$
					15 0 0 29 4 2 34 4 2
	Intersect.		12.2		

Mary Op 2 Phase 1 Signals

R Marvin
2035 PM

I90 WB Off Ramp/Johnson Area Type: Non CBD
Analysis Duration: 15 mins.
Case: I90 WB Ramp Johnson Mary Op2 Phase 1

203	35 PM		Case: I90 WB Ramp Johnson Mary Op2 Phase 1												
	Lanes		Geometry: Movements Serviced by Lane and Lane Widths (feet)												
	Approach	Outbound	Lane 1		Lane 2		Lane 3		Lane 4		La	ne 5	5 Lane 6		
EB	0	0													
WB	2	1	LT	12.0	R	12.0									
NB	2	1	L	12.0	Т	12.0									
SB	1	1	T	12.0											
	<u>'</u>		East				West			North			South		
Data			L	Т	R	L	T	R	L	Т	R	L	T	R	
Move	Movement Volume (vph)			0	0	175	1	188	260	930	0	0	622	0	
PHF	PHF			0.90	0.90	0.95	0.95	0.95	0.95	0.95	0.90	0.90	0.95	0.90	
% He	% Heavy Vehicles			2	2	8	0	8	6	4	2	2	4	2	
Lane	Lane Groups						LT	R	L	Т			T		
Arriv	Arrival Type						3	3	3	3			3		
RTO	RTOR Vol (vph)			0			50			0			0		
Peds/	Peds/Hour			5			0			5			5		
% Gr	ade		0				0			0			0		
Buses	Buses/Hour			0			0		0				0		
Parke	Parkers/Hour (Left Right)														
Signal Settings: Actuated			Operational Analysis			ysis	is Cycle Length:			90.0 Sec Lost Ti			ne Per Cycle: 10.0 Sec		
Phase: 1			2	3		4	5	6		7	8	Pe	Ped Only		
EB															
WB					LTP										
NB		LT		LT											
SB	SB			T											
	Green 1			40.0	25.0									0	
Yello	w All Red	0.0	0.0 3	3.5 1.5	3.5 1.	.5									

Capacity Analysis Results Approach:												
	Approach:											
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS		
WB												
	* LT	461	0.111	0.278	LT	0.401	26.6	С	26.4	C		
	R	415	0.097	0.278	R	0.349	26.2	С				
NB	Lper	188	0.000	0.500					22.5	С		
	Lpro	284	0.161	0.167	L	0.581	15.5	В				
	* T	1116	0.536	0.611	T	0.877	24.5	C				
SB												
	T	812	0.359	0.444	T	0.807	30.1	C	30.1	C		

Intersection: Delay = 25.3 sec/veh SIG/Cinema v3.08

Int. LOS=C

 $X_c = 0.73$ * Critical Lane Group

 \sum (v/s)Crit= 0.65

Marvin & Associates

Mary Op 2 Phase 1 Signals R Marvin 2035 PM I90 WB Off Ramp/Johnson 06/08/2013

Case: I90 WB Ramp Johnson Mary Op2 Phase 1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	622
	All		10.5	0.0	188 -1 -175
WB	LT	3 / 5	10.4	0.0	
	R	3 / 5	10.7	0.0	
	All		13.0	0.0	
NB	L	5 / 5	10.3	0.0	
	Т	12 / 14	13.9	0.0	
	All		10.3	0.0	
					1 2 3
SB	Т	10 / 11	10.3	0.0	
					15 0 0 39 4 2 24 4 2
	Inte	rsect.	11.7		

HCM Analysis Summary

Mary Op 2 Phase 1 Signals

N Frontage/Johnson
Area Type: Non CBD

R Marvin
2035 PM

O6/08/2013
Analysis Duration: 15 mins.
Case: Johnson N Frontage Mary Op 2 Phase 1

203	35 PM							Case	e: Johns	son N F	rontage	Mary O _I	2 Phas	se 1		
	Lanes					(Geome	etry: Mo	vements	Serviced	by Lane a	nd Lane V	/idths (f	eet)		
	Approach	Outbound		Lane	e 1		Lane	2	La	ane 3	La	ine 4	La	ine 5	La	ne 6
EB	2	1	L		12.0	Tl	R	12.0								
WB	2	1	L	_	12.0	TI	R	12.0								
NB	3	1	L	.	12.0	Т	r	12.0	R	12.0						
SB	3	2	L	_	12.0	Т		12.0	TR	12.0						
				•	East				West			North			South	
	Data		L	_	T	R	2	L	Т	R	L	T	R	L	Т	R
Move	ement Volur	ne (vph)	15	50	25	21	10	25	20	25	195	893	30	5	675	100
PHF			0.9	90	0.90	0.9	90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
% He	avy Vehicle	es		1	0		8	1	1	1	8	2	1	1	2	2
Lane	Groups		L	_	TR			L	TR		L	T	R	L	TR	
Arriv	al Type		3	3	3			3	3		3	3	3	3	3	
RTO	R Vol (vph)				100				5			5			20	
Peds/	Hour				0				5			5			0	
% Gr	ade				0				0			0			0	
Buses	s/Hour				0				0			0			0	
Parke	ers/Hour (Le	eft Right)														
Signa	al Settings: A	Actuated			Operati	onal A	nalysi	s	Cyc	e Length:	90.0 Se	С	Lost Tin	ne Per Cyc	le: 10.0 S	Sec
Phase	e:	1		2	2	3	3	4	-	5	6		7	8	Pe	ed Only
EB		LTP														
WB		LTP														
NB				L	ГР		P									
SB						LT										
Greei		20.0			0.0		7.0									0
Yello	w All Red	3.5	1.5	3.0	0.0	3.5	1.5									

					. 1.					,
	1	1	Capac	city Analysis R	lesults		T	T	Approa	ch:
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay	
App	Group	(vpĥ)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB										
	* L	301	0.123	0.222	L	0.555	32.4	C	31.5	C
	TR	346	0.096	0.222	TR	0.434	30.4	C		
WB										
	L	258	0.024	0.222	L	0.109	28.0	C	28.0	C
	TR	384	0.025	0.222	TR	0.115	28.0	С		
NB										
	L	371	0.130	0.222	L	0.585	32.9	C	18.8	В
	* T	1242	0.532	0.667	T	0.799	16.1	В		
	R	1062	0.018	0.667	R	0.026	5.1	A		
SB										
	L	178	0.014	0.411	L	0.034	16.2	В	22.3	С
	TR	1432	0.241	0.411	TR	0.586	22.3	С		

Intersection: Delay = 21.9 sec/veh SIG/Cinema v3.08

Int. LOS=C

= 0.74 * Critical Lane Group

 \sum (v/s)Crit= 0.66

Marvin & Associates

Page 1

Mary Op 2 Phase 1 Signals R Marvin 2035 PM N Frontage/Johnson 06/08/2013

Case: Johnson N Frontage Mary Op 2 Phase 1

App	Lane Group L TR	Queues Per Lane Avg/Max (veh) 4 / 6 3 / 6	Average Speed (mph) 9.4 16.3	Spillback in Worst Lane (% of Peak Period) 0.0 0.0	675 100 5 — 25 — 20 — 25
	All		12.1	0.0	
WB	L	1 / 2	8.3	0.0	
	TR	1 / 2	11.5	0.0	<u> </u>
					$\begin{array}{cccccccccccccccccccccccccccccccccccc$
	All		10.2	0.0	$\begin{array}{c c} 23 \\ 210 \end{array} \longrightarrow \begin{array}{c c} & & & & & & & & & & & & & & & & \\ \end{array}$
NB	L	6 / 7	4.8	0.0	
	T	9 / 12	15.5	0.0	
	R	1 / 1	17.6	0.0	195 30 893
	All		12.7	0.0	
SB	L	1 / 2	8.1	0.0	1 2 3 11
	TR	6/9	12.5	0.0	
					19 4 2 20 7 3 0 36 6 4 2
	All		12.3	0.0	
	Inte	rsect.	12.4		

	TW	O-WAY STOP	CONTR	OL S	UMN	//ARY			
General Information	า		Site I	nform	natio	on			
Analyst	R Marvin		Interse	ection			Mary Opt	2 & Johns	on N
Agency/Co.	Marvin As	ssociates	Lusiadi	ation.			Phase 1 MDT		
Date Performed	6/12/13		Jurisdi		r		2035		
Analysis Time Period	Design H	our PM	Analys	is rea	ll		2035		
Project Description Bill	lings Bypass		L				I		
East/West Street: Mary			North/S	South S	Stree	t: Johnso	n Lane N		
Intersection Orientation:			Study I	Period	(hrs)	: 0.25			
Vehicle Volumes ar	nd Adjustme	nts							
Major Street		Eastbound					Westbou	nd	
Movement	1	2	3			4	5		6
	L	Т	R			L	Т		R
Volume (veh/h)	10	974					690		5
Peak-Hour Factor, PHF	0.95	0.95	1.00)		1.00	0.95		0.95
Hourly Flow Rate, HFR (veh/h)	10	1025	0			0	726		5
Percent Heavy Vehicles	4					0			
Median Type		-		Undi	vided	I		-	
RT Channelized			0						0
Lanes	1	1	0			0	1		0
Configuration	L	T							TR
Upstream Signal		0					0		
Minor Street		Northbound					Southbou	ind	
Movement	7	8	9			10	11		12
	L	Т	R			L	Т		R
Volume (veh/h)						0			30
Peak-Hour Factor, PHF	1.00	1.00	1.00			0.60	1.00		0.60
Hourly Flow Rate, HFR (veh/h)	0	0	0			0	0		49
Percent Heavy Vehicles	0	0	0			5	0		5
Percent Grade (%)		0	<u> </u>				0		
Flared Approach		N					N		
Storage		0					0		
RT Channelized			0						0
Lanes	0	0	0			0	0		0
Configuration							LR		
Delay, Queue Length, a	nd Level of Se	rvice							
Approach	Eastbound	Westbound		Northb	ound		S	outhbound	
Movement	1	4	7	8		9	10	11	12
Lane Configuration	L							LR	
v (veh/h)	10							49	
C (m) (veh/h)	864							418	
v/c	0.01							0.12	
95% queue length	0.04							0.39	
Control Delay (s/veh)	9.2			 				14.8	
LOS	A							В	
Approach Delay (s/veh)						<u> </u>	 	14.8	<u> </u>
Approach LOS								B	
Copyright © 2010 University of Flo			.,	CS+ TM	\/o'	- F 6	Gener	ated: 6/12/20	13 11.48 1

	TW	O-WAY STOP	CONTR	OL S	UMN	//ARY			
General Information	า		Site I	nforn	natio	on			
Analyst	R Marvin		Interse	ection			Mary Op2	2 & Coulson	n Rd
Agency/Co.	Marvin As	ssociates	Lusiadi	ation.			Phase 1 MDT		
Date Performed	6/12/13		Jurisdi Analys		r		2035		
Analysis Time Period	Design H	our PM	Allalys	15 1 6	ll		2033		
Project Description Bill	lings Bypass						1		
East/West Street: Mary			North/S	South S	Stree	t: Coulsor	n Road		
Intersection Orientation:			Study I	Period	(hrs)	: 0.25			
Vehicle Volumes ar	nd Adjustme	nts							
Major Street		Eastbound					Westbou	nd	
Movement	1	2	3			4	5		6
	L	Т	R			L	Т		R
Volume (veh/h)	55	919					610		5
Peak-Hour Factor, PHF	0.95	0.95	1.00)		1.00	0.95		0.95
Hourly Flow Rate, HFR (veh/h)	57	967	0			0	642		5
Percent Heavy Vehicles	4					0			
Median Type				Undi	vided	I			
RT Channelized			0						0
Lanes	1	1	0			0	1		0
Configuration	L	T							TR
Upstream Signal		0					0		
Minor Street		Northbound					Southbou	ınd	
Movement	7	8	9			10	11		12
	L	Т	R			L	Т		R
Volume (veh/h)						5			80
Peak-Hour Factor, PHF	1.00	1.00	1.00)		0.70	1.00		0.70
Hourly Flow Rate, HFR (veh/h)	0	0	0			7	0		114
Percent Heavy Vehicles	0	0	0			5	0		5
Percent Grade (%)		0	•				0		
Flared Approach		N					N		
Storage		0					0		
RT Channelized			0						0
Lanes	0	0	0			0	0		0
Configuration							LR		
Delay, Queue Length, a	nd Level of Se	rvice							
Approach	Eastbound	Westbound		Northb	ound		S	outhbound	
Movement	1	4	7	8		9	10	11	12
Lane Configuration	L							LR	
v (veh/h)	57							121	
C (m) (veh/h)	929							377	
v/c	0.06							0.32	
95% queue length	0.20							1.36	
Control Delay (s/veh)	9.1							19.0	
LOS	A							С	
Approach Delay (s/veh)								19.0	
Approach LOS							 	C	
Copyright © 2010 University of Flo			.,,	CS+TM	\/ora;	n F 6	Gener	ated: 6/12/20	13 11·53 A

Site: Mary Alignment Option 1 Intersection with Five Mile adn Mary Street

Mary Alignment Option 1 Phase 1 Intersection of Mary Alignment with Mary Street & Five Mile Road Roundabout

Nov ID Turn Flow HV Satin Delay Service Vehicles Distance Queued Stop Rate Service Per veh Rt	Moven	nent Perf		ehicles								
Veh	May ID	Turn		LIV/								Average
South: Mary Street NB	טו ייטואו	Tulli					Service			Queued		Speed
3 L 5 0.0 0.140 16.8 LOS B 0.7 17.4 0.67 0.94 8 T 54 0.0 0.140 8.6 LOS A 0.7 17.4 0.67 0.72 18 R 22 0.0 0.140 10.2 LOS B 0.7 17.4 0.67 0.77 Approach 82 0.0 0.140 9.6 LOS A 0.7 17.4 0.67 0.75 East: Mary Alignment WB 1 L 22 0.0 0.749 13.2 LOS B 10.9 279.8 0.55 0.72 6 T 745 4.0 0.749 5.1 LOS A 10.9 279.8 0.55 0.42 16 R 243 2.0 0.749 5.6 LOS A 10.9 279.8 0.55 0.49 Approach 1010 3.4 0.749 5.6 LOS A 10.9 279.8 0.5	South: N	Mary Stroc		%	V/C	sec		ven	π		per ven	mph
8 T 54 0.0 0.140 8.6 LOS A 0.7 17.4 0.67 0.72 18 R 22 0.0 0.140 10.2 LOS B 0.7 17.4 0.67 0.77 Approach 82 0.0 0.140 9.6 LOS A 0.7 17.4 0.67 0.75 East: Mary Alignment WB 1 L 22 0.0 0.749 13.2 LOS B 10.9 279.8 0.55 0.72 6 T 745 4.0 0.749 5.1 LOS A 10.9 279.8 0.55 0.42 16 R 243 2.0 0.749 6.6 LOS A 10.9 279.8 0.55 0.42 Approach 1010 3.4 0.749 5.6 LOS A 10.9 279.8 0.55 0.49 North: Five Mile Road SB T 1 1 0.0 0.363 19.3 LOS B 2.4 <td></td> <td>,</td> <td></td> <td>0.0</td> <td>0.140</td> <td>16.0</td> <td>LOCB</td> <td>0.7</td> <td>17.4</td> <td>0.67</td> <td>0.04</td> <td>28.5</td>		,		0.0	0.140	16.0	LOCB	0.7	17.4	0.67	0.04	28.5
18 R 22 0.0 0.140 10.2 LOS B 0.7 17.4 0.67 0.77 Approach 82 0.0 0.140 9.6 LOS A 0.7 17.4 0.67 0.75 East: Mary Alignment WB USA 0.7 17.4 0.67 0.75 1 L 22 0.0 0.749 13.2 LOS B 10.9 279.8 0.55 0.72 6 T 745 4.0 0.749 5.1 LOS A 10.9 279.8 0.55 0.42 16 R 243 2.0 0.749 6.6 LOS A 10.9 279.8 0.55 0.49 Approach 1010 3.4 0.749 5.6 LOS A 10.9 279.8 0.55 0.49 North: Five Mile Road SB 7 L 180 2.0 0.363 19.3 LOS B 2.4 60.9 0.86 0.95 4 T 11 <td></td> <td>_</td> <td>_</td> <td></td> <td></td> <td></td> <td></td> <td>_</td> <td></td> <td></td> <td></td> <td></td>		_	_					_				
Approach 82 0.0 0.140 9.6 LOS A 0.7 17.4 0.67 0.75 East: Mary Alignment WB 1 L 22 0.0 0.749 13.2 LOS B 10.9 279.8 0.55 0.72 6 T 745 4.0 0.749 5.1 LOS A 10.9 279.8 0.55 0.42 16 R 243 2.0 0.749 6.6 LOS A 10.9 279.8 0.55 0.42 Approach 1010 3.4 0.749 5.6 LOS A 10.9 279.8 0.55 0.49 North: Five Mile Road SB 7 L 180 2.0 0.363 19.3 LOS B 2.4 60.9 0.86 0.95 4 T 11 0.0 0.363 11.0 LOS B 2.4 60.9 0.86 0.88 14 R 5 1.0 0.363 12.6 LOS B 2.4 60.	_	•						_			_	31.5
East: Mary Alignment WB 1	18	R										31.2
1 L 22 0.0 0.749 13.2 LOS B 10.9 279.8 0.55 0.72 6 T 745 4.0 0.749 5.1 LOS A 10.9 279.8 0.55 0.42 16 R 243 2.0 0.749 6.6 LOS A 10.9 279.8 0.55 0.49 Approach 1010 3.4 0.749 5.6 LOS A 10.9 279.8 0.55 0.49 Approach 1010 3.4 0.749 5.6 LOS A 10.9 279.8 0.55 0.49 Approach 1010 3.4 0.749 5.6 LOS A 10.9 279.8 0.55 0.49 North: Five Mille Road SB ***********************************	Approac	ch	82	0.0	0.140	9.6	LOS A	0.7	17.4	0.67	0.75	31.2
6 T 745 4.0 0.749 5.1 LOS A 10.9 279.8 0.55 0.42 16 R 243 2.0 0.749 6.6 LOS A 10.9 279.8 0.55 0.49 Approach 1010 3.4 0.749 5.6 LOS A 10.9 279.8 0.55 0.44 North: Five Mile Road SB 7 L 180 2.0 0.363 19.3 LOS B 2.4 60.9 0.86 0.95 4 T 11 0.0 0.363 11.0 LOS B 2.4 60.9 0.86 0.88 14 R 5 1.0 0.363 12.6 LOS B 2.4 60.9 0.86 0.90 Approach 197 1.9 0.363 18.6 LOS B 2.4 60.9 0.86 0.94 West: Mary Alignment EB 5 L 5 1.0 0.488 14.2 LOS B 3.8 99.1 0.61 0.86 2 T 477 4.0 0.488 6.1 LOS A 3.8 99.1 0.61 0.53 12 R 5 0.0 0.488 7.5 LOS A 3.8 99.1 0.61 0.63	East: M	ary Alignm	ent WB									
16 R 243 2.0 0.749 6.6 LOS A 10.9 279.8 0.55 0.49 Approach 1010 3.4 0.749 5.6 LOS A 10.9 279.8 0.55 0.49 North: Five Mile Road SB 7 L 180 2.0 0.363 19.3 LOS B 2.4 60.9 0.86 0.95 4 T 11 0.0 0.363 11.0 LOS B 2.4 60.9 0.86 0.88 14 R 5 1.0 0.363 12.6 LOS B 2.4 60.9 0.86 0.90 Approach 197 1.9 0.363 18.6 LOS B 2.4 60.9 0.86 0.94 West: Mary Alignment EB 5 L 5 1.0 0.488 14.2 LOS B 3.8 99.1 0.61 0.86 2 T 477 4.0 0.488 6.1 LOS A	1	L	22	0.0	0.749	13.2	LOS B	10.9	279.8	0.55	0.72	30.3
Approach 1010 3.4 0.749 5.6 LOS A 10.9 279.8 0.55 0.44 North: Five Mile Road SB 7 L 180 2.0 0.363 19.3 LOS B 2.4 60.9 0.86 0.95 4 T 11 0.0 0.363 11.0 LOS B 2.4 60.9 0.86 0.88 14 R 5 1.0 0.363 12.6 LOS B 2.4 60.9 0.86 0.90 Approach 197 1.9 0.363 18.6 LOS B 2.4 60.9 0.86 0.94 West: Mary Alignment EB 5 L 5 1.0 0.488 14.2 LOS B 3.8 99.1 0.61 0.86 2 T 477 4.0 0.488 6.1 LOS A 3.8 99.1 0.61 0.53 12 R 5 0.0 0.488 7.5 LOS A 3.8 </td <td>6</td> <td>Т</td> <td>745</td> <td>4.0</td> <td>0.749</td> <td>5.1</td> <td>LOS A</td> <td>10.9</td> <td>279.8</td> <td>0.55</td> <td>0.42</td> <td>32.3</td>	6	Т	745	4.0	0.749	5.1	LOS A	10.9	279.8	0.55	0.42	32.3
North: Five Mile Road SB 7 L	16	R	243	2.0	0.749	6.6	LOS A	10.9	279.8	0.55	0.49	32.0
7 L 180 2.0 0.363 19.3 LOS B 2.4 60.9 0.86 0.95 4 T 11 0.0 0.363 11.0 LOS B 2.4 60.9 0.86 0.88 14 R 5 1.0 0.363 12.6 LOS B 2.4 60.9 0.86 0.90 Approach 197 1.9 0.363 18.6 LOS B 2.4 60.9 0.86 0.94 West: Mary Alignment EB 5 L 5 1.0 0.488 14.2 LOS B 3.8 99.1 0.61 0.86 2 T 477 4.0 0.488 6.1 LOS A 3.8 99.1 0.61 0.53 12 R 5 0.0 0.488 7.5 LOS A 3.8 99.1 0.61 0.63	Approac	ch	1010	3.4	0.749	5.6	LOSA	10.9	279.8	0.55	0.44	32.2
4 T 11 0.0 0.363 11.0 LOS B 2.4 60.9 0.86 0.88 14 R 5 1.0 0.363 12.6 LOS B 2.4 60.9 0.86 0.90 Approach 197 1.9 0.363 18.6 LOS B 2.4 60.9 0.86 0.94 West: Mary Alignment EB 5 L 5 1.0 0.488 14.2 LOS B 3.8 99.1 0.61 0.86 2 T 477 4.0 0.488 6.1 LOS A 3.8 99.1 0.61 0.53 12 R 5 0.0 0.488 7.5 LOS A 3.8 99.1 0.61 0.63	North: F	ive Mile R	oad SB									
14 R 5 1.0 0.363 12.6 LOS B 2.4 60.9 0.86 0.90 Approach 197 1.9 0.363 18.6 LOS B 2.4 60.9 0.86 0.94 West: Mary Alignment EB 5 L 5 1.0 0.488 14.2 LOS B 3.8 99.1 0.61 0.86 2 T 477 4.0 0.488 6.1 LOS A 3.8 99.1 0.61 0.53 12 R 5 0.0 0.488 7.5 LOS A 3.8 99.1 0.61 0.63	7	L	180	2.0	0.363	19.3	LOS B	2.4	60.9	0.86	0.95	26.5
Approach 197 1.9 0.363 18.6 LOS B 2.4 60.9 0.86 0.94 West: Mary Alignment EB 5 L 5 1.0 0.488 14.2 LOS B 3.8 99.1 0.61 0.86 2 T 477 4.0 0.488 6.1 LOS A 3.8 99.1 0.61 0.53 12 R 5 0.0 0.488 7.5 LOS A 3.8 99.1 0.61 0.63	4	Т	11	0.0	0.363	11.0	LOS B	2.4	60.9	0.86	0.88	28.7
West: Mary Alignment EB 5 L 5 1.0 0.488 14.2 LOS B 3.8 99.1 0.61 0.86 2 T 477 4.0 0.488 6.1 LOS A 3.8 99.1 0.61 0.53 12 R 5 0.0 0.488 7.5 LOS A 3.8 99.1 0.61 0.63	14	R	5	1.0	0.363	12.6	LOS B	2.4	60.9	0.86	0.90	28.5
5 L 5 1.0 0.488 14.2 LOS B 3.8 99.1 0.61 0.86 2 T 477 4.0 0.488 6.1 LOS A 3.8 99.1 0.61 0.53 12 R 5 0.0 0.488 7.5 LOS A 3.8 99.1 0.61 0.63	Approac	ch	197	1.9	0.363	18.6	LOS B	2.4	60.9	0.86	0.94	26.7
2 T 477 4.0 0.488 6.1 LOS A 3.8 99.1 0.61 0.53 12 R 5 0.0 0.488 7.5 LOS A 3.8 99.1 0.61 0.63	West: N	lary Alignn	nent EB									
12 R 5 0.0 0.488 7.5 LOS A 3.8 99.1 0.61 0.63	5	L	5	1.0	0.488	14.2	LOS B	3.8	99.1	0.61	0.86	30.1
	2	Т	477	4.0	0.488	6.1	LOS A	3.8	99.1	0.61	0.53	32.1
Approach 488 3.9 0.488 6.2 LOS A 3.8 99.1 0.61 0.54	12	R	5	0.0	0.488	7.5	LOS A	3.8	99.1	0.61	0.63	31.9
	Approac	ch	488	3.9	0.488	6.2	LOS A	3.8	99.1	0.61	0.54	32.0
All Vehicles 1776 3.2 0.749 7.4 LOS A 10.9 279.8 0.61 0.54	All Vehi	cles	1776	3.2	0.749	7.4	LOSA	10.9	279.8	0.61	0.54	31.3

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Vehicle movement LOS values are based on average delay per movement

Intersection and Approach LOS values are based on average delay for all vehicle movements.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Wednesday, June 12, 2013 4:45:27 PM SIDRA INTERSECTION 5.1.13.2093

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Users\Bob\Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\FINAL EIS

TRAFFIC\Mary Op 1 Mary_5 Mile Opt1 Phase 1 Cap.sip 8001325, MARVIN & ASSOCIATES, SINGLE



Site: Mary Alignment Option 2 Intersection with Five Mile & Mary Street

Mary Alignment Option 2 Phase 1 Intersection of Mary Alignment with Mary Street & Five Mile Road Roundabout

Movem	ent Perf	ormance - Ve	ehicles								
Mov ID	Turn	Demand	HV	Deg.	Average	Level of	95% Back o		Prop.	Effective	Average
טו ייטוייו	Tuiti	Flow veh/h	%	Satn v/c	Delay sec	Service	Vehicles veh	Distance ft	Queued	Stop Rate per veh	Speed
South: N	Mary Stree		70	V/C	Sec		ven	11		per ven	mph
3	L	5	0.0	0.118	16.6	LOS B	0.7	17.1	0.71	0.88	28.6
8	T	54	0.0	0.118	8.6	LOSA	0.7	17.1	0.71	0.69	31.3
18	R	22	0.0	0.118	9.8	LOSA	0.7	17.1	0.71	0.73	31.3
Approac	ch	82	0.0	0.118	9.4	LOS A	0.7	17.1	0.71	0.72	31.1
East: Ma	ary Alignm	ent WB									
1	L	22	0.0	0.719	13.1	LOS B	9.8	251.2	0.51	0.73	30.2
6	Т	723	4.0	0.719	5.2	LOSA	9.8	251.2	0.51	0.41	32.4
16	R	243	2.0	0.719	6.4	LOS A	9.8	251.2	0.51	0.48	32.2
Approac	h	988	3.4	0.719	5.6	LOS A	9.8	251.2	0.51	0.44	32.3
North: F	ive Mile R	oad SB									
7	L	180	2.0	0.333	18.6	LOS B	2.2	55.4	0.84	0.92	26.9
4	Т	11	0.0	0.333	10.5	LOS B	2.2	55.4	0.84	0.85	29.2
14	R	5	1.0	0.333	11.8	LOS B	2.2	55.4	0.84	0.86	29.0
Approac	ch	197	1.9	0.333	18.0	LOS B	2.2	55.4	0.84	0.91	27.1
West: M	lary Alignn	nent EB									
5	L	5	1.0	0.463	14.0	LOS B	3.6	91.8	0.59	0.85	30.1
2	Т	466	4.0	0.463	6.1	LOS A	3.6	91.8	0.59	0.53	32.1
12	R	5	0.0	0.463	7.3	LOS A	3.6	91.8	0.59	0.61	32.0
Approac	ch	477	3.9	0.463	6.2	LOS A	3.6	91.8	0.59	0.54	32.1
All Vehic	cles	1743	3.2	0.719	7.4	LOS A	9.8	251.2	0.58	0.53	31.4

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Vehicle movement LOS values are based on average delay per movement

Intersection and Approach LOS values are based on average delay for all vehicle movements.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Wednesday, June 12, 2013 11:40:18 AM SIDRA INTERSECTION 5.1.13.2093

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Users\Bob\Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\FINAL EIS TRAFFIC\Mary Opt 2 5 Mile Phase 1 Cap\Mary Align Mary_5 Mile Opt2 PM 2035.sip

8001325, MARVIN & ASSOCIATES, SINGLE



Site: Mary Alignment Bitteroot Alt B 2035 PM

Mary Street Op1 Alignment Bitteroot Phase 1 Roundabout

Movem	nent Per	formance - V	ehicles								
Mov ID	Turn	Demand	HV	Deg.	Average	Level of	95% Back o		Prop.	Effective	Average
IVIOV ID	Tuiti	Flow veh/h	%	Satn v/c	Delay sec	Service	Vehicles veh	Distance ft	Queued	Stop Rate per veh	Speed mph
South: E	Bitteroot N		/0	V/C	366		Ven	11		per veri	Шрп
3	L	22	0.0	0.285	11.0	LOS B	1.7	43.1	0.63	0.89	24.9
8	Т	120	0.0	0.285	3.7	LOS A	1.7	43.1	0.63	0.49	26.2
18	R	98	0.0	0.285	5.4	LOS A	1.7	43.1	0.63	0.61	26.2
Approac	ch	239	0.0	0.285	5.1	LOSA	1.7	43.1	0.63	0.58	26.1
East: Ma	ary Alignn	nent WB									
1	L	112	0.0	0.646	14.2	LOS B	6.4	163.0	0.65	0.78	29.9
6	Т	502	4.0	0.646	6.1	LOSA	6.4	163.0	0.65	0.54	31.6
16	R	54	0.0	0.646	7.5	LOS A	6.4	163.0	0.65	0.61	31.5
Approac	ch	668	3.0	0.646	7.6	LOSA	6.4	163.0	0.65	0.59	31.3
North: B	Sitteroot S	В									
7	L	43	1.0	0.203	12.7	LOS B	1.2	31.3	0.75	0.89	24.1
4	T	54	0.0	0.203	5.4	LOS A	1.2	31.3	0.75	0.69	25.4
14	R	33	0.0	0.203	7.1	LOS A	1.2	31.3	0.75	0.74	25.6
Approac	ch	130	0.3	0.203	8.3	LOSA	1.2	31.3	0.75	0.77	25.0
West: M	lary Aligni	ment EB									
5	L	11	0.0	0.382	14.0	LOS B	2.5	64.4	0.52	0.88	30.0
2	Т	352	4.0	0.382	5.9	LOS A	2.5	64.4	0.52	0.52	32.6
12	R	11	0.0	0.382	7.4	LOS A	2.5	64.4	0.52	0.61	32.3
Approac	ch	374	3.8	0.382	6.2	LOS A	2.5	64.4	0.52	0.53	32.5
All Vehic	cles	1412	2.5	0.646	6.8	LOS A	6.4	163.0	0.62	0.59	30.0

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Vehicle movement LOS values are based on average delay per movement

Intersection and Approach LOS values are based on average delay for all vehicle movements.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Thursday, June 13, 2013 1:34:27 PM SIDRA INTERSECTION 5.1.13.2093

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com

Project: C:\Users\Bob\Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\FINAL EIS TRAFFIC\Mary Align Op 2 Intersections 5 to Hawthorne Cap\Mary Align Bitteroot Alt B 2035 PM.sip

8001325, MARVIN & ASSOCIATES, SINGLE



	TW	O-WAY STOP	CONTR	OL SI	JMI	MARY				
General Information	1		Site II	nform	atio	on				
Analyst	R Marvin		Interse				Mary St &	2 Bittero	ot Phase	
Agency/Co.	Marvin As	ssociates	Jurisdi				MDT	. 5	<u> </u>	<u> </u>
Date Performed	10/8/2011	1	Analys	is Yea	r		Year 203	5		
Analysis Time Period	Design H	our PM								
Project Description Bil	lings Bypass		· II							
East/West Street: Mary						t: <i>Bitteroo</i>	t			
Intersection Orientation:	North-South		Study F	Period	(hrs)	: 0.25				
Vehicle Volumes ar	nd Adjustme	nts								
Major Street		Northbound					Southbou	ınd		
Movement	1	2	3			4	5		6	
	L	Т	R			L	Т		R	
Volume (veh/h)	30	175	25			5	113		50	
Peak-Hour Factor, PHF	0.70	0.70	0.70	'		0.70	0.70		0.70	
Hourly Flow Rate, HFR (veh/h)	42	250	35			7	161		71	
Percent Heavy Vehicles	0					0				
Median Type				Undiv	/idec	1				
RT Channelized			0						0	
Lanes	0	1	0			0	1		0	
Configuration	LTR					LTR				
Upstream Signal		0					0			
Minor Street		Eastbound					Westbou	nd		
Movement	7	8	9			10	11		12	
	L	Т	R			L	Т		R	
Volume (veh/h)	40	30	40			10	15		15	
Peak-Hour Factor, PHF	0.70	0.70	0.70)		0.60	0.60		0.60	
Hourly Flow Rate, HFR (veh/h)	57	42	57			16	24		24	
Percent Heavy Vehicles	0	0	0			0	0		0	
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0						0	
Lanes	0	1	0			0	1		0	
Configuration		LTR					LTR			
Delay, Queue Length, a	nd Level of Se	rvice								
Approach	Northbound	Southbound	,	Westbo	ound		[Eastbou	nd	
Movement	1	4	7	8		9	10	11	12	2
Lane Configuration	LTR	LTR		LTF	₹			LTR		
v (veh/h)	42	7		64				156		
C (m) (veh/h)	1348	1289		463				488		_
v/c	0.03	0.01		0.14				0.32		
95% queue length	0.10	0.02		0.48			†	1.36	_	
Control Delay (s/veh)	7.8	7.8		14.0				15.8		
LOS	A A	A A		В	-			70.0	+	
Approach Delay (s/veh)				14.0	<u> </u>	I		15.8		
Approach LOS				14.0 B			-	75.6 C		
Copyright © 2010 University of Fl				HCS+TM					3/2013 1:3	

HCS+TM Version 5.6

Generated: 6/13/2013 1:37 PM

		O-WAY STOP						
General Information	า		Site I	nforma	tion			
Analyst	R Marvin		Interse	ection		Mary Alig Phase 1	n Op2 &	Hawth
Agency/Co.	Marvin &	Assoc	Jurisdi	ction		City Billin	ac	
Date Performed	9/28/2011	1		is Year		2035	ys	
Analysis Time Period	Peak PM		Allalys	ois real		2033		
Project Description Bili	lings Bypass El	S	L					
ast/West Street: Mary			North/S	South St	reet: <i>Hawth</i>	orne		
ntersection Orientation:			Study F	Period (h	nrs): 0.25			
/ehicle Volumes an	nd Adjustme	nts						
/lajor Street		Eastbound				Westbou	nd	
Movement	1	2	3		4	5		6
	L	Т	R		L	Т		R
/olume (veh/h)		404	5		50	602		
Peak-Hour Factor, PHF	1.00	0.90	0.90)	0.90	0.90		1.00
Hourly Flow Rate, HFR veh/h)	0	448	5		55	668		0
Percent Heavy Vehicles	0				0			
/ledian Type			- i	Vay Left	Turn Lane			
RT Channelized			0					0
anes	0	1	0		1	1		0
Configuration			TR		L	Т		
Jpstream Signal	<u></u> _	0				0		
/linor Street		Northbound				Southbou	ınd	
Movement	7	8	9		10	11		12
	L	Т	R		L	T		R
/olume (veh/h)	5		40					
Peak-Hour Factor, PHF	0.80	1.00	0.80	'	1.00	1.00		1.00
lourly Flow Rate, HFR veh/h)	6	0	49		0	0		0
Percent Heavy Vehicles	0	0	0		0	0		0
Percent Grade (%)		0				0		
Flared Approach		N				Ν		
Storage		0				0		
RT Channelized			0					0
anes	0	0	0		0	0		0
Configuration		LR						
Delay, Queue Length, a		ii-						
Approach	Eastbound	Westbound		Northbou			outhbour	
Novement	1	4	7	8	9	10	11	12
ane Configuration		L		LR				+
(veh/h)		55		55				
C (m) (veh/h)		1118		557				
r/c		0.05		0.10				
95% queue length		0.16		0.33				
Control Delay (s/veh)		8.4		12.2				
.OS		Α		В				
Approach Delay (s/veh)				12.2	•		-	-
appidacii Delay (Siveli) [

HCS+TM Version 5.6

Generated: 6/13/2013 1:40 PM

	TW	O-WAY STOP	CONTR	OL SU	JMMARY			
General Information	n		Site II	nform	ation			
Analyst	R Marvin		Interse	ection		HWY 312	2 & 5 Mile /	Alt Phase
Agency/Co.	Marvin A	ssociates	Jurisdi	otion		MDT		
Date Performed	10/3/201			is Year		2035		
Analysis Time Period	Design H	our PM	Allalys	ois real		2035		
Project Description Bil	lings Bypass							
East/West Street: HWY			North/S	South S	treet: Five N	1ile Road		
Intersection Orientation:	East-West		Study F	Period (hrs): 0.25			
Vehicle Volumes ar	nd Adjustme	nts						
Major Street		Eastbound				Westbou	nd	
Movement	1	2	3		4	5		6
	L	T	R		L	Т		R
Volume (veh/h)	0	470	20		156	310		0
Peak-Hour Factor, PHF	0.90	0.90	0.90		0.90	0.90		0.90
Hourly Flow Rate, HFR (veh/h)	0	522	22		173	344		0
Percent Heavy Vehicles	0				3	 		
Median Type				Undiv	ided			
RT Channelized			0					0
Lanes	1	2	0		1	2		0
Configuration	L	T	TR		L	Т		TR
Upstream Signal		0				0		
Minor Street		Northbound	-			Southbou	ınd	
Movement	7	8	9		10	11		12
	L	Т	R		L	Т		R
Volume (veh/h)	30	0	224		5	5		5
Peak-Hour Factor, PHF	0.90	1.00	0.90		0.60	0.60		0.60
Hourly Flow Rate, HFR (veh/h)	33	0	248		8	8		8
Percent Heavy Vehicles	3	0	3		0	0		0
Percent Grade (%)		0	<u> </u>			0		
Flared Approach	1	N				N		
Storage		0	1			0		
RT Channelized			0					0
Lanes	0	1	1		0	1		0
Configuration	LT		R			LTR		
Delay, Queue Length, a	nd Level of Se	rvice						
Approach	Eastbound	Westbound	1	Northbo	ound	S	Southbound	d
Movement	1	4	7	8	9	10	11	12
Lane Configuration	L	L	LT		R		LTR	
v (veh/h)	0	173	33		248		24	
C (m) (veh/h)	1226	1014	148		762	1	190	1
v/c	0.00	0.17	0.22		0.33	†	0.13	
95% queue length	0.00	0.61	0.81		1.42	+	0.43	
Control Delay (s/veh)	7.9	9.3	36.2		12.0	+	26.7	1
LOS	7.9 A	9.5 A	50.2 E	 	12.0 B	+	D D	
Approach Delay (s/veh)			<u> </u>	14.8		+	26.7	1
				14.0 B	1	+	20.7 D	
Approach LOS Copyright © 2010 University of Fl	<u></u>				/ersion 5.6		ated: 6/13/20	

	TW	O-WAY STOP	CONTR	OL S	UMI	MARY				
General Information	n		Site I	nform	natio	on				
Analyst	R Marvin		Interse	ection			Dover & I	Five Mi	le Pl	nase 1
Agency/Co.	Marvin As	ssociates	Jurisdi				MDT			
Date Performed	7/1/2013		Analys	is Yea	ır		2035 Five	Mile F	Rd A	lign
Analysis Time Period	Peak PM									
Project Description			•							
East/West Street: Dove						t: Five Mi	le Road			
Intersection Orientation:	North-South		Study I	Period	(hrs)	: 0.25				
Vehicle Volumes a	<u>nd Adjustme</u>									
Major Street		Northbound					Southbou	ınd		
Movement	1	2	3			4	5			6
\	L	T	R				T 450			R
Volume (veh/h) Peak-Hour Factor, PHF	30 0.92	234 0.92	50 0.92			5 0.90	156 0.90			<u>5</u>).90
Hourly Flow Rate, HFR						0.90		-		
(veh/h)	32	254	54			5	173			5
Percent Heavy Vehicles	1					1				
Median Type		<u>.</u>		Undi	vided	1				
RT Channelized			0							0
Lanes	1	1	0			1	1			0
Configuration	L		TR			L				TR
Upstream Signal		0					0			
Minor Street		Eastbound					Westbou	nd		
Movement	7	8	9			10	11			12
	L	Т	R			L	Т			R
Volume (veh/h)	10	85	20			30	65			10
Peak-Hour Factor, PHF	0.85	0.85	0.85			0.80	0.80		C	.80
Hourly Flow Rate, HFR (veh/h)	11	99	23			37	81			12
Percent Heavy Vehicles	0	2	0			2	0			0
Percent Grade (%)		0					0			
Flared Approach		N					N			
Storage		0					0			
RT Channelized			0							0
Lanes	0	1	0			0	1			0
Configuration		LTR					LTR			
Delay, Queue Length, a										
Approach	Northbound	Southbound		Westb				Eastbo		
Movement	1	4	7	8		9	10	11		12
Lane Configuration	L	L		LTF				LTF		
v (veh/h)	32	5		130)			133	}	
C (m) (veh/h)	1404	1258		418	3			459		
v/c	0.02	0.00		0.3	1			0.29	9	
95% queue length	0.07	0.01		1.3	1			1.19	9	
Control Delay (s/veh)	7.6	7.9		17.	5			16.0)	
LOS	Α	Α		С				С		
Approach Delay (s/veh)				17.	5	8.		16.0		
Approach LOS				С				С		
			•	TN			•			

HCS+TM Version 5.6

Site: Five Mile Road Alignment Mary Street Intersection

Five Mile Road Alignment Phase 1 Mary Street Intersection Year 2035 PM Design Hour Roundabout

Movem	nent Perf	ormance - Ve	hicles								
Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back o Vehicles	Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	ft		per veh	mph
South E	:ast: Five I	Mile Align NWB									
3X	L	537	4.0	0.581	12.7	LOS B	6.0	154.8	0.26	0.70	29.8
8X	Т	298	3.0	0.581	4.4	LOS A	6.0	154.8	0.26	0.32	33.7
Approac	ch	835	3.6	0.581	9.7	LOS A	6.0	154.8	0.26	0.56	31.0
North W	est: Five	Mile Align SEB									
4X	T	202	2.0	0.316	8.4	LOS A	1.9	47.9	0.70	0.74	31.5
14X	R	33	1.0	0.316	9.9	LOS A	1.9	47.9	0.70	0.78	31.5
Approac	ch	235	1.9	0.316	8.6	LOSA	1.9	47.9	0.70	0.74	31.5
South V	Vest: Mary	Street NEB									
5X	L	33	1.0	0.431	13.9	LOS B	2.7	68.5	0.51	0.80	29.6
12X	R	354	3.0	0.431	7.3	LOS A	2.7	68.5	0.51	0.60	31.7
Approac	ch	387	2.8	0.431	7.9	LOS A	2.7	68.5	0.51	0.62	31.5
All Vehi	cles	1457	3.1	0.581	9.1	LOS A	6.0	154.8	0.40	0.61	31.2

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Vehicle movement LOS values are based on average delay per movement

Intersection and Approach LOS values are based on average delay for all vehicle movements.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model used.

Processed: Thursday, June 13, 2013 1:46:46 PM SIDRA INTERSECTION 5.1.13.2093

Copyright © 2000-2011 Akcelik and Associates Pty Ltd www.sidrasolutions.com Project: C:\Users\Bob\Documents\A PROJECT FOLDERS\10-698 Billings Bypass River Crossing\FINAL EIS

TRAFFIC\5 Mile Align Intersections Phase 1 Cap\Five Mile Align Mary Int PM 2035.sip

8001325, MARVIN & ASSOCIATES, SINGLE



HCM Analysis Summary

Mary Op2 Phase 1 Main Street/Bypass Area Type: Non CBD

R Marvin 06/14/2013 Analysis Duration: 15 mins.

	narvin 85 PM			Case: Mary Align US 87 HWT 312 Phase 1											nins.			
	Lanes						Geom	etry: Mo	vemen	ts Se	rviced b	y Lane ar	d Lane W	idths (fe	eet)			
	Approach	Outbound		Lane	: 1		Lane	e 2 Lane 3			Laı	ne 4	La	ne 5	Laı	ne 6		
EB	5	3	L	_	12.0	L	Т	12.0	Т		12.0	Т	12.0	R	12.0			
WB	4	3	L	_	12.0	7	Γ	12.0	Т		12.0	TR	12.0					
NB	3	2	L		12.0	L	Т	12.0	TR		12.0							
SB	2	1	L	_	12.0	7	Г	12.0										
					East				Wes	t			North			South		
	Data		L	_	T	F	2	L	Т		R	L	Т	R	L	Т	R	
Move	ment Volur	ne (vph)	53	39	825	2:	54	5	545	5	10	337	210	5	10	100	0	
PHF			0.9	95	0.95	0.9	95	0.95	0.95	5	0.95	0.95	0.95	0.95	0.95	0.95	0.90	
% He	avy Vehicle	es		2	2 4		1	2		2	3	4	2	2	4	2		
Lane	Groups		L	_	LT	F	١ ا	L	TR			L	LTR		L	Т		
Arriv	al Type		3	3	3	3	3	3	3			3	3		3	3		
RTOI	R Vol (vph)				25			5				2			0			
Peds/	Hour				5			5				5		0				
% Gr	ade				0				0			0			0			
Buses	/Hour				0				0			0				0		
Parke	rs/Hour (Le	eft Right)								-								
Signa	l Settings: A	Actuated		(Operati	onal A	nalysi	is	Су	cle L	ength:	95.0 Sec	;	Lost Tim	ne Per Cycle: 20.0 Sec			
Phase	:	1		2	2	3	3	4			5	6		7	8	Pe	d Only	
EB		LTP																
WB				LT	R													
NB						L	ГР											
SB								LT										
Greer		30.0			3.0		9.0		.0								0	
Yello	w All Red	3.5	1.5	3.5	1.5	3.5	1.5	3.5	1.5									

				·	1,					1
	1		Capac	city Analysis R	esults		ı		Approa	cn:
	Lane	Cap	v/s	g/C Ratio	Lane	v/c	Delay		Delay	
App	Group	(vph)	Ratio	Ratio	Group	Ratio	(sec/veh)	LOS	(sec/veh)	LOS
EB										
	L	559	0.192	0.316	L	0.608	28.9	C	29.0	C
	* LT	1589	0.218	0.316	LT	0.689	29.5	C		
	R	487	0.156	0.316	R	0.495	26.6	C		
WB										
	L	339	0.003	0.189	L	0.015	31.3	С	35.9	D
	* TR	962	0.114	0.189	TR	0.602	36.0	D		
NB										
	* L	350	0.122	0.200	L	0.609	36.8	D	35.3	D
	LTR	687	0.107	0.200	LTR	0.533	34.4	С		
SB										
	L	149	0.006	0.084	L	0.074	40.2	D	50.9	D
	* T	154	0.057	0.084	T	0.682	52.0	D		

Intersection: Delay = $32.4 \,\text{sec/veh}$ Int. LOS=C $X_c = 0.65$ * Critical Lane Group $\Sigma (\text{v/s})$ Crit= 0.51 SIG/Cinema v3.08 Page 1

Mary Op2 Phase 1 R Marvin 2035 PM Main Street/Bypass 06/14/2013

Case: Mary Align US 87 HWT 312 Phase 1

App EB	Lane Group L LT	Queues Per Lane Avg/Max (veh) 8 / 10	Average Speed (mph) 5.0	Spillback in Worst Lane (% of Peak Period) 0.0	100 100 100 100 100 100 100 100
	R	1/3	19.1	0.0	
	All	1/3	9.6	0.0	
	AII		9.0	0.0	
WB	L	0 / 2	6.9	0.0	<u> </u>
	TR	4 / 6	8.5	0.0	<u></u>
	All		8.5	0.0	
NB	L	5 / 5	4.7	0.0	539 —
	LTR	4 / 5	10.6	0.0	$254 \rightarrow$
					337 5
	All		8.6	0.0	210
SB	L	0 / 2	8.8	0.0	
	Т	2/3	7.7	0.0	
					$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
	All		7.8	0.0	
	Inte	rsect.	9.1		

HCM Analysis Summary

Mary Op2 Phase 1Main Street/Bench BlvdArea Type: Non CBDR Marvin
2035 PM06/14/2013Analysis Duration: 15 mins.LanesGeometry: Movements Serviced by Lane and Lane Widths (feet)

	Lanes					Ge	Geometry: Movements Serviced by Lane and Lane Widths (feet)											
	Approach	Outbound	L	ane 1		L	aņe	2	I	Lane	3	Lar	ne 4	La	ne 5		Lar	ne 6
EB	3	3	T	12	2.0	T		12.0	Т		12.0							
WB	3	3	L	12	2.0	T	T		Т		12.0							
NB	2	1	L	12	2.0	R		12.0										
SB	2	1	T	12	2.0	R		12.0										
				Ea	ast				West	t			North				South	
	Data		L	-	Γ	R		L	Т		R	L	T	R	L		T	R
Move	ement Volu	me (vph)	0	11	89	0		245	637		0	105	0	420		0	75	315
PHF			0.90	0.	95	0.90		0.95	0.95		0.90	0.95	0.90	0.95	0.9	90	0.95	0.95
% He	avy Vehicle	es	2		3	2		3	2		2	0	2	1		2	1	3
Lane	Lane Groups T		Γ			L	Т			L		R			T	R		
Arriv	al Type				3			3	3			3		3			3	3
RTO	R Vol (vph))			0				0				200				140	
Peds/	Hour				5			5			0					5		
% Gr	ade				0			0				0			0			
Buses	s/Hour				0				0			0					0	
Parke	ers/Hour (Le	eft Right)								-								
Signa	l Settings:	Actuated		Оре	eration	nal Ana	lysi	s	Сус	cle L	ength:	95.0 Sec	:	Lost Tim	ne Per	Cycle	: 14.0 S	ec
Phase	:	1		2		3		4			5	6		7	8	;	Pe	d Only
EB	Т																	
WB	B LT LT																	
NB	NB LR																	
SB						TP												
Greei		14.0		44.0		23.0		<u> </u>										0
Yello	w All Red	4.0	0.0 3.	5 1	.5	3.5	1.5											

			~		4.					
		T	Capac	ity Analysis R	esults		1		Approa	ch:
App	Lane Group	Cap (vph)	v/s Ratio	g/C Ratio	Lane Group	v/c Ratio	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
EB										
	* T	2332	0.249	0.463	Т	0.537	19.1	В	19.1	В
WB	Lper	129	0.000	0.516					11.0	В
WB	* Lpei	258	0.000	0.310	L	0.667	20.5	С	11.0	Б
	T	2310	0.190	0.653	T	0.290	7.4	A		
NB										
	L	323	0.083	0.242	L	0.344	30.0	С	32.5	С
	* R	387	0.145	0.242	R	0.599	33.7	С		
SB										
	T	455	0.042	0.242	T	0.174	28.5	С	30.5	С
	R	377	0.118	0.242	R	0.488	31.3	С		

Intersection: Delay = 19.1 sec/veh SIG/Cinema v3.08

Int. LOS=B

* Critical Lane Group

 \sum (v/s)Crit= 0.54

X_c= 0.63 * C₁ Marvin & Associates

Page 1

Mary Op2 Phase 1 R Marvin 2035 PM Main Street/Bench Blvd 06/14/2013

Case: Bench US 87 w Mary Align Phase 1

App	Lane Group	Queues Per Lane Avg/Max (veh)	Average Speed (mph)	Spillback in Worst Lane (% of Peak Period)	75
ЕВ	Т	6/9	12.9	0.0	- 637
					245
	All		12.9	0.0	
WB	L	5 / 10	8.5	0.0	
	T	3 / 5	20.4	0.0	
	All		16.0	0.0	
NB	L	2 / 6	10.8	0.0	1189
	R	4 / 7	15.3	0.0	105 420
	All		13.9	0.0	
SB	Т	2 / 4	9.1	0.0	
	R	1 / 2	23.6	0.0	$\begin{array}{ c c c c c c c c c c c c c c c c c c c$
	All		17.6	0.0	
	Inte	rsect.	14.4		