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FINAL REPORT

Interstate 90

Missoula East-West Corridor Study (Phase 1)

Project No. IM90-2(104)94,UPN 4855

April 16, 2004

CH2MHILL

Technical Report

Missoula I-90 East-West, Corridor Study (Phase I)

MDT Project IM90-2(104)94, UPN 4855

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April 16, 2004

Prepared for

Montana Department of Transportation

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Executive Summary

The Missoula I-90 East-West Corridor Study represents the first phase (Phase I) of a two-phase effort to determine the level of required improvements to a 16-mile mainline section of Interstate 90 in Missoula, Montana. The Missoula urban area represents one of the fastest areas of growth within Montana. In the fall of 2002 the Montana Department of Transportation (MDT) selected CH2M HILL to perform an assessment of existing physical and traffic operations conditions along the corridor between Milepost 94 (west of the DeSmet Interchange) and Milepost 110 (just east of the Bonner Interchange).

Built in the mid-1960s, I-90 now carries more than 21,000 vehicles per day on its busiest section in the study area. The analysis confirms that the mainline of I-90 currently has sufficient capacity to carry this volume. Operational issues arise, however, from the interface of I-90 with the seven interchanges with the local roadway network, particularly the Orange Street (Exit 104) and Van Buren Street (Exit 105) interchanges.

Based on the land use and transportation planning assumptions of the Missoula Transportation Plan, the MDT developed future year (2025) traffic projections for the study area. These projections resulted in traffic growth rates of 1 to 4 percent along the corridor. It was also assumed that no transportation network improvements would be made before 2025, other than those identified within the Missoula Transportation Plan. As a result, the future year analysis yields an increased need for potential traffic signals at 14 non-signalized intersections.

While it is not the intent of the Phase 1 Study to identify alternative design solutions, the results of the Phase 1 Study fall into five (5) categories for consideration under the Phase 2 effort. The following areas are considered as focus areas:

A. RAMP GEOMETRY AND SIGHT DISTANCE

A review of the existing ramp geometry indicates that several of the interchange ramps can be termed to be non-compliant with the current geometric guidelines for ramp taper rates, deceleration, acceleration, and queue storage distances. These interchanges warrant detailed evaluation of ramp geometry and approach sight distances.

The appropriateness of existing taper rates, deceleration and acceleration lane lengths should be evaluated in the following areas:

Exit 96 DeSmet Interchange
- Sight distance on the approach to the eastbound off ramp (MP 95.8 to MP96.0).

Exit 101 Reserve St. Interchange
- Westbound On-ramp acceleration distance.
- Eastbound On-ramp acceleration distance.

Exit 104 Orange St. Interchange
- Eastbound On-ramp acceleration distance should be considered in the context of an auxiliary lane between the Orange St. and VanBuren St. interchanges.

Exit 105 VanBuren St. Interchange
- Westbound On-ramp acceleration distance
- Eastbound On-ramp acceleration distance

Exit 107 East Missoula Interchange
- Westbound On-ramp acceleration distance
- Eastbound On-ramp acceleration distance

Exit 110 Bonner Interchange
- Westbound On-ramp acceleration distance
- Eastbound Off-ramp taper and deceleration distance

B. MAINLINE GEOMETRY

A number of alignment and cross section issues were identified for the I-90 mainline. These included:

- **MP 95.3 – MP 95.8, EB I-90** – the extended grade of 4% for 0.5 miles results in a speed reduction for large heavy vehicles.
- **MP 103.2 – MP 105.5, EB and WB I-90** – Superelevation does not meet AASHTO criteria. Median barrier reduces shoulder width to less than 4 feet.
- **MP 107.1 - MP 107.6, EB and WB I-90** – Superelevation does not meet AASHTO criteria
- **MP 108.3, EB and WB I-90** -Shoulder widths on bridges over Clark Fork River do not meet AASHTO criteria
- **MP 108.7 – MP 109.2, EB and WB I-90** – Mainline stopping sight distance is negatively impacted by the short crest vertical curve
- **MP 109.4, EB and WB I-90** – Shoulder widths on bridges over Clark Fork River do not meet AASHTO criteria
- **MP 109.5 – MP 109.8, EB and WB I-90** – Superelevation does not meet AASHTO criteria
- **MP 110.0 – MP 109.8, EB and WB I-90** – Sight distance is restricted by a short crest vertical curve at the bridge over the railroad.

C. TRAFFIC OPERATIONS

As previously noted, the Phase 1 Study analysis identified the potential need for traffic signals at 14 non-signalized intersections by the year 2025. Immediate needs for traffic signals were identified at the following interchange locations:

Orange Street Eastbound Ramps – was found to be deficient during the AM peak hour.

VanBuren Street Westbound Ramps – was found to be deficient during both the AM and PM peak hours.

VanBuren Street Eastbound Ramps – was found to be deficient during the PM peak hour.

It is recommended that traffic signal warrants analyses should be performed at the above locations to validate the conclusions prior to design.

By the year 2025, the analysis indicates the potential need for traffic signals at four (4) other interchange ramp intersections and seven (7) local intersections in the study area. The interchange locations are:

DeSmet Interchange Westbound Ramps - was found to be deficient during both the AM and PM peak hours.

DeSmet Interchange Eastbound Off-Ramp - was found to be deficient during both the AM and PM peak hours.

Orange Street Interchange Westbound Ramps - was found to be deficient during both the AM and PM peak hours.

East Missoula Interchange Eastbound Ramps - was found to be deficient during the PM peak hour.

The seven local intersections are identified in Table 13 of the report. It is recommended that traffic volumes and operations be monitored on a regular basis for all intersections anticipated to require signals by the year 2025.

D. INTERCHANGE MODIFICATIONS

Based on the outcome of the Phase 1 Study which identified the needs for ramp and ramp junction improvements, predominantly at the Orange Street and VanBuren Street Interchanges, it is recommended that MDT consider the potential reconfiguration of those interchanges. As previously identified, the addition of an auxiliary lane between the two may be warranted and should be considered as one of several possible solutions. Other alternatives, such as reconfiguration of one or both interchanges, or their linkage via a collector–distributor (CD) road system should also be evaluated.

E. NOISE

The Phase 1 Study provided conclusive evidence of potential impacts of I-90 noise on residential areas, particularly the Rattlesnake Canyon area of Missoula. As a result, it is recommended that any significant improvement scenarios for I-90 should consider noise abatement as part of the project scope.

SUMMARY

The net result of this Phase 1 Study is the identified need to plan for congestion mitigation measures, traffic operational improvements, as well as detailed geometric review and improvements to the Interstate 90 mainline and its interchanges with local Missoula streets. This includes the need to develop potential interchange modifications, including possible reconfigurations, as well as addition of traffic signals at the ramp/local street intersections.

Project Information

Study Area

The Missoula County area (pop. 95,800) represents one of the fastest growth areas within Montana. The MDT-led Missoula I-90 East-West Corridor Study represents the first phase (Phase I) of a two-phase effort to determine the level of required improvements to a 15.6-mile mainline section of Interstate 90 through the county and city of Missoula. Figure 1 illustrates the project location.

Interstate 90 is a 4-lane interstate on the National Highway System that serves as both a local, regional, and interstate freight and trucking route as well as a regional primary route for commuter, commercial, and recreational travel. There are 7 interchanges within the study area. They include:

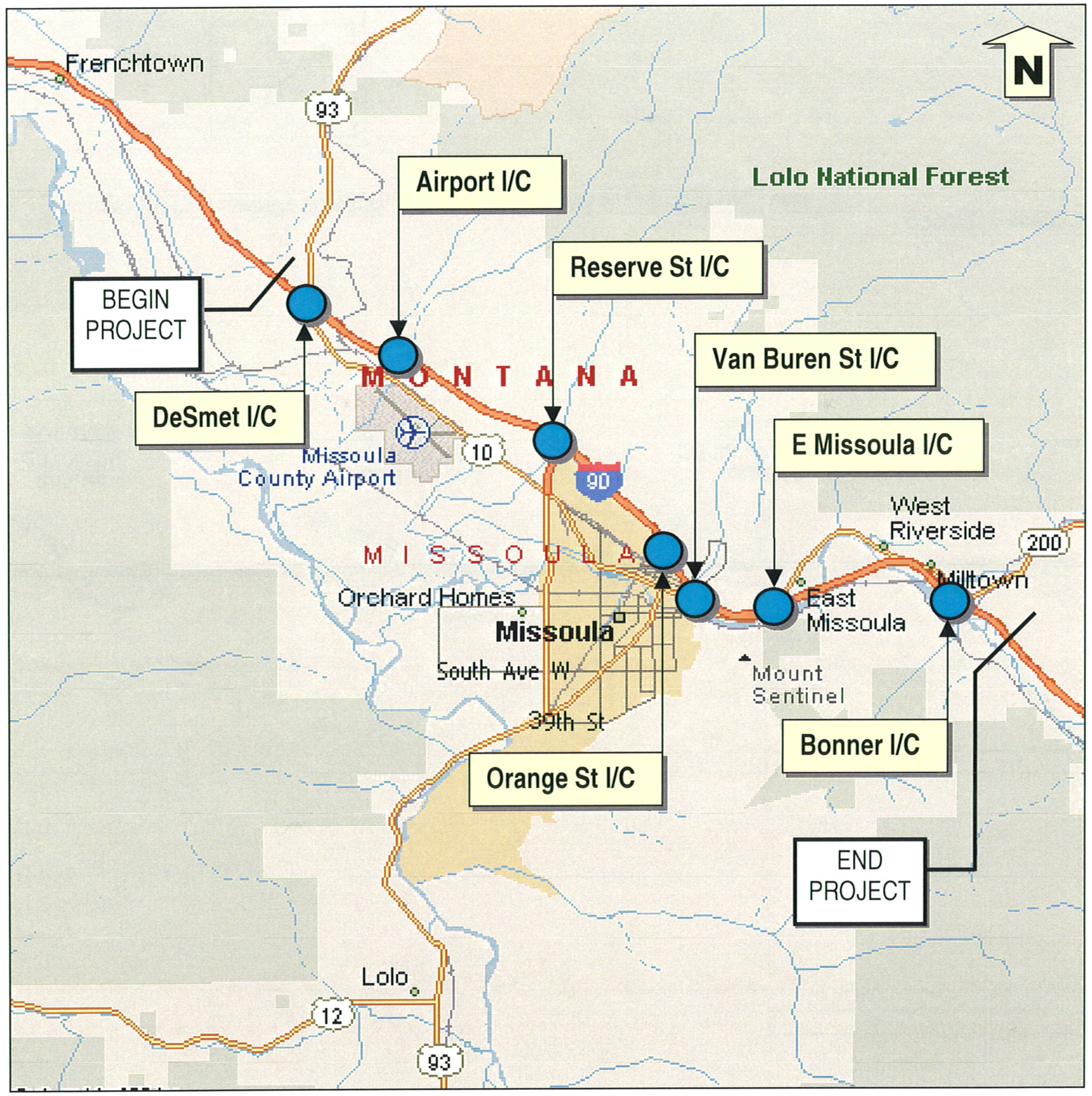
- DeSmet (US 93, SR 200) - RM 96.334
- Reserve Street (US 93) - RM 101.708
- Van Buren Street - RM 105.633
- Bonner (SR 200) - RM 109.204
- Airway Boulevard Interchange - RM 99.94
- Orange Street - RM 104.78
- East Missoula - RM 107.27

Traffic control at the intersections of the interchange ramps and the adjoining routes is a mix of stop and yield sign control and traffic signals. Signalized operations are only present at the Reserve Street interchange. However, signal systems at the adjacent intersections (Orange Street/Spruce Street and Van Buren Street/Broadway) meter traffic flows and, thus, potentially impact interchange operations.

The I-90 facility is characterized by generally level terrain and transitions from rural to urban land uses. Speed limits are posted at 75 mph (65 mph for trucks) for approximately 83% of the segment length with reduced speeds (65 mph) posted in the vicinity of Exit 105 (Van Buren Street) and Exit 107 (East Missoula Highway). The reduced speed segment between Orange Street and Van Buren Street carries the highest volume of traffic each day with 20,450 vehicles per day (vpd) and peak hour volumes of 1640 vehicles per hour (vph) during the afternoon peak hour. Observed travel patterns highlight not only the importance of I-90 to the Missoula community for peak hour commuter access to/from downtown, but also indicates its important functional interface with major US and state routes.

The 7 interchanges serve varying land uses and purposes. The DeSmet interchange (Exit 96) is the westernmost interchange in the study area and lies within a lightly developed industrial and rural area. This trumpet-style interchange was modified from a conventional diamond shape in 1994 to reduce capacity and safety problems associated with eastbound on-ramp access from US 93. Truck traffic is significant (17% trucks) as truck-stop commercial services are located on each side of the interchange. Heavy industrial activity lies west along Pulp Mill Road. To the east, SR200/US 93 becomes Broadway (SR474), running parallel to I-90 through Missoula. Broadway serves as a key alternate route for local Missoula-based traffic.

Figure 1: Location Plan
Missoula MT, I-90 East-West, Corridor Study



The Airway Boulevard interchange (Exit 99) was constructed in 1996. This interchange provides direct access to the Missoula International Airport and the surrounding industrial lands. Currently, the interchange is a three-leg diamond interchange. This interchange will be modified to accommodate a new connection to Gooden Keil Road, serving a residential area, which lies approximately 0.4 miles north of the interchange. This future project is the only "committed" network improvement recognized by MDT that may impact the I-90 corridor. However, potential impacts are projected to be minor.

Approximately 1.7 miles to the east lies the Reserve Street interchange (Exit 101). The interchange is a full-diamond interchange serving the high-growth commercial and retail-oriented Reserve Street (US93) corridor. This interchange was improved in 1998 and includes a full actuated traffic control system at the I-90 ramps.

Further east, the Orange Street (Exit 104) and Van Buren Street (Exit 105) interchanges serve the urban city center of Missoula. Each of these interchanges is in a full-diamond configuration operating under stop-sign control. While the Orange Street interchange is a three-leg layout and the Van Buren Street is a four-leg, each handles approximately the same volumes of AM and PM peak hour traffic. Van Buren Street also serves as a designated bike route between the residential areas (Rattlesnake Canyon) north of I-90 and the east side of the city proper, including the University of Montana area. Access to Broadway is closest at these interchanges.

Continuing easterly, Broadway, which parallels I-90 in the city proper, continues as the East Missoula Highway. The highway meets I-90 at the East Missoula interchange (Exit 107). This full-diamond, stop-sign-controlled interchange serves the predominant rural residential area. The traffic flow data strongly implies that East Missoula Highway serves as an alternative route from the city proper to I-90 during the afternoon peak hour.

The Bonner interchange (Exit 107) is a trumpet-style interchange connecting I-90 to State Route 210. This continuous-flow, rural interchange provides access to truck service and rest areas and is, therefore, subject to considerable on and off traffic from I-90.

Background

The study area segment of mainline Interstate 90 was constructed during 1966 and 1967 as a 4-lane rural interstate. The segment is predominantly classified as urban, although the posted speed limit is 75 mph, except within the city limits (RM 105.3-RM 107.75) where the speed is reduced to 65 mph. The corridor pavement was rehabilitated from RM 94 to the Van Buren Street interchange (RM 105.63) in 1991. The plant mix bituminous pavement shoulders were rehabilitated, and slope improvements were made in certain median areas in the year 2000. Two projects are under development to again rehabilitate the portland cement concrete pavement and overlay the pavement with plant mix bituminous pavement. Figure 2 illustrates the history of the corridor.

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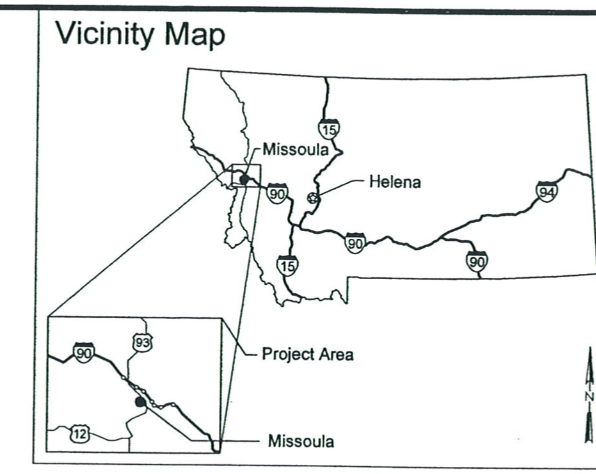
MDT Contracts:

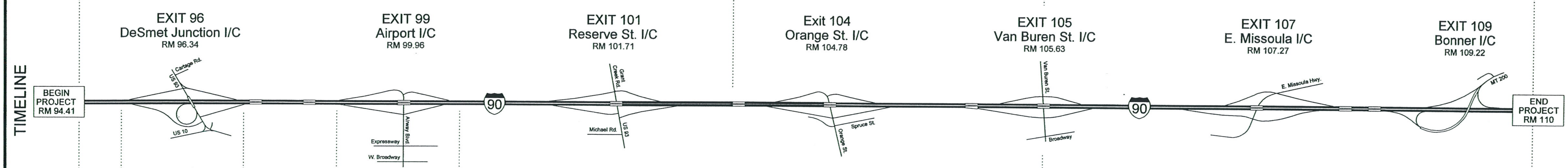


I-90 MDT Contracts Timeline:

1966 | I-IG 90-2(25)95 MISSOULA-WEST SECTION - RM 94.4-102.16

1967 | 1967 I-90-2(27)95 MISSOULA URBAN SECTION RM102.16-105.633

1966 | I-IG-909-2(14)105 VAN BUREN ST IN MISSOULA TO BONNER - RM 105.683-110.0



1991 | PCCP RM 94-105.6 REHABILITATED UNDER IR-90-2(78)94 MISSOULA WEST

1994 | 1994 IM 90-2(84)96 F I/C IMPROVEMENTS[1]

1997 | 1997 DPI 0195 (001) F I-90 AIRPORT I/C[2]

2000 | PMB5 SHOULDER AND MEDIAN FILLED UNDER I IM 90-2(98)94, 7.6 km E OF FRENCHTOWN [2807]

PRESENT (2003): BEING DEVELOPED AS A PROJECT: IM 90-2(103)94, 7 km E OF FRENCHTOWN [4572]

PRESENT(2003): UNDER CONSTRUCTION:IM-90-2(102)106 MISSOULA BONNER [3853] PCCP CRACK AND SEALED W/ 120 mm OVERLAY

[1] 1994 IM 90-2(84)96 F, STR., WIDEN., INT. IMPROVEMENTS (LOOP RAMP)

[2] 1997 DPI 0195 (001) F GRADE, GRAVEL, PL. MIX SURF. & STRUCTURES MISSOULA I-90 AIRPORT INTERCHANGE

The City of Missoula is currently engaged in a study to update its own transportation master plan. Within that study the City defines how it intends to meet its existing and future vehicular, as well as non-motorized, transportation needs. The update targets the year 2025 for its future year projections. At this time MDT does not anticipate major modifications to the I-90 corridor as a result of this study. However, the future travel demand projections for the corridor are based on the areawide transportation plan travel demand forecast model.

In October of 2002 the MDT selected CH2M HILL to perform Phase I of the study. Traffic data was immediately collected at that time in order to take advantage of weather conditions and athletic special events schedules associated with the University of Montana, which also impact the transportation network.

Scope of Work

Phase I (this study) is intended to document existing and future operations/physical attributes/deficiencies of the corridor for both morning and evening peak periods as well as the predominant special events at the University. Phase II (not part of this contract) will be performed to develop alternative solutions to the problems and deficiencies identified. The scope of work for this phase only includes analysis and evaluations of traffic, accident history, and geometric conditions. In addition, the MDT has asked that a noise study be performed to address concerns expressed by the City and residents west of the corridor relative to highway noise. Based on the intent as a planning level study the following items will not be addressed:

- Traffic signal warrants and any proposed plans
- Utilities
- Environmental conditions, with the exception of noise
- Roadway lighting
- Right-of-way requirements
- Intersection and interchange modifications, except as they relate to identified capacity or operational deficiencies
- Typical sections, except as they relate to capacity, problems and deficiencies
- Pedestrian and non-motorized needs
- Signage, except as provided by record drawings and related to operational deficiencies

The study report is intended as a summary document, supplemented by technical memoranda and appended data. In addition, the operational analysis includes the development of traffic operations simulation models using both SYNCHRO/SIM TRAFFIC and the Federal Highway Administration (FHWA)-sponsored CORSIM network model.

Transportation

Existing Conditions

Weekday Peak Periods

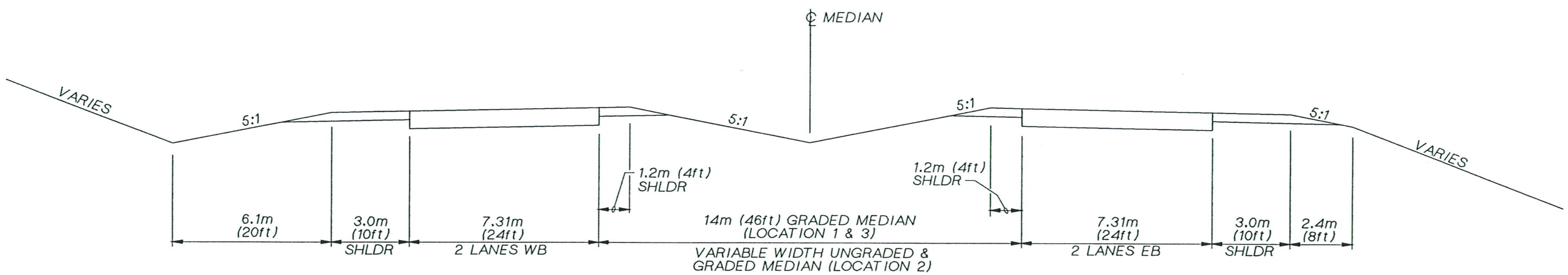
The data for analysis of existing conditions and features of the corridor included field reviews and photo logs, aerial mapping (Missoula County, April 1999), and record drawings from the MDT. Accepted design criteria are based on the requirements, recommendations, and guidelines of the American Association of State Highway and Transportation Officials (AASHTO) *A Policy on Geometric Design of Highways and Streets, 2002 Edition*, the MDT *Road Design Manual*, and the MDT *Traffic Engineering Manual*

An evaluation of the existing I-90 facility was accomplished by separate analysis of physical features covering two general categories: geometric features and operational features. It should be noted that current federal and state practice limits the design of major facilities to a design speed of 110 kmph (70 mph). The evaluation and analysis was performed within that limitation.

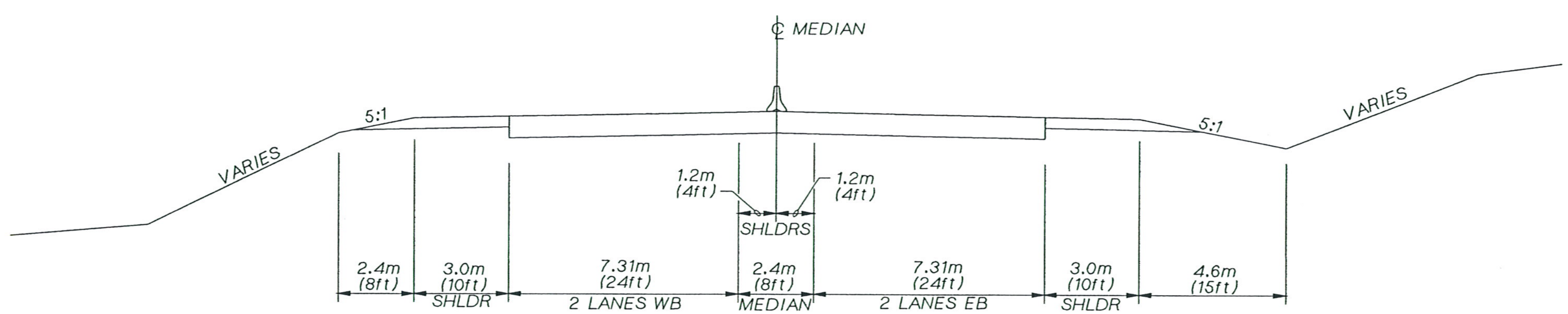
Geometric Features

In the first category, geometric features, the physical design of individual roadway elements was evaluated. The elements included the following:

- **Horizontal Alignment**
  Horizontal alignment was evaluated on the basis of horizontal curvature.
- **Vertical Alignment**
  Vertical alignment was evaluated on the basis of the speed reduction a heavy truck would be likely to experience.
- **Cross Section**
  Cross-sectional features evaluated included lane widths, shoulder width (left and right), median width, superelevation rate, roadside design (clear zone, steepness of slope), and roadside barrier design. Existing typical sections are shown in Figure 3.
- **Entrance/Exit Design**
  The design of entrances and exits at the mainline was evaluated on the basis of two criteria. The first was acceleration or deceleration length as measured by the length of taper or taper plus parallel lane on each ramp. The second was curvature in the vicinity of the physical nose.
- **Ramp Geometry**
  Ramp geometry was subjectively evaluated for adherence to general principles of geometric design.



LOCATION 1 = MP 94.414 TO 97.33
LOCATION 2 = MP 97.33 TO 103.63
LOCATION 3 = MP 107.48 TO 110.00



MP 103.63 TO 107.48

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CH2MHILL	MONTANA DEPARTMENT OF TRANSPORTATION MISSOULA MT, I-90 EAST WEST PHASE 1 CORRIDOR STUDY	I-90 TYPICAL SECTIONS	FIGURE 3

Operational Features

Elements included in the second category, operational features, were selected to evaluate the extent of smooth and efficient traffic operations throughout the corridor. Operational features included the following elements:

- **Lane Balance**
  Lane balance is an operational feature designed to minimize lane changing and erratic maneuvers at interchange ramps. This principle requires that drivers in the right lane have the option of continuing on the mainline without having to exit at single-lane exits. For 2-lane exits, exiting from the mainline must be optional from the freeway lane left of the lane being dropped.
- For entrance ramps, no more than one of the ramp lanes may be merged with a mainline lane. A second ramp lane must be continued as a lane added to the mainline (auxiliary lane) for an appropriate distance (minimum 750 meters).
- **Ramp Spacing**
  Ramp spacing was evaluated on the basis of the distance between successive ramp terminals.
- **Decision Sight Distance**
  Decision sight distance was evaluated in advance of each exit ramp.
- **Stopping Sight Distance**
  Stopping sight distance was evaluated both vertically and horizontally. Stopping sight distance related to vertical alignment was rated on the basis of the corresponding design speed of vertical curves.

Figure 4 summarizes some of the key characteristics of the corridor.

Geometrics and Features

Table 1 summarizes the evaluation criteria used to develop the summary conditions diagrams shown in Appendix Exhibit 1.

Each evaluation element has a measured value associated with it. Based on current design practice, criteria were selected to rate the measured value for each occurrence of an element for evaluation as either "Good," "Fair" or "Poor."

TABLE 1
Evaluation Criteria for the Existing Facility

Geometric Features

Horizontal Alignment Criteria

	Rating		
Criteria	**Good**	**Fair**	**Poor**
Radius of Curve (m)	>900	900 - 500	<500
(ft.)	>3000	3000 - 1820	<1820

Vertical Alignment Criteria

	Rating Criteria		
Measured Value	**Good**	**Fair**	**Poor**
Speed Reduction of Climbing Trucks	<15 kmph (10 mph)	15 – 25 kmph (10 - 15 mph)	> 25 kmph (15 mph)
Maximum Downgrades	< 3%	3 - 4%	> 4%

Cross Section Criteria

	Rating Criteria		
Measured Value	**Good**	**Fair**	**Poor**
Lane Width	3.6m (12 ft.)	-	< ~~>~~ 3.6 (12 ft.)
Outside Shoulder Width	3.0m (10 ft.)	-	< ~~>~~ 3.0m (10 ft.)
Inside Shoulder Width	1.2m (4 ft.)	-	< ~~>~~ 1.2m (4 ft.)
Superelevation	meets standards	> ±1%	1%>e> 2%
Clear Zone distances	meets standards	-	does not meet standards
Barriers	meets standards	-	does not meet standards

Note: Lowest rating of measured value prevails.

Entrance Ramp Criteria

	Rating Criteria		
Measured Value	**Good**	**Fair**	**Poor**
Taper Rate			
Taper Design	> 60:1	60:1 - 50:1	< 50:1
Parallel Design	>90m (300 ft,)	90 – 80 m	< 80 m (260 ft.)
Acceleration Length	meets standards	-	does not meet standards

Note: Lowest rating of measured value prevails.

TABLE 1 (Continued)
Evaluation Criteria for the Existing Facility

Geometric Features			
Exit Ramp Criteria			
	Rating Criteria		
Measured Value	**Good**	**Fair**	**Poor**
Taper Rate			
Taper Design (Diverge Angle)	2° - 5°	-	> 5°
Parallel Design	>75 m (250 ft.)	65 - 75 m	< 65 m (210 ft.)
Deceleration Length to 1st Geometric Control	meets standards	-	does not meet standards

Note: Lowest rating of measured value prevails.

Ramp Geometry Criteria

Rating based on various elements including curvature and grade.

Ramp Spacing Criteria			
	Rating Criteria		
Measured Value	**Good**	**Fair**	**Poor**
Distance Between			
Entry - Entry	> 350m (1150 ft.)	350 – 250m (1150-820 ft.)	< 250m (820 ft.)
Exit - Exit	> 350m (1150 ft.)	350 – 250m (1150-820 ft.)	< 250m (820 ft.)
Entry. - Exit	> 750m (2450 ft.)	750 – 450m (2450 – 1480 ft.)	< 450m (1480 ft.)
Exit - Entry	> 250m (820 ft.)	250 – 150m (820 – 500 ft.)	< 150m (500 ft.)

Note: Lowest rating of measured value prevails.

Lane Balance Criteria			
	Rating		
Criteria	**Good**	**Fair**	**Poor**
	Ramp terminal has lane balance	NA	Ramp terminal lacks lane balance

TABLE 1 (Continued)
Evaluation Criteria for the Existing Facility

Geometric Features			
Decision Sight Distance (DSD) Criteria			
	Rating Criteria		
Measured Value	**Good**	**Fair**	**Poor**
Sight distance in Advance at Exit Gore	> 600m (1970 ft.)	600 – 300m (1970 – 980 ft.)	< 300m (980 ft.)

Note: Lowest rating of measured value prevails.

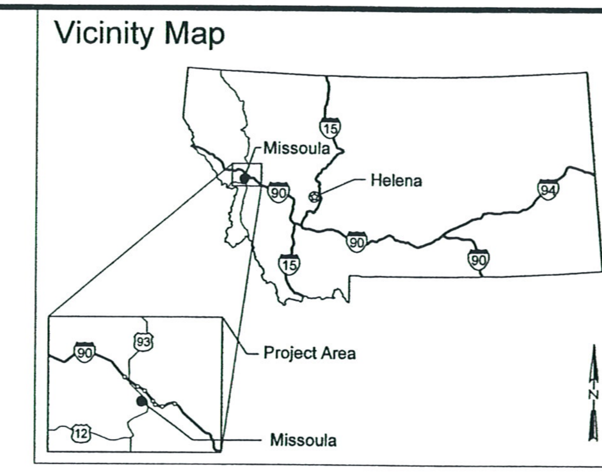
Stopping Sight Distance (SSD) Criteria			
	Rating Criteria		
Measured Value	**Good**	**Fair**	**Poor**
Design speed of vertical curves	> 110 kmph (70mph)	80 – 110 kmph (50 – 70 mph)	< 80 kmph (50mph)
Horizontal Sight Distance	> 220m (720 ft.)	160 – 220 m (525 – 720 ft.)	< 160m (525 ft.)

Note: Lowest rating of measured value prevails.

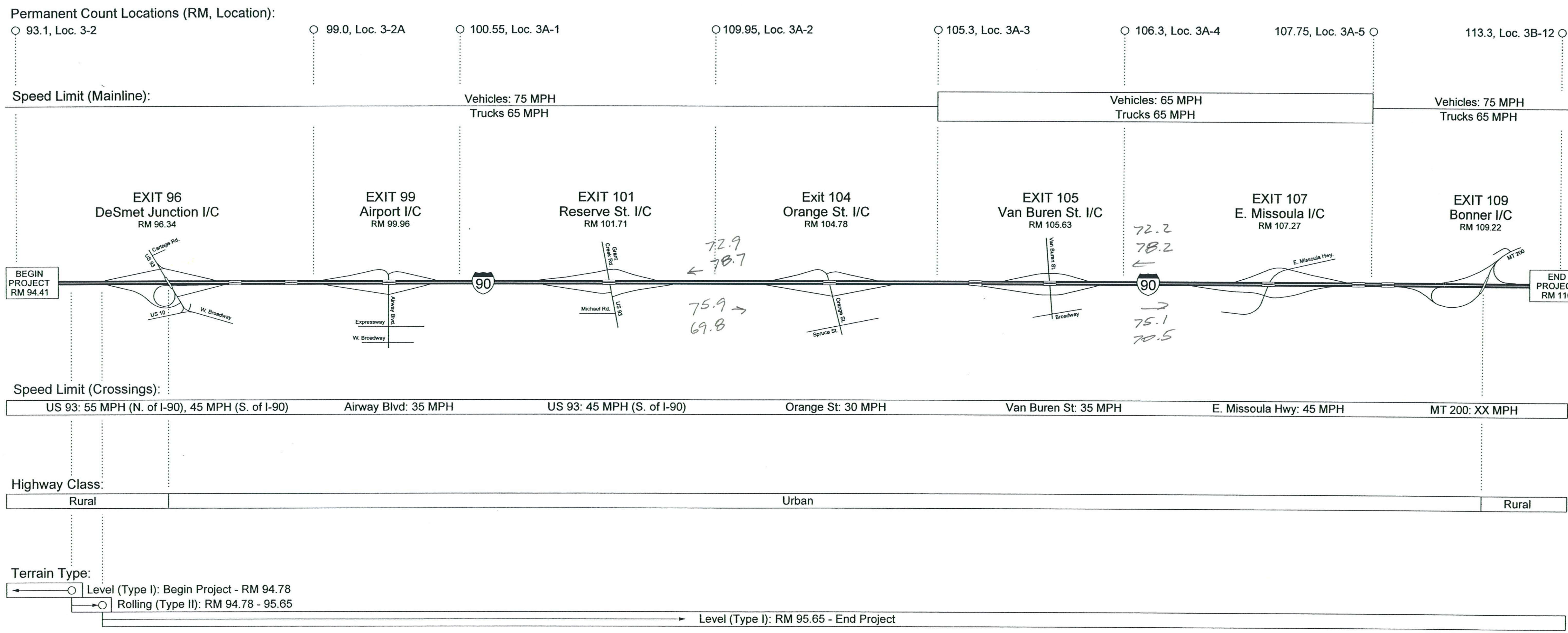
Based on the geometric analysis performed, and shown in Appendix Exhibit 1, it appears that the most predominant and potentially deficient feature along the corridor are the ramp entry and exit conditions, particularly at the Reserve Street, Orange Street, Van Buren Street, East Missoula, and Bonner interchanges. While these issues will be discussed further in the "Deficiencies" section of this report, the significance of the analysis warrants explanation by example.

Ramp Design

Entry Ramps. For a highway design speed of 110 kmph (70 mph), the length of the speed change (acceleration) lane is the longer of two distances. The acceleration length (L_a) is the distance from the speed-controlling point (ramp curve) to the point where left edge of ramp and the freeway thru lane meet at a 3.6 m (12 ft.) offset. At this point, the speed differential between ramp and thru traffic should theoretically be within 8 kmph (5 mph). The minimum gap acceptance length (L_g) is the distance between ramp "nose" and the merge point. From a stop condition, such as from a local arterial, the acceleration length for a design speed of 110 kmph (70 mph) is 500 m (1620 feet). Assuming that the entry vehicle can achieve a speed of 25 kmph (40 mph) at the point of ramp curvature, then 305 m (1000 feet) is required. This distance must be adjusted to account for the impact of grades, however, since the steepness and the length of grade greatly impact the speed which vehicles, particularly trucks, can achieve before merging.



Corridor Characteristics:



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CH2MHILL	MONTANA DEPARTMENT OF TRANSPORTATION MISSOULA MT, I-90 EAST WEST PHASE 1 CORRIDOR STUDY	I-90 CORRIDOR KEY FEATURES	FIGURE 4

When the Orange Street Eastbound On Ramp is reviewed we find the following:

Orange Street Eastbound On-Ramp

Criteria	Measured (ft)	Measured (m)	Grade Factor	Exist Queue (AM/PM) ft.	2025 Queue (AM/PM) ft.	Required (ft)	Adjusted* Required (ft)	Adjusted* Required (m)	Meets Required	Queue Impacts	Notes:
L_a	1335	407	2	N/A	N/A	1620	3240	988	NO		Assumed from Stop Condition
L_g	500	153		N/A	N/A	300		92	YES		
Taper Rate	50:1					50:1 to 70:1			YES		
Grade	5.70%										ASSESSMENT: Does not meet geometric guidelines

The results of this review suggests that the eastbound on-ramp acceleration length may be inadequate based on current design practices, for the desired level of service. Typical design practice provides that a range of solutions may be practical, and that balancing of multiple factors (grade, critical length, curvature, taper rate and style) is required to determine the adequacy of the existing design.

Exit Ramps. Taper-type exit ramps are similarly designed to accommodate proper speed changes from the freeway to exit ramp. Deceleration lengths are defined as the stopping distance required to typically reach a stop condition. The length of queue from the stop or signal-controlled arterial intersection, as well as ramp grades, are also factors in determining the available or required length. For the 110 kmph (70mph) design speed for flat ramp grades (<2%), the required distance is 180 meters (615 feet). Similar to exit ramps, this distance is measured to the point of speed control (ramp curve) from the point where the ramp diverges from the thru lane. On curvilinear ramps, a length of parallel lane is also typically provided to achieve the distance required.

For the Van Buren Street EB off-ramp the following was found:

VanBuren Street Eastbound Off-Ramp

Criteria	Measured (ft)	Measured (m)	Grade Factor	Exist Queue (AM/PM) ft.	2025 Queue (AM/PM) ft.	Required (ft)	Adjusted* Required (ft)	Adjusted* Required (m)	Meets Required	Queue Impacts	Notes:
L_d	1454	444	1.35	88 / 91	691 / 272	615	830	188	YES	YES	Assumed to terminate at Stop Condition
Total Ramp Length	1604	489									
Diverge Angle	4.50					2 - 5 degrees			YES		
Grade	-4.50%										ASSESSMENT: Projected 2025 AM queues would impact L_d.

For the Van Buren Street Eastbound off-ramp the above results suggest that the geometrics meet the guidelines and that existing queue lengths may be accommodated.

Similar analyses were performed for each interchange ramp along the study corridor. The results of those analyses are included in Appendix Exhibit 1.2.

Interchange Spacing. AASHTO guidelines (Chapter 10) suggest the following criteria for spacing successive freeway interchanges, as measured along centerline between cross street structures:

Urban 1.5 km (1.0 mile)
Rural 3.0 km (2.0 miles)

The spacing between the Orange and Van Buren Street interchanges is 1.37 km (0.85 miles).

Distance between Successive Ramps. The required absolute distance between successive ramp terminals (entry followed by exit) is determined by analysis of weaving operations. For typical taper ramp entry followed by taper ramp exit where no auxiliary lanes are provided, the ramp merge or diverge operation of each movement typically extends to a 450 m (1500 ft.) length of influence. When the influence lengths overlap, due to a distance less than 450 m (1500 ft.), the worse case condition controls. When this distance is not present AASHTO actually suggests that an auxiliary lane be provided and weaving analysis dictate the appropriate separation of the ramps.

Traffic Volumes

Historic traffic data for I-90 are available from a permanent count station at MP 114.5, approximately 0.5 miles east of the Turah interchange. This location, although it is 4.5 miles east of the study area boundary, is indicative of general travel growth for the I-90 mainline. Figure 5 illustrates the general growth trend over the last 20 years at that location, an average rate of 3.4% per year. In addition, annual traffic count data is available for the I-90 mainline at a location between the Orange and Van Buren interchanges. Figure 6 illustrates these data from 1993 to 2002. This segment also experienced an average growth rate of 3.4% per year.

FIGURE 5
I-90 Historic Growth 1980-2002 (at Turah Interchange)

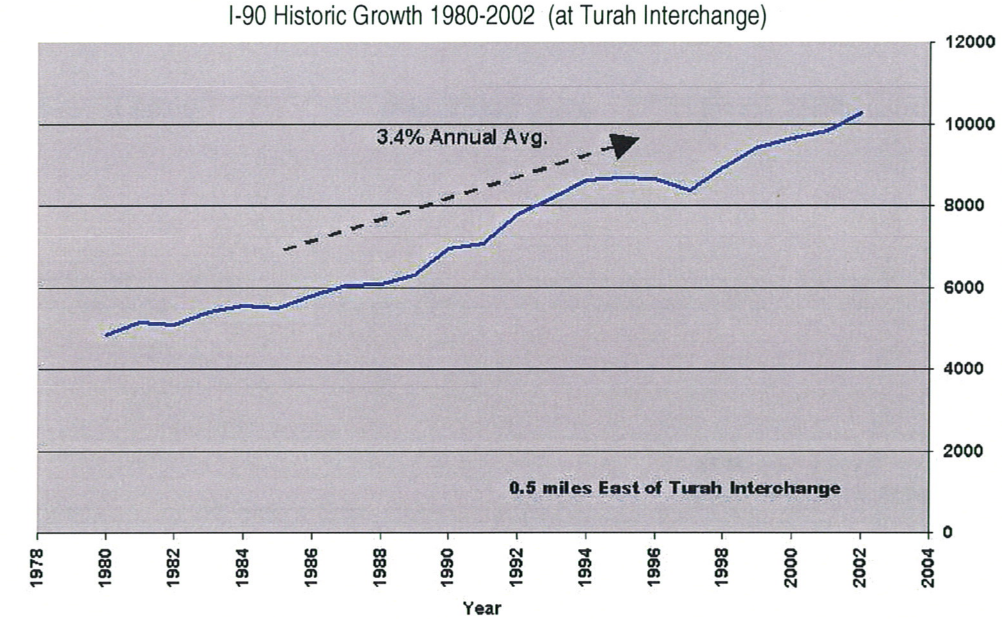
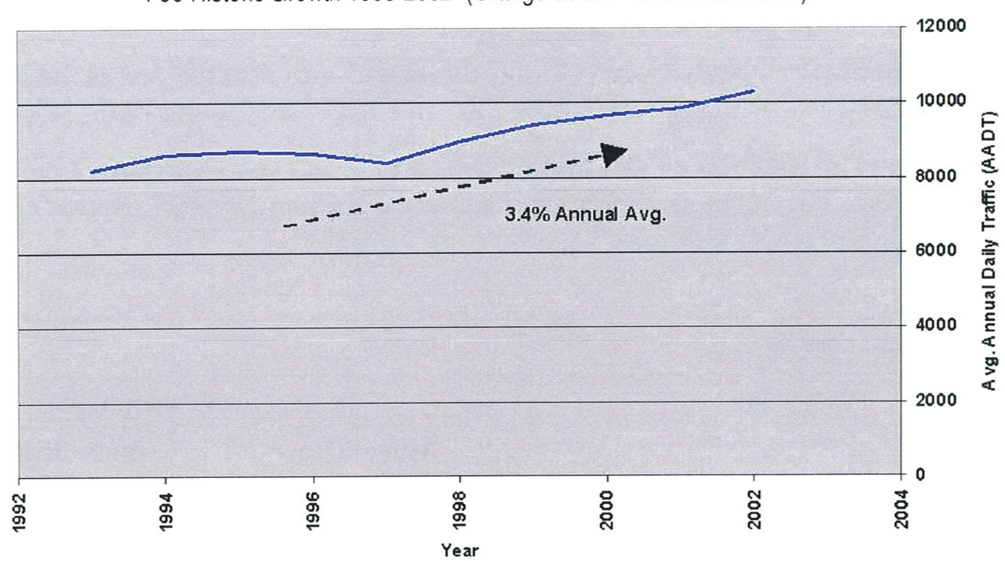


FIGURE 6
I-90 Historic Growth 1993-2002 (Orange Street - Van Buren Street)



Traffic data for the corridor were also collected as part of this study on the mainline, ramps, and at intersections. Mainline traffic counts were taken continuously for multiple days at six mainline locations within the study area (see Figure 2 for permanent count station locations). A summary of the data is included in the Appendix as Exhibit 3. Table 2 illustrates the peak hour volumes, speed, and truck volumes for these counts. These counts indicated that peak hour travel peaks are the periods of 7 to 8 AM and 4 to 6 PM. Because of similar traffic volumes, the afternoon peak hour of 5 to 6 PM was chosen for analysis purposes. Figures 7A and 7B show the variations in peak hour traffic flow over the entire length of the study section for morning and afternoon peak periods.

TABLE 2
I-90 Sample Traffic Flow Data

Missoula MT, I-90 East West Corridor Study-Phase 1

Mainline Traffic Data Inventory:
Sample Peak Counts

Legend:

Segment	Location
3A-1	Between Airway Blvd (RM 99.94) and Reserve St. (RM 101.78)
3A-2	Between Reserve St. (RM 101.78) and Orange St.(RM 104.78)
3A-3	Between Orange St. (RM 104.78) and Van Buren St. (RM 105.63)
3A-4	Between Van Buren St. (RM 105.63) and E. Missoula I/C (RM 107.27)
3A-5	Between E. Missoula I/C (RM 107.27) and Bonner I/C (RM 109.22)
3B-12	Between Bonner I/C (RM 109.22) and Turah

Segment	Station	EB	WB	Start	End	AM Peak Period	AM Peak Hour Volume	PM Peak Period	PM Peak Hour Volume	Truck %	Speed (Avg.) MPH	Speed (85th%) MPH
3A-1	I-90 RP 100.5	X		Nov. 04, 2002	Nov. 10, 2002	7-8 AM	625	4-5 PM	590	17.8		
3A-1	I-90 RP 100.5		X	Nov. 25, 2002	Dec. 01, 2002	11-12 AM	575	4-5 PM	825	10.9		
3A-2	I-90 RP 103.5	X		Oct. 28, 2002	Nov. 03, 2002	7-8 AM	675	5-6 PM	670	17.2	66.6	73.5
3A-2	I-90 RP 103.5		X	Oct. 28, 2002	Nov. 03, 2002	7-8 AM	490	5-6 PM	700	17.6	66.9	74
3A-3	I-90 RP 105.3	X		Oct. 28, 2002	Nov. 03, 2002	11-12 AM	525	5-6 PM	1000			
3A-3	I-90 RP 105.3		X	Oct. 28, 2002	Nov. 03, 2002	7-8 AM	950	4-5 PM	725			
3A-3	I-90 RP 105.3		X	Nov. 18, 2002	Nov. 24, 2002	7-8 AM	915	3-4 PM	710	15.7		
3A-3	I-90 RP 105.3	X		Nov. 25, 2002	Dec. 01, 2002	11-12 AM	550	5-6 PM	850			
3A-3	I-90 RP 105.3		X	Nov. 25, 2002	Dec. 01, 2002	7-8 AM	800	4-5 PM	875			
3A-4	I-90 RP 106.3	X		Oct. 28, 2002	Oct. 30, 2002	11-12 AM	430	5-6 PM	700	17.3	65.1	71.6
3A-4	I-90 RP 106.3		X	Oct. 28, 2002	Oct. 30, 2002	7-8 AM	865	3-4 PM	685	15.1	66.7	73.2
3A-5	I-90 RP 107.7	X		Oct. 21, 2002	Oct. 27, 2002	11-12 AM	515	5-6 PM	950	16.2	78	76.5
3A-5	I-90 RP 107.7		X	Oct. 21, 2002	Oct. 27, 2002	7-8 AM	740	4-5 PM	600	14.6	71	77.7
3A-5	I-90 RP 107.7	X		Nov. 11, 2002	Nov. 17, 2002	7-8 AM	660	4-5 PM	550	17.6		
3A-5	I-90 RP 107.7		X	Nov. 18, 2002	Nov. 24, 2002	7-8 AM	455	5-6 PM	765	16.7		
3B-12	I-90 RP 113.5	X		Oct. 21, 2002	Oct. 27, 2002	10-11 PM	340	5-6 PM	475	22.5	72.8	74.8
3B-12	I-90 RP 113.5		X	Oct. 21, 2002	Oct. 27, 2002	7-8 AM	385	5-6 PM	350	20.5	79.7	81.4
3B-12	I-90 RP 113.5	X		Nov. 25, 2002	Dec. 01, 2002	11-12 PM	400	4-5 PM	500	14.4		
3B-12	I-90 RP 113.5		X	Nov. 25, 2002	Dec. 01, 2002	11-12 PM	410	2-3 PM	475	13.8		

FIGURE 7A
I-90 AM Peak Hour Traffic Flow

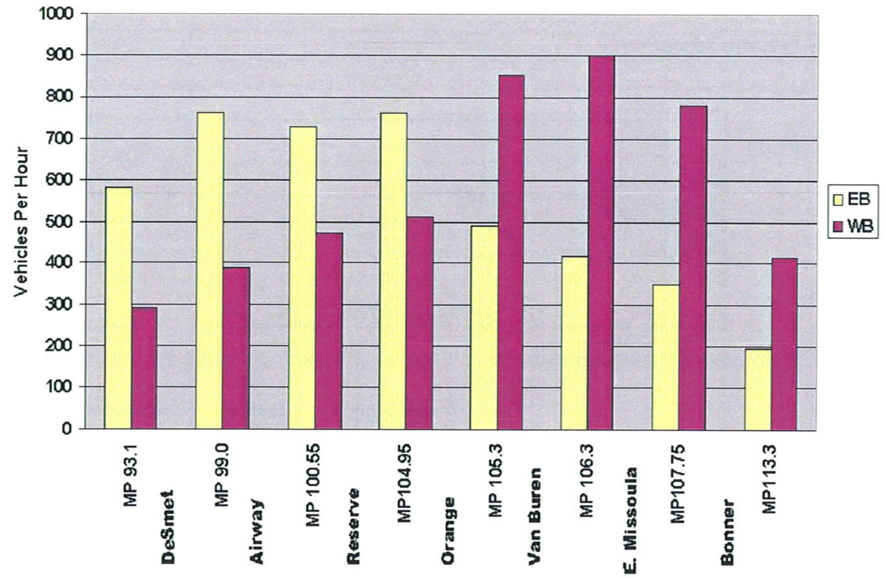
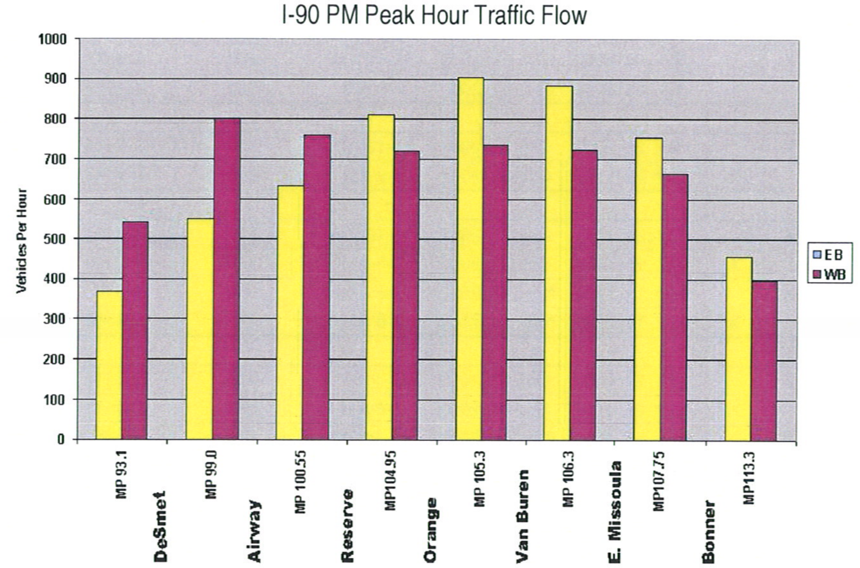


FIGURE 7B
I-90 PM Peak Hour Traffic Flow



Manual turning movement counts were obtained for 18 study intersections. These intersections were jointly selected with MDT based on their potential for impact on mainline and ramp traffic operations. Figure 8 identifies the study intersections.

In addition, traffic counts were taken on the day of peak special-event traffic associated with the University of Montana. Historically, this is the date of the University of Montana/Montana State University football game. MDT and local officials indicated that interchange congestion occurs at the Orange Street and Van Buren Street interchanges during this event. It was felt that the data may allow improved special event traffic planning by local officials.

Mainline, ramp, and intersection turning movement counts are summarized in Figures 9A through 9D for both peak periods. All volumes shown have been adjusted based on seasonal adjustment factors to represent average annual weekday traffic conditions as well as to achieve corridor network balance.

The data illustrates that the segment between Orange Street and Van Buren Street is the heaviest traveled during both peak periods, with approximately 1350 and 1640 vehicles per hour, respectively.

As Table 3 illustrates, the intersection of Van Buren Street and Broadway experiences the highest peak hour volumes of the study intersections. Amongst the study interchanges, the Reserve Street ramp intersections carry the highest traffic volumes.

TABLE 3
Intersection Approach Volumes

Intersection	Total Approach Volume (vph)	
	AM Peak Hour	PM Peak Hour
Broadway/US 200 @ Pulp Mill Road	928	1064
Broadway /US 200 @ EB On-Ramp	898	968
Broadway /US 200 @ EB Off-Ramp	756	1313
Broadway /US 200 @ WB Ramps	981	923
Broadway /US 200 @ Cartage Road	930	1190
Airways Blvd. @ W. Broadway	1045	1253
Airways Blvd. @ Expressway Street	578	654
Airways Blvd. @ EB Ramps	325	332
Airways Blvd. @ WB Ramps	152	164
Reserve Street @ Grant Creek Road	1308	1527
Reserve Street @ EB Ramps	1368	1588
Reserve Street @ WB Ramps	1031	1175
Orange Street @ Spruce Street	1631	2302
Orange Street @ EB Ramps	1017	1214
Orange Street @ WB Ramps	539	625
Van Buren Street @ Broadway	1711	2325
Van Buren Street @ EB Ramps	1182	1434
Van Buren Street @ WB Ramps	1060	1214
East Missoula Road @ EB Ramps	449	707
East Missoula Road @ WB Ramps	609	785

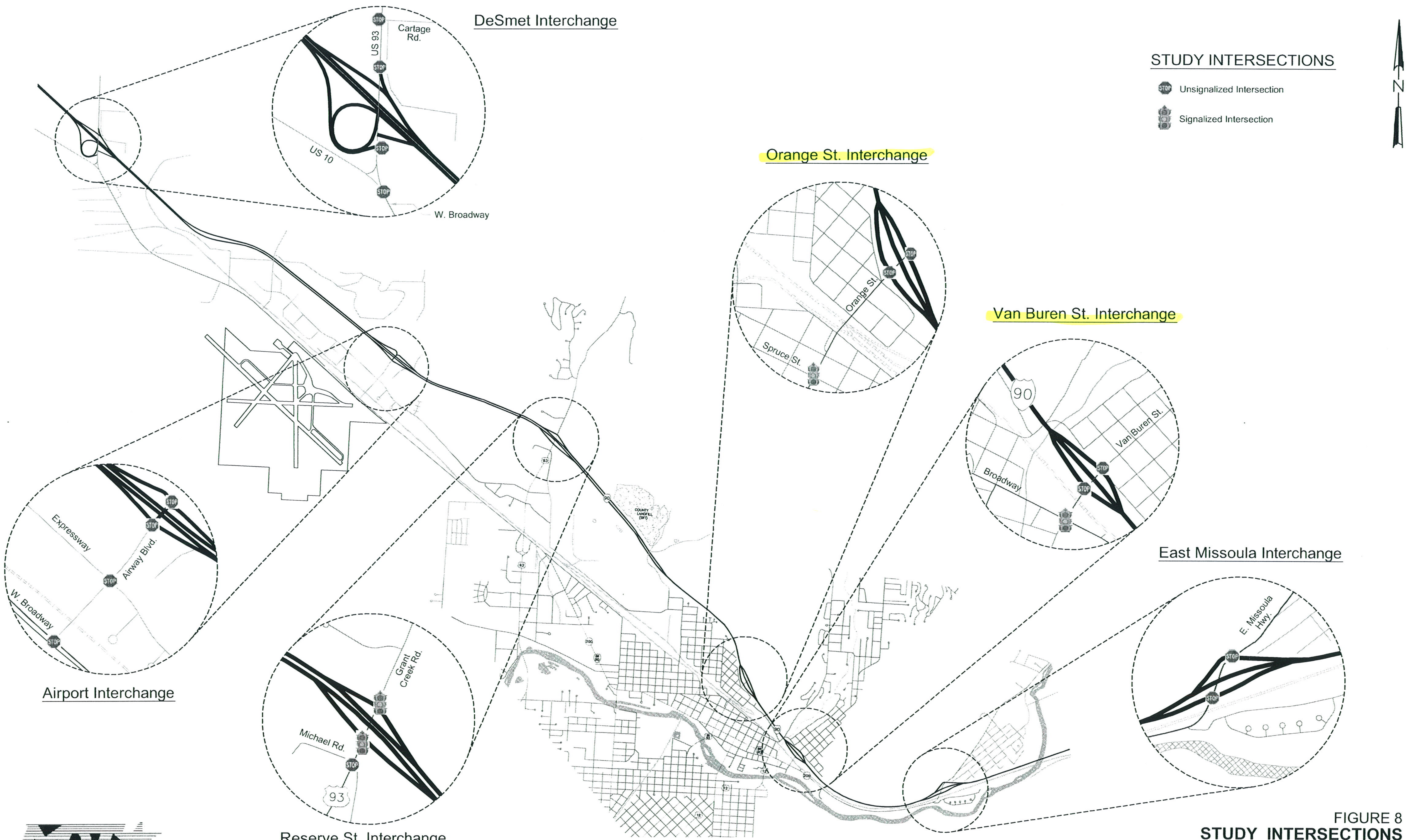


FIGURE 8
STUDY INTERSECTIONS

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MISSOULA, MT I-90 EAST WEST, CORRIDOR STUDY PHASE 1

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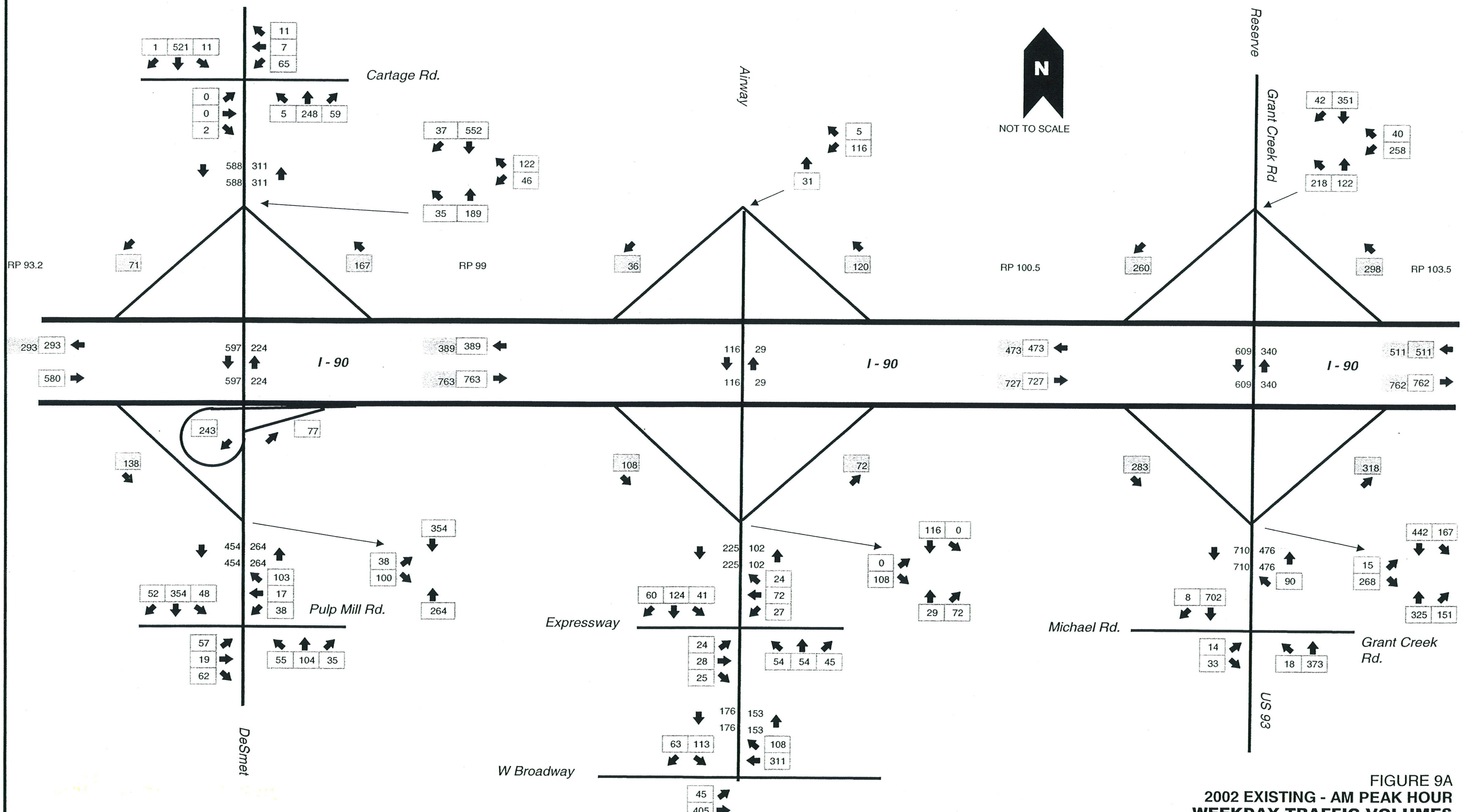

FIGURE 9A
2002 EXISTING - AM PEAK HOUR
WEEKDAY TRAFFIC VOLUMES
DESMET TO RESERVE STREET INTERCHANGES

MDT *serving you with pride*

MISSOULA, MT, I-90 EAST WEST, CORRIDOR STUDY PHASE 1

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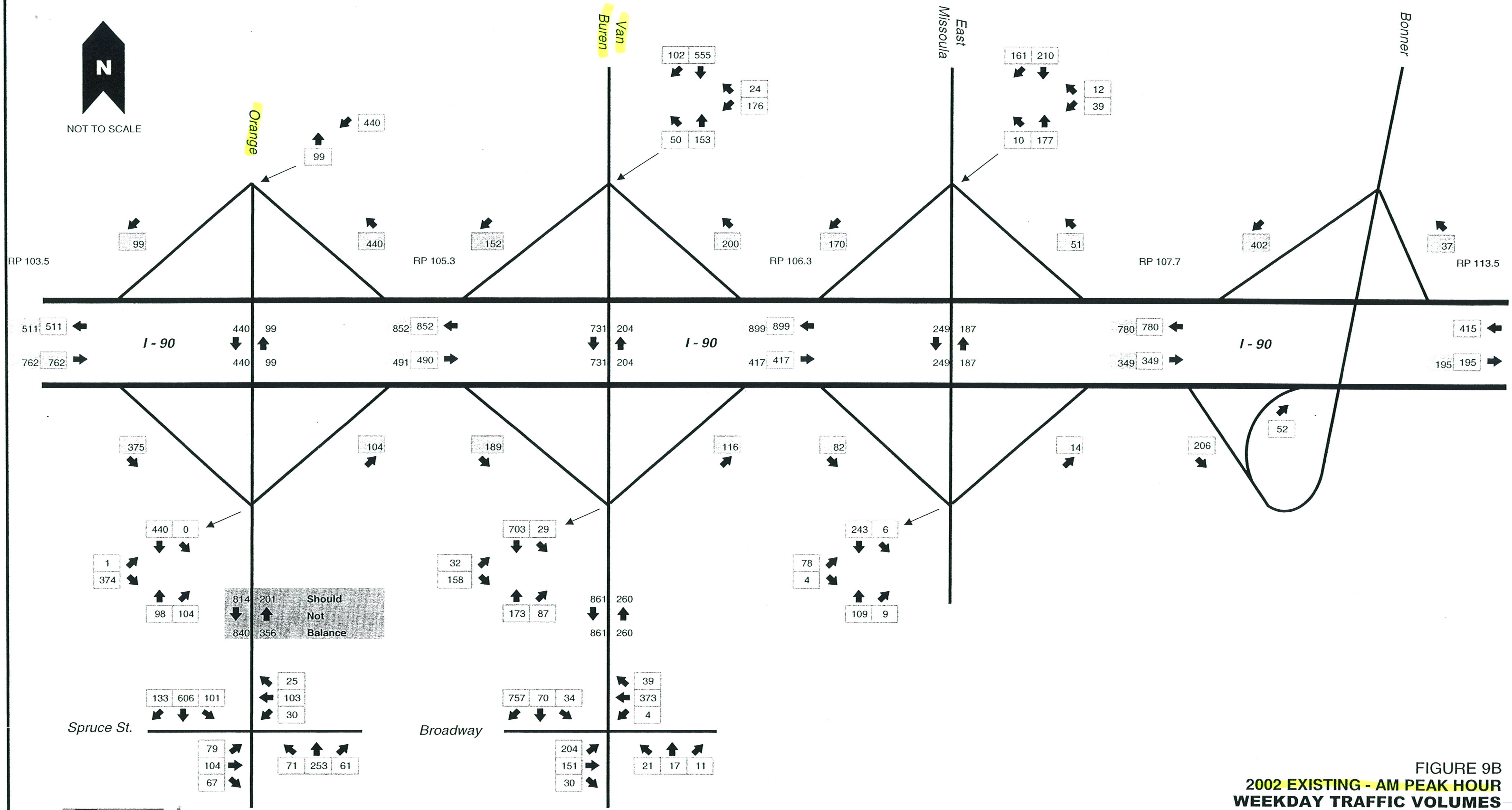

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MISSOULA, MT, I-90 EAST WEST, CORRIDOR STUDY PHASE 1

FIGURE 9B

2002 EXISTING - AM PEAK HOUR

WEEKDAY TRAFFIC VOLUMES

ORANGE STREET TO BONNER INTERCHANGES

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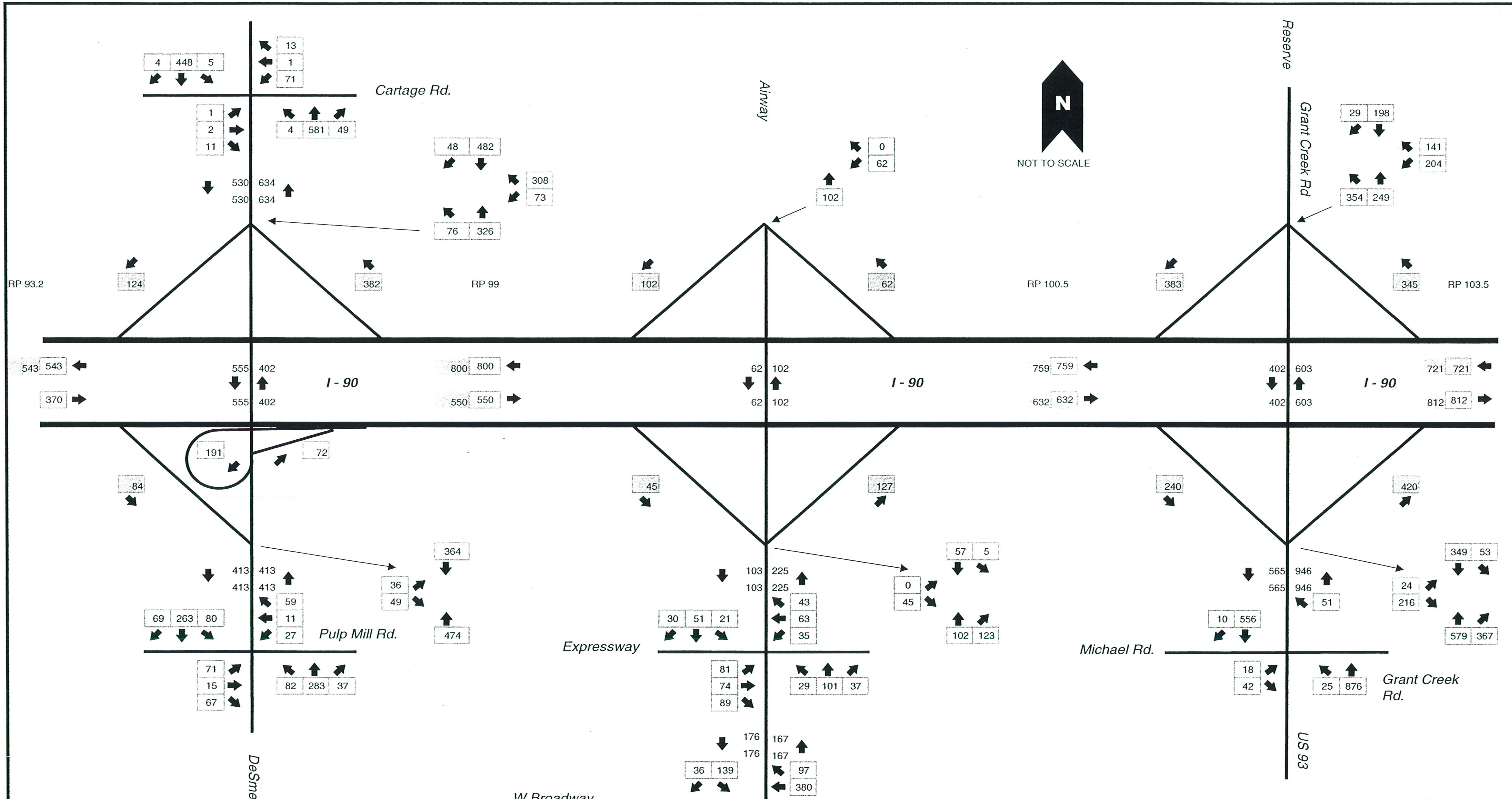

FIGURE 9C
2002 EXISTING - PM PEAK HOUR
WEEKDAY TRAFFIC VOLUMES
DESMET TO RESERVE STREET INTERCHANGES

MDT serving you with pride

MISSOULA, MT, I-90 EAST WEST, CORRIDOR STUDY PHASE 1

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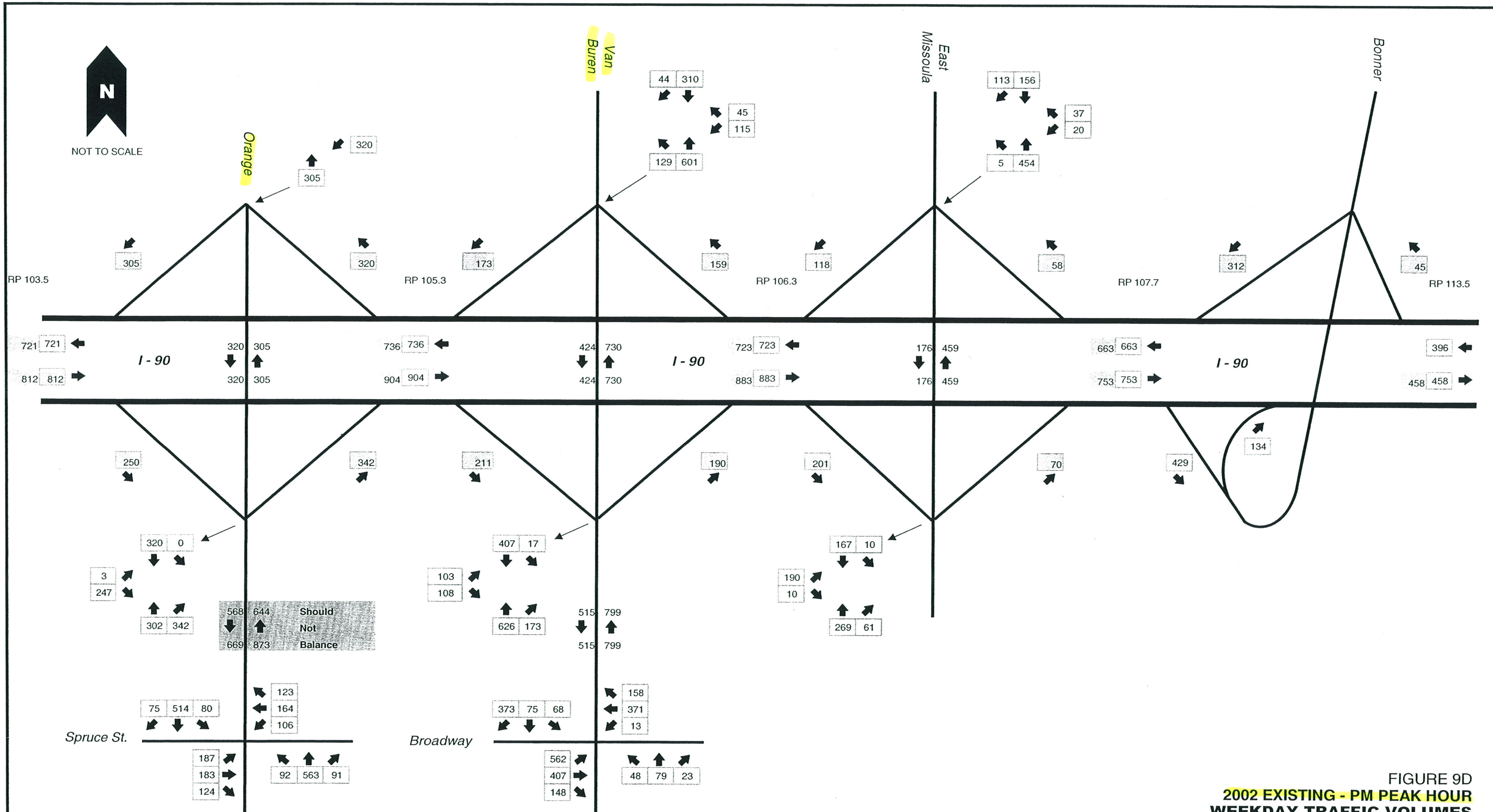

FIGURE 9D

2002 EXISTING - PM PEAK HOUR

WEEKDAY TRAFFIC VOLUMES

ORANGE STREET TO BONNER INTERCHANGES

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MISSOULA, MT, I-90 EAST WEST, CORRIDOR STUDY PHASE 1

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Traffic Operations

Methodology

The analysis of traffic operations for the I-90 corridor involved the use of three (3) primary analysis software tools: CORSIM, SYNCHRO and HCS. CORSIM, as part of the TSIS (Traffic Software Integrated System), is a comprehensive, microscopic traffic simulation model, applicable to freeways and surface streets, with a complete selection of traffic control devices. CORSIM simulates traffic and traffic control systems using commonly accepted vehicle and driver behavior models. The CORSIM micro-simulation model was developed to simulate existing year (2002) freeway traffic operations along the I-90 corridor from the DeSmet interchange in the west to the Bonner interchange in the east. The CORSIM simulation model covers existing on- and off-ramps. When combined with the SYNCHRO model, frontage roads and specified local intersections were modeled as well. AM and PM peak periods were analyzed.

To create the CORSIM model, an aerial photograph base was imported into the CORSIM network building tool (TRAFED), and approximately 230 individual nodes were connected to create a "link-node" network that resembled the actual I-90 corridor. These links could be updated individually to specify roadway geometric features for the mainline and ramps, such as number of lanes, auxiliary lane lengths, grade, and horizontal curvature. This information was determined from aerial photographs, as-built drawings, and field visit surveys of the roadways. Each individual link was also updated with specific operating conditions such as speed limit. For example, the speed limit along the mainline near the Orange, Van Buren, and East Missoula interchanges was input lower than the rest of the corridor to reflect a lower posted speed in these urban areas.

Once the model was built, freeway mainline and ramp volumes were input. Raw mainline and ramp volumes were first balanced and then formulated in the text editor of CORSIM. In this text editor, mainline entering volumes were assigned to specific lanes, off-ramp volumes were assigned as a percent of the upstream mainline volume, and truck and HOV percentages were input at each entering volume node.

The above information is the minimum needed to "run" a CORSIM model. Our model was expanded to include areas that were fine-tuned to reflect more accurately operating conditions along the I-90 corridor, such as speed limit and truck lanes. The maximum free-flow speed limit input accepted by CORSIM is 110 kmph (70 mph), but the actual roadway in question has measured speeds up to 130 kmph (80 mph). To account for this, the "car-following sensitivity" factor was increased, which allows a vehicle to be less sensitive to the vehicle it follows, therefore increasing the movement of the entire fleet. This factor was adjusted and calibrated until the average travel time of a vehicle through the corridor matched our field data travel time of approximately 14 minutes.

Trucks and heavy vehicles in the model were biased to the right travel lane of I-90 to reflect "real-life" conditions. Without this specification, these heavy vehicles are normally free to travel in any lane of the freeway, but to more accurately capture the effect of slow vehicles in the on- and off-ramp lanes, a designation in the CORSIM text editor was used to bias trucks to one lane.

Once the CORSIM and SYNCHRO models were completed and calibrated separately, the SYNCHRO models were imported to CORSIM by individual interchange, and connected in TRAFED to their respective interchange ramps.

Ramp junctions and adjacent arterial intersections were analyzed using the SYNCHRO/SIM TRAFFIC software package. SYNCHRO allows the analysis of existing signal timing plans as well as the optimization of signal timing parameters to match traffic flow rates. SYNCHRO is based on methodologies of the *2000 Highway Capacity Manual* for determination of the operating level of service (LOS) of the intersection. Additional measures of effectiveness (MOE) include average vehicle delay, and maximum, average, and 95th percentile queues. Once established, the SYNCHRO model output was integrated with the CORSIM model to establish the total network simulation that included both the freeway and the 20 adjacent study intersections.

The methodologies of the *2000 Highway Capacity Manual* were used to determine freeway basic segment or mainline operating LOS as well as for entry- and exit-ramp operations. Mainline LOS was calculated for each segment and is a function of the number and width of lanes, lateral clearance, terrain, free flow speed and interchange spacing. In addition, interchange ramp merge and diverge section LOS was also computed.

Mainline and Ramps

Table 4 summarizes the results of the analysis for both eastbound and westbound directions on the mainline I-90. MDT has determined that LOS B represents acceptable operating condition policy for the freeway. LOS B represents reasonably free flow and free flow speeds are maintained. While speed is a major concern of drivers in characterizing a freeway segment, it is the ability to maneuver within traffic and the proximity to other traffic that are equally noticeable concerns. Thus, this ability relates to density of the traffic stream measured in passenger cars per mile per lane. For LOS B, the ability to maneuver within traffic is only slightly restricted, and the general level of physical and psychological driver comfort is still high. The effects of minor incidents and point breakdowns are easily absorbed within the facilities operation.

At ramps and ramp junctions the LOS is also a function of vehicle density. Maneuvering into the deceleration or ramp exit lanes, or merging into the through travel lane from the on-ramp results in a competition for limited space. The geometric characteristics of the ramp junction, the length and type of deceleration or acceleration lanes, the free flow speed of the ramp, influences of grades and sight distances, and other factors affect the driver's ability to comfortably enter or exit the freeway. At LOS B, merging and diverging maneuvers become noticeable to through drivers, and merging drivers must adjust speeds to accomplish smooth transitions from the acceleration lane to the freeway.

As Table 4 indicates, all segments and ramps operate acceptably for the studied peak hour periods. It should be noted that the methodology does not take into account a few key factors for the I-90 corridor. The first factor is that truck traffic is restricted on I-90 to the use of the outer lane. The second factor is that there is a speed differential for truck traffic, which is 105 kmph (65 mph) throughout the length of the corridor. The third factor is that the methodology assumes a maximum free flow speed of 60 kmph (35mph) for the ramps.

Through a sensitivity analysis, the influences of these three factors were found to be negligible on the results obtained. The sensitivity analysis performed included the selection of the highest-density ramp merge and diverge scenarios. To account for restriction of trucks to the outer lane, the percent of heavy vehicles was factored upward for the lane 1 (outer) traffic volumes. The factor of speed differential affects the input free flow speed for the segment. This is a non-issue as the maximum free flow speed for the freeway is 110 kmph (70 mph), and observed operating speeds exceed this value for both lane 1 and lane 2. The third factor is based on the lack of actual field data for ramp speeds. To account for this lack of data, a minimum ramp free flow speed of 15 mph was also input rather than the suggested default value of 60 kmph (35 mph). The net result of these factors is that the resulting LOS does not change for any of the analyses.

TABLE 4
Summary of Existing AM and PM Peak Hour Freeway Operations

I-90 Segment	Segment Type	2002 AM Existing		2002 PM Existing	
	Mainline/Merge/Diverge	LOS	Density[1]	LOS	Density[1]
Eastbound					
West of DeSmet I/C[2]	Mainline	A	5.7	A	3.5
DeSmet EB Off-Ramp	Diverge	A	9.0	A	6.6
Between DeSmet I/C Ramps	Mainline	A	3.8	A	2.4
DeSmet EB On-Ramp	Merge	A	8.1	A	6.2
Between DeSmet and Airport I/C	Mainline	A	6.5	A	4.6
Airport EB Off-Ramp	Diverge	B	10.5	A	8.0
Between Airport I/C Ramps	Mainline	A	5.6	A	4.2
Airport EB On-Ramp	Merge	A	8.9	A	7.4
Between Airport and Reserve Street I/C	Mainline	A	6.2	A	5.3
Reserve Street EB Off-Ramp	Diverge	B	10.7	A	9.5
Between Reserve Street I/C Ramps	Mainline	A	3.8	A	3.3
Reserve Street EB On-Ramp	Merge	A	8.9	A	8.7
Between Reserve and Orange Street I/C	Mainline	A	6.6	A	6.9
Orange Street EB Off-Ramp	Diverge	B	11.0	B	11.3
Between Orange Street I/C Ramps	Mainline	A	3.3	A	4.7
Orange Street EB On-Ramp	Merge	A	6.4	A	9.7
Between Orange and Van Buren Streets I/C	Mainline	A	4.2	A	7.6
Van Buren Street EB Off-Ramp	Diverge	A	7.0	B	11.3
Between Van Buren Street I/C Ramps	Mainline	A	2.6	A	5.9
Van Buren Street EB On-Ramp	Merge	A	5.6	B	10.3
Between Van Buren Street and East Missoula I/C	Mainline	A	3.6	A	7.5
East Missoula EB Off-Ramp	Diverge	A	6.8	B	11.6
Between East Missoula I/C Ramps	Mainline	A	2.9	A	5.7
East Missoula EB On-Ramp	Merge	A	5.0	A	8.7
Between East Missoula and Bonner I/C	Mainline	A	3.0	A	6.2
Bonner EB Off-Ramp	Diverge	A	6.5	B	10.8
Between Bonner I/C Ramps	Mainline	A	1.2	A	2.7
Bonner EB On-Ramp	Merge	A	1.7	A	4.2
East of Bonner I/C	Mainline	A	1.7	A	3.8

TABLE 4 (Continued)
Summary of Existing AM and PM Peak Hour Freeway Operations

I-90 Segment	Segment Type	2002 AM Existing		2002 PM Existing	
	Mainline/Merge/Diverge	LOS	Density[1]	LOS	Density[1]
Westbound					
East of Bonner I/C	Mainline	A	3.6	A	3.2
Bonner WB Off-Ramp	Diverge	A	6.9	A	6.4
Between Bonner I/C Ramps	Mainline	A	3.3	A	2.8
Bonner WB On-Ramp	Merge	A	9.0	A	7.5
Between East Missoula and Bonner I/C	Mainline	A	6.7	A	5.2
East Missoula WB Off-Ramp	Diverge	B	11.1	A	9.2
Between East Missoula I/C Ramps	Mainline	A	6.3	A	4.8
East Missoula WB On-Ramp	Merge	B	10.0	A	7.6
Between Van Buren Street and East Missoula I/C	Mainline	A	7.8	A	5.8
Van Buren Street WB Off-Ramp	Diverge	B	12.6	B	10.1
Between Van Buren Street I/C Ramps	Mainline	A	6.1	A	4.5
Van Buren Street WB On-Ramp	Merge	A	9.2	A	7.6
Between Orange and Van Buren Streets I/C	Mainline	A	7.3	A	5.9
Orange Street WB Off-Ramp	Diverge	B	12.0	B	10.1
Between Orange Street I/C Ramps	Mainline	A	3.5	A	3.3
Orange Street WB On-Ramp	Merge	A	5.8	A	7.2
Between Reserve and Orange Streets I/C	Mainline	A	4.4	A	5.8
Reserve Street WB Off-Ramp	Diverge	A	8.2	A	10.0
Between Reserve Street I/C Ramps	Mainline	A	1.8	A	3.0
Reserve Street WB On-Ramp	Merge	A	5.9	A	7.9
Between Airport and Reserve Street I/C	Mainline	A	4.1	A	6.1
Airport WB Off-Ramp	Diverge	A	7.6	B	10.2
Between Airport I/C Ramps	Mainline	A	3.1	A	5.6
Airport WB On-Ramp	Merge	A	5.4	A	9.1
Between DeSmet and Airport I/C	Mainline	A	3.4	A	6.4
DeSmet WB Off-Ramp	Diverge	A	7.0	B	10.9
Between DeSmet I/C Ramps	Mainline	A	1.9	A	3.4
DeSmet WB On-Ramp	Merge	A	4.3	A	6.4
West of DeSmet I/C[2]	Mainline	A	2.9	A	5.0

[1] Density reported in units of passenger cars per mile per lane (pc/mi/ln). Density thresholds vary depending if the segment is a mainline or merge/diverge. Refer to Appendix Exhibit 4 for Density to LOS thresholds.

[2] The segment was analyzed with grade specific terrain as well as average terrain factors. Worst case results are reported.

Intersections

While the above results are indicative of good freeway operations, the CORSIM model assumes that there are no influences due to downstream conditions at off-ramps that affect deceleration and stopping distances, or upstream influences at an on-ramp that affect acceleration speeds and ramp volumes. Thus, the above results do not present the whole picture. Ramp junctions with the adjacent streets are also evaluated to determine the impact of the controlled intersection on freeway operations. These impacts are typically projected as queue lengths for the off-ramps.

"Acceptable" LOS was defined by the MDT as LOS C at signalized intersections. LOS C is indicative of average control delay between 20 and 35 seconds per vehicle entering and leaving the intersection. For comparison purposes, the theoretical capacity of the intersection (LOS E) is characterized by average delays between 55 and 80 seconds per vehicle. For stop-sign-controlled intersections, the performance measure for characterizing the LOS is also the control, or average, delay per vehicle. Other factors, such as queue lengths, delays to major street traffic, and volume-to-capacity ratio are also used to describe the performance of these intersections.

Table 5 presents a summary of the LOS analysis for the study intersections. It is emphasized that all analyses results for signalized intersections are based on existing signal timing, which may not be the optimum.

TABLE 5
Summary of Existing AM and PM Peak Hour Intersection Operations

	2002 AM Existing		2002 PM Existing	
Intersection[2, 3, 4]	LOS	Delay[1]	LOS	Delay[1]
US 93 and Cartage Road	**D[4]**	**26.7**	**E**	**45.3**
I-90 DeSmet WB Ramps and US 93	B	12.5	C	20.4
I-90 DeSmet EB Off-Ramp and US 93	B	14.7	C	17.3
West Broadway and Pulp Mill Road	**D**	**32.6**	**F**	**69.4**
I-90 Airport WB Ramps and Airway Blvd.	A	9.5	B	10.0
I-90 Airport EB Ramps and Airway Blvd.	A	9.7	A	8.9
Airway Blvd. and Expressway	B	14.8	B	13.3
Airway Blvd. and West Broadway	C	20.6	**E**	**35.6**
I-90 Reserve Street WB Ramps and Grant Creek Road	*C*	*34.2[2]*	***D***	***38.0***
I-90 Reserve Street EB Ramps and US 93	*C*	*32.2*	***E***	***68.5***
US 93 and Michael Road/Grant Creek Road	C	17.5	C	17.3
I-90 Orange Street WB Ramps and Orange Street	C	15.3	C	16.0
I-90 Orange Street EB Ramps and Orange Street	**F**	**68.4**	B	13.9
Orange Street and Spruce Street[5]	*A*	*9.4*	*B*	*19.4*
I-90 Van Buren Street WB Ramps and Van Buren Street	**F**	**274.1**	**F**	**189.0**
I-90 Van Buren Street EB Ramps and Van Buren Street	C	23.8	**D**	**25.7**
Van Buren Street and East Broadway	***D***	***36.0***	*C*	*20.6*
I-90 East Missoula WB Ramps and East Missoula Hwy.	B	14.1	C	15.1
I-90 East Missoula EB Ramps and East Broadway	B	14.6	C	23.9

TABLE 5 (Continued)
Summary of Existing AM and PM Peak Hour Intersection Operations

	2002 AM Existing		2002 PM Existing	
Intersection[2, 3, 4]	LOS	Delay[1]	LOS	Delay[1]

[1] Delay reported in units of seconds per vehicle. Delay thresholds vary depending if the intersection is signalized or unsignalized. Refer to Appendix Exhibit 4 for Delay to LOS thresholds.

[2] Signalized intersection results are in *italic* type.

[3] Worst stop-controlled approach LOS and Delay reported for unsignalized intersections.

[4] Intersections operating worse than threshold LOS C are in bold type.

[5] Field data collected at Orange Street and Spruce Street indicated an unusually high number of heavy vehicles in the traffic stream, between 20 and 40 percent through the peak-hour. Field verification will be needed if future operations degrade as a result of high heavy vehicle percentages.

Operations on the freeway may be impacted by queues that extend either up the off-ramps or through the ramp intersections on the connecting arterials. The CORSIM model (Figure 10 in the Figures appendix) provides a predictive view of average and 95th percentile queues.

Figures 11A and 11B summarize the analyses results for the study network. Figures 12A through 12G (see Figures appendix) show the intersection specific-lane movement designations and the performance measures for the controlling approach or lanes.

Table 6 presents a summary of the I-90 ramp lengths and the modeled 95th percentile queue distances for those ramps impacted by intersection operations.

TABLE 6
I-90 Ramp Queue Impacts

Ramp	Total Length (feet)	Taper Length (feet)	Available Deceleration and Storage (feet)	Worst Case 95th Percentile Queue (feet)	Remaining Deceleration Length (feet)
Orange Street					
Eastbound Off AM Peak	1240	206	1035	376 (AM)	659
Van Buren Street					
Eastbound Off PM Peak	1605	150	1455	91 (PM)	1364
Westbound Off AM Peak	1072	180	605	401	204
Westbound Off PM Peak	1072	180	605	221	394

The above data indicates that for the existing AM and PM peak periods, theoretical queue distances should not impact freeway mainline operations. However, this does not imply that the ramps actually have adequate deceleration length at the present time. The queuing influences should be evaluated as deficiencies and alternatives are further evaluated.

Operating Speeds

Vehicle speeds for the I-90 mainline were obtained for the study at four of the permanent traffic count stations. As previously noted, the posted speed is 120 kmph (75 mph) in the rural section and 105 kmph (65 mph) in the urban section. Trucks are restricted to the outer lane (Lane 1) at a posted speed of 65 mph for the entire section length. Table 7 illustrates a summary of the speed data.

TABLE 7
I-90 Summary Speed Data (actual data reported in English units only)

Location	Posted Speed (mph) Lane 1/ Lane 2	Average Speed (mph)	85th Percentile Speed (mph)	% Over Posted (mph)**
(3A-2) Reserve Street - Orange Street	65/75			
Eastbound Lane 1		63.0	69.8	7.4%
Lane 2		69.3	75.9	1.2%
Westbound Lane 1		65.7	72.9	12.1%
Lane 2		71.7	78.7	4.9%
(3A-4) Van Buren Street – East Missoula Road	65/65			
Eastbound Lane 1		63.9	70.5	8.5%
Lane 2		69.0	75.1	15.5%
Westbound Lane 1		65.7	72.2	11.1%
Lane 2		71.8	78.2	20.3%
(3A-5) East Missoula Road - Bonner	65/75			
Eastbound Lane 1		68.4	75.0	15.4%
Lane 2		75.0	80.8	7.7%
Westbound Lane 1		69.7	76.9	18.3%
Lane 2		74.8	80.2	6.9%
(3B-12) East of Bonner	65/75			
Eastbound Lane 1		71.8	79.0	21.5%
Lane 2		77.1	82.9	10.5%
Westbound Lane 1		73.8	80.8	24.3%
Lane 2		79.3	84.4	12.5%

**Note: Lane 1 posted speed is 65 mph for trucks, and not all vehicles. Therefore, data should be used with caution

As the data above indicate, non-compliance with the posted speed limit appears to be a significant issue within the corridor. Although there is a 10-mph speed differential between trucks (restricted to lane 1) and passenger vehicles, the actual speed differential between lanes 1 and 2 averages between 5 and 6 mph. This is not unreasonable, since lane 1 carries other vehicles.

To further understand the operating speed issues, a Pace Speed analysis was performed. The "Pace Speed" represents the 10 mph range of operating speeds achieved by the highest percentage of vehicles. Frequency distribution analyses to determine the pace speeds are contained in Appendix Exhibit 7 and are summarized in Table 8. The data is presented by lane and direction for the various freeway segments.

TABLE 8
Operating Pace Speed Analysis Summary

Segment Location	Lane 1 (Outer)	Lane 2 (Inner)
I-90 Eastbound		
3A-2 RM	59.7 – 69.7 mph	64.9 – 74.9 mph
3A-4 RM**	60.1 – 70.1 mph	64.7 – 74.7 mph
3A–5 RM	64.6 – 74.6 mph	70.1 – 80.1 mph
3B-12 RM	65.1 – 75.1 mph	74.5 – 84.5 mph
I-90 Westbound		
3A-2 RM	61.4 – 71.4 mph	65.3 – 75.3 mph
3A-4 RM**	60.2 – 70.2 mph	65.4 – 75.4 mph
3A–5 RM	64.8 – 74.8 mph	70.1 – 80.1 mph
3B-12 RM	70.2 – 80.2 mph	75.2 – 85.2 mph

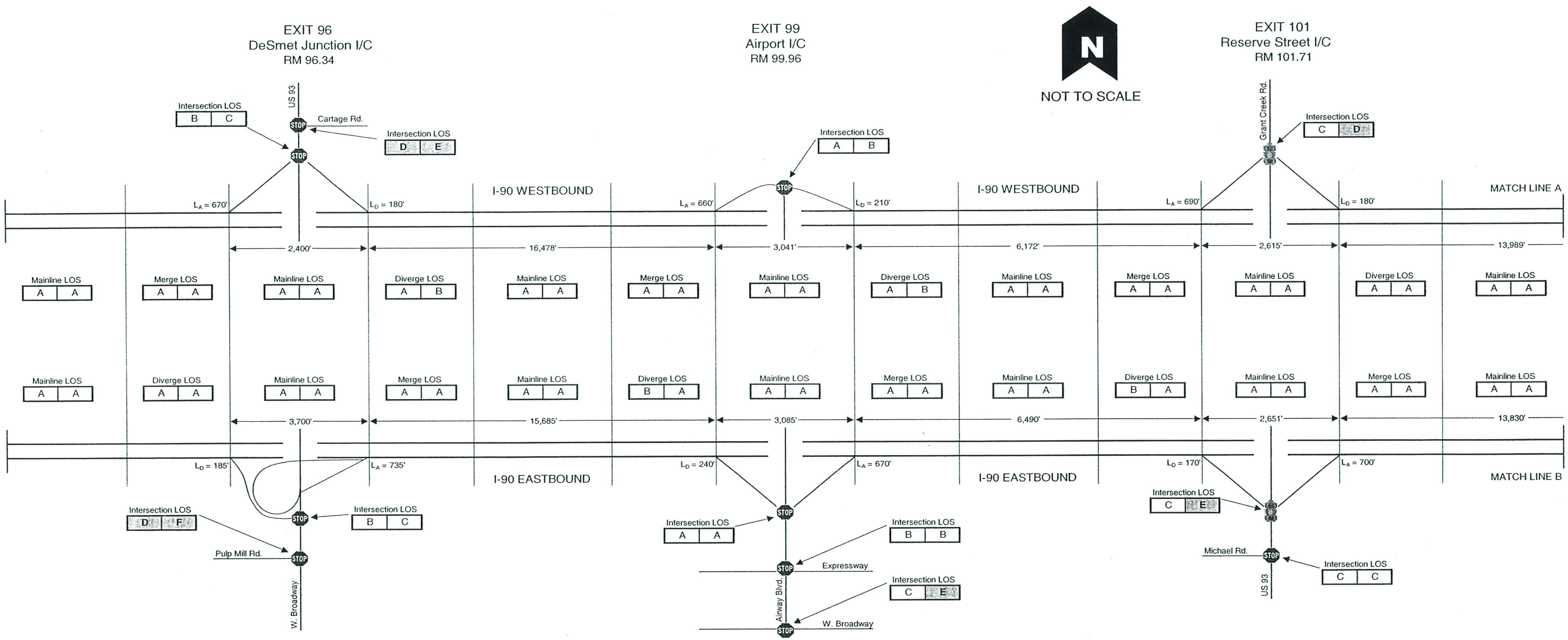
** NOTE: Posted speed is 65 mph for trucks in Lane 1, 75 mph for all other vehicles in Lane 1 and Lane 2 except in Location 3A-4 where both lanes are posted at 65 mph.

The results of the analysis indicates that pace speed increases as drivers travel from west to east. Significant increases in pace and 85th percentile speeds are measured as vehicles leave the urban area eastbound, and enter the urban area westbound, between the East Missoula and Bonner interchanges. Westbound Lane 2 pace remains 5 mph higher through the urban area although a speed reduction is posted.

Safety

In support of the project planning for the I-90 corridor study, MDT performed a crash analysis for the 16-mile corridor segment for calendar years 1999 through 2001. This analysis was updated as part of the study for the year 2002 to reflect the 3 year calendar period of 2000- 2002. A technical memorandum related to this study is included in the Appendix as Exhibit 5.

Figure 13 illustrates the crash history of the segment. 132 vehicle crash incidents were reported in 2002. This represents a 36% increase from the previous year 2001 and is 33% higher than the previous 3-year (1999-2001) analysis period average of 99 crash incidents per year. During the most recent analysis period (2000-2002), a total of 323 crashes was reported, with 65.9% of those involving only one vehicle.



LEGEND

Level-of-Service	
2002 AM	2002 PM

- Freeway segments operating worse than threshold LOS B are highlighted in **bold** text.
- Local intersections operating worse than threshold LOS C are highlighted in **bold** text.
- Study signalized intersection
- Study stop-controlled intersection
- ← 1,100' → Segment length in units of feet.
- L_A is acceleration lane length (HCM 2000, Exhibit 13-18) for on-ramp.
- L_D is deceleration lane length (HCM 2000, Exhibit 13-19) for off-ramp.

FIGURE 11A
2002 EXISTING - AM & PM PEAK
I-90 FREEWAY & LOCAL INTERSECTION LEVEL-OF-SERVICE RESULTS DESMET TO RESERVE STREET INTERCHANGES

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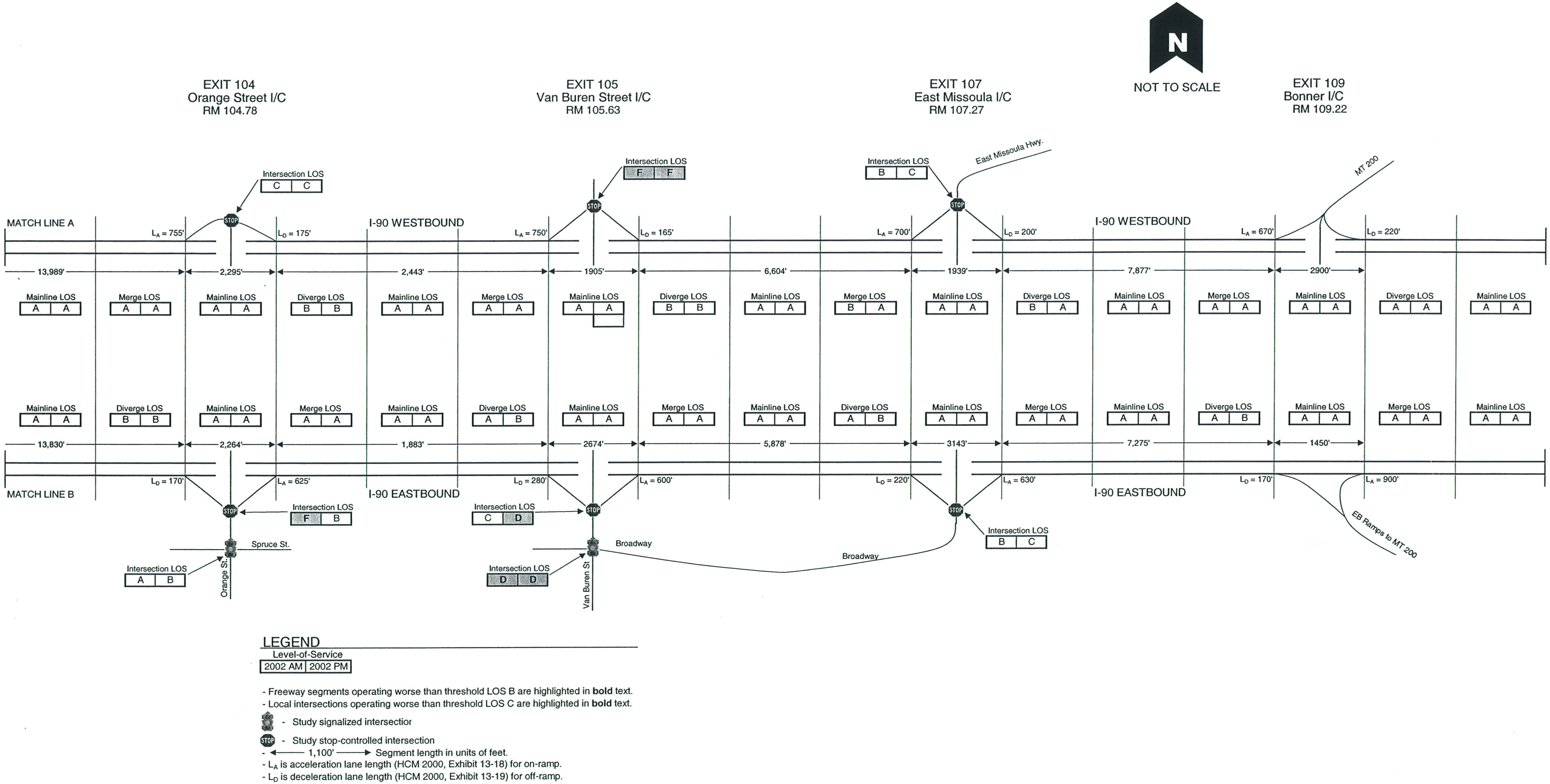

FIGURE 11B
2002 EXISTING - AM & PM PEAK
I-90 FREEWAY & LOCAL INTERSECTION LEVEL-OF-SERVICE RESULTS
ORANGE STREET TO BONNER INTERCHANGES

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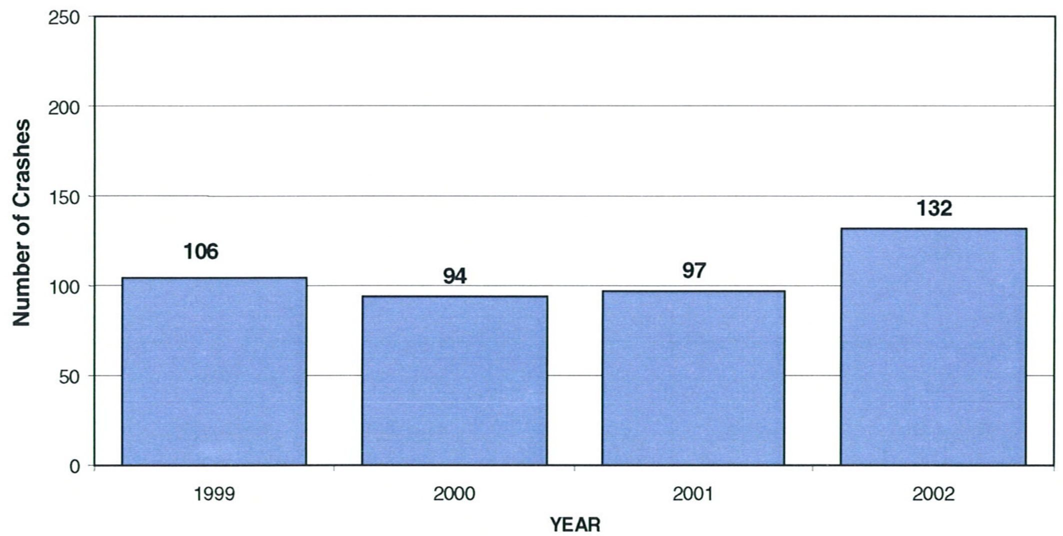
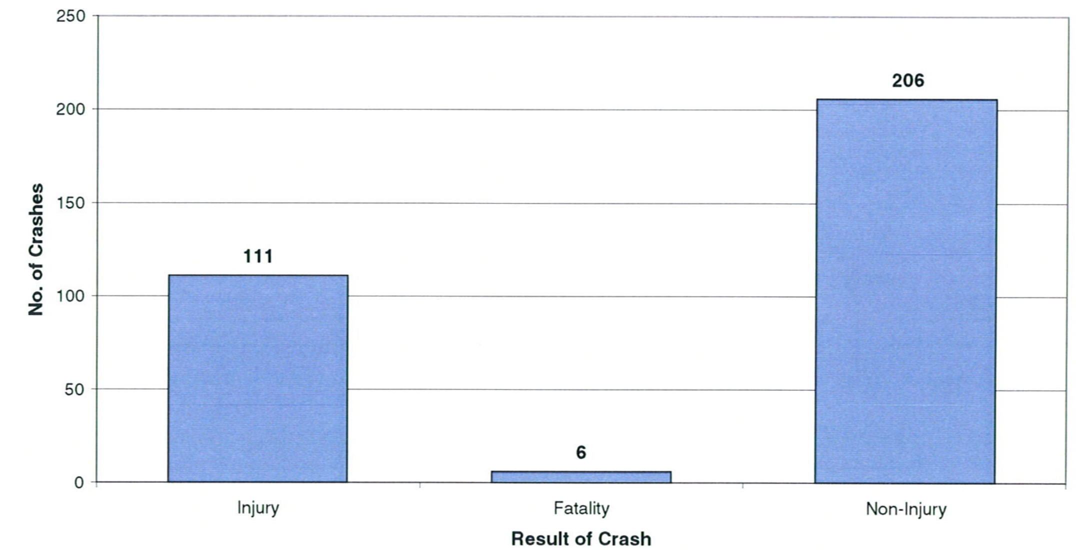
FIGURE 13
I-90 CRASH ANALYSIS (2000-2002)
MP 94- MP 110.2



As a result, the all vehicle crash rate along the corridor increased from 1.05 to 1.16 crashes per million vehicle miles. This rate is equivalent to the statewide average rate for rural interstate highways. The severity index and rate decreased for the period. Truck crashes and severity also decreased. However, the truck crash rate (11.1 crashes per million vehicle miles) remains significantly higher than the statewide average of 0.85. Of the 323 total accidents, there were 6 fatality crashes recorded. 34% of the crashes involved personal injury (Figure 14).

Appendix Exhibit 1 illustrates the crash rates along the corridor. The evaluation criteria are based on the statewide average for freeway facilities. "Good" relates to a rate less than 0.5 crashes per million vehicle miles. "Poor" indicates segments where the rate exceeds the statewide average of 1.16 crashes per million vehicle miles. Appendix Exhibit 1.1 also illustrates crash locations and severity for the years 2000-2002. Multiple crashes in close proximity are grouped into crash "cluster" locations.

FIGURE 14
I-90 CRASH RESULTS (2000-2002)
MP 94- MP 110.2



Pertinent characteristics of the crashes included the ages of the drivers and the times of day of the incidents. As Figure 15 shows, a high percentage of the crashes involved drivers in the 19- to 25-year-old age range. 61% of the drivers were male. This is similar to statewide and national trends. The greatest percentage of crashes occurred in the early evening, between 6 and 9 PM (see Figure 16). This occurs after the evening peak traffic period along the corridor (see Figure 17).

FIGURE 15
I-90 ACCIDENTS BY DRIVER AGE
(MP 94.0 - MP 110.2)

FIGURE 16
I-90 CRASHES BY TIME OF DAY
(MP 94.0 - MP 110.2)

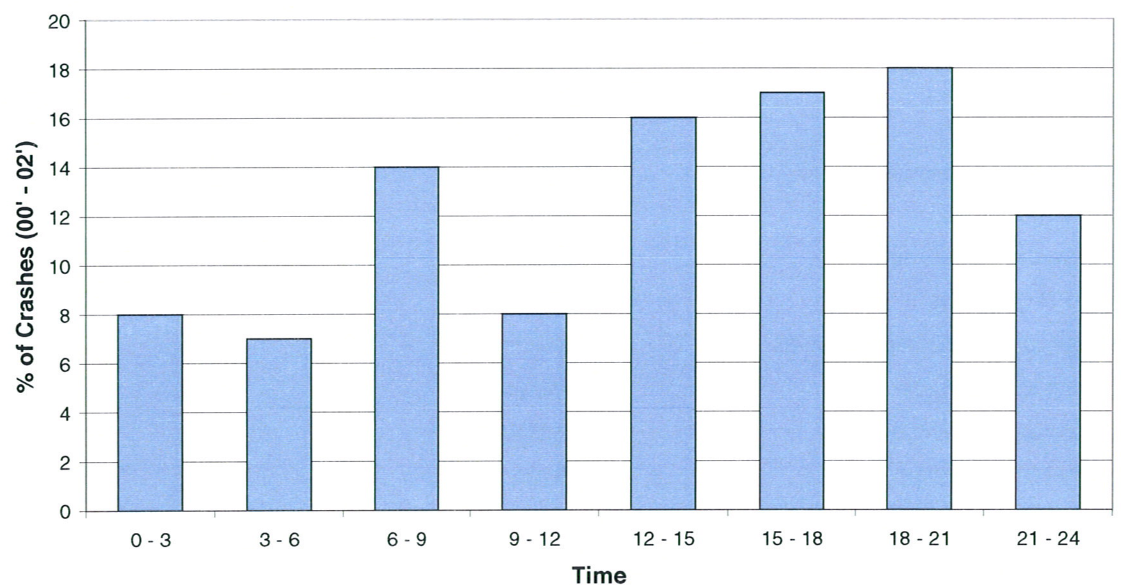
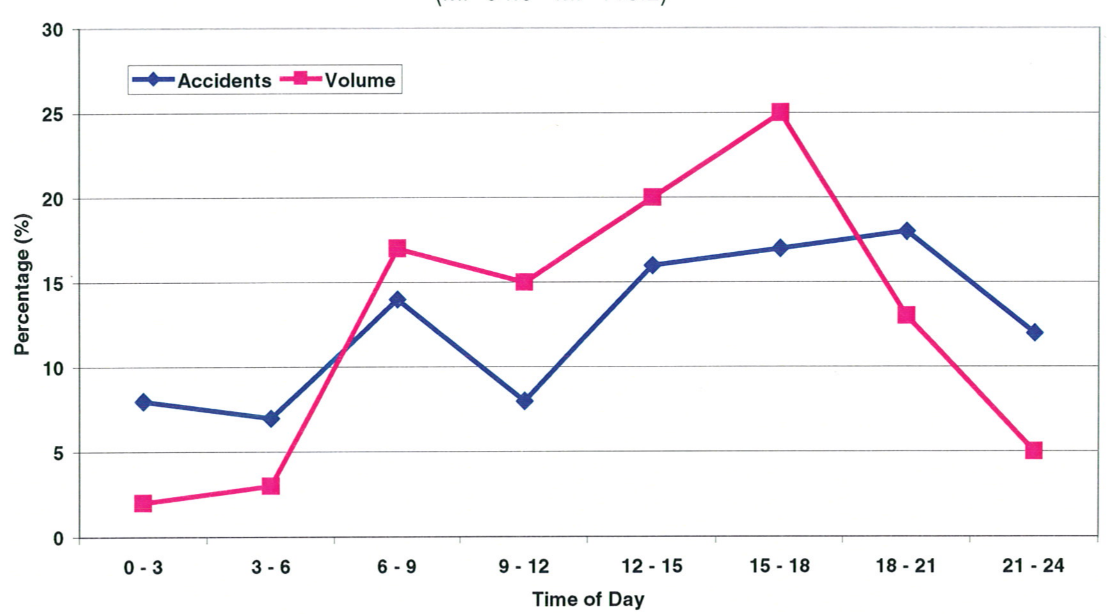
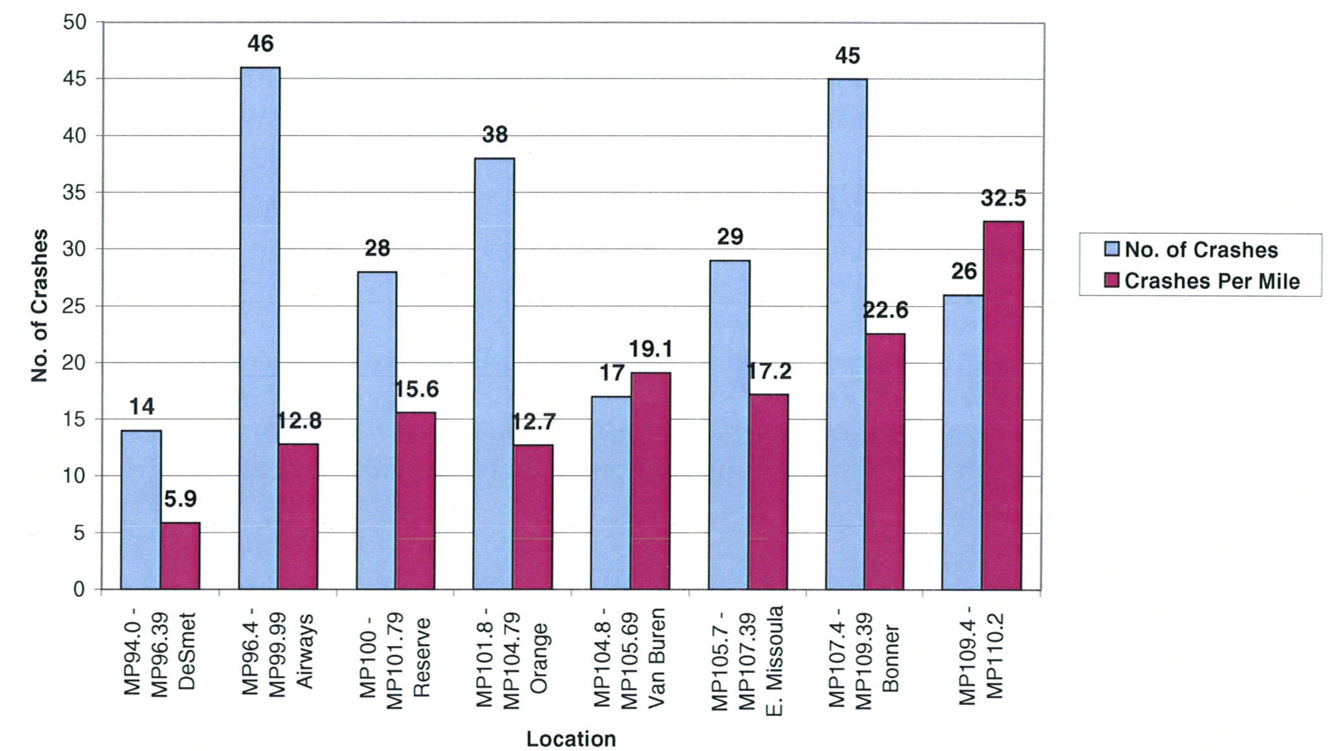


FIGURE 17
I-90 COMPARISON - % OF CRASHES AND FREEWAY VOLUME
(MP 94.0 - MP 110.2)



As Figure 18 indicates, the crash data was also reviewed for location information. It was found that the greatest number of non-junction (mainline)-related crashes per mile within the study area occurs between the East Missoula and Bonner interchanges. This equates to a crash rate of 1.28 crashes per million vehicle miles. Intersection and interchange junction crashes account for another 25% of the reported crashes. The largest cluster of these occurred at the Reserve Street signalized interchange.

FIGURE 18
I-90 CRASH LOCATION BY SEGMENT (NON-JUNCTION)



A large proportion of the MDT provided crash records were not specific relative to crash location or direct cause. As a result the crash analysis is not conclusive relative to direct causes or trends. However, familiarity with the corridor and its operations suggest several other factors that will influence safety of the corridor. These include:

- A lack of parallel acceleration and deceleration lanes on the mainline
- A lack of auxiliary lanes between closely spaced interchanges
- Complexity of the interchange
- Proximity of near side barriers
- Potential congestion related queuing on ramps
- Speed differentials, 75 mph vs. 65 mph on mainline
- Speed differentials – ramp entry and exit vs. mainline

- Interchange spacing
- Illumination levels
- Advanced signage placement
- Ramp geometrics, particularly sight distance

Non-Motorized Travel Modes

Non-motorized travel modes are not anticipated to greatly impact the I-90 corridor area, nor vice-versa. As previously mentioned, Van Buren Street is a designated bicycle route into and from the City proper. An exclusive 4-foot bicycle lane is provided. Pedestrian resources (sidewalks) are present through the Van Buren Street and Reserve Street interchanges. Concurrent pedestrian phases are provided at the Reserve Street interchange signal system. Sidewalks also extend out Orange Street to the I-90 interchange but terminate there.

Non-motorized travel modes will be subject to extensive review and discussion within the Missoula Transportation Plan Update.

Deficiencies

The analysis results highlight the operating and safety characteristics of the I-90 corridor. For the existing conditions case the term "deficiencies" is a strong one. No truly significant deficiencies were identified as a result of the geometric, operational and safety assessments. However, there were areas where traffic operations might be improved or geometrics might be upgraded as traffic growth occurs.

Special Event Period

As previously indicated, the impact of special event traffic at the University of Montana was also studied as it relates to the I-90 Corridor. Particularly, the annual University of Montana versus Montana State football game has been documented to result in the largest capacity crowds converging on the university area during weekend peak traffic times.

Within the study area, the Orange Street and Van Buren Street interchanges are impacted. Figures 19A and 19B show the special event peak hour volumes. The mainline volumes (peak two way of 1675 vph) during the pre-game peak hour was approximately 25% higher than the typical weekday morning peak. The post-game afternoon peak volume (1743 vph) was 6.3% higher than the weekday afternoon peak period. This higher volume remains within the range of traffic fluctuations typically experienced due to day-of-week or seasonal variations. As Table 9 indicates, mainline freeway, as well as ramp junction operations, were calculated to operate within acceptable levels of service.

Ramp junction queues were found to be much more extensive during the special event period. Projected queues at the Van Buren Street interchange exceed 20 vehicles and extend back onto the mainline. This was confirmed through field observations.

TABLE 9
Summary of Existing Special Event, Saturday, November 23, 2002 – AM and PM Peak Hour Freeway Operations

I-90 Segment	Segment Type	2002 AM Event		2002 PM Event	
	Mainline/ Merge/Diverge	LOS	Density[1]	LOS	Density[1]
Eastbound					
Between Reserve and Orange Street I/C	Mainline	A	8.2	A	4.2
Orange Street EB Off-Ramp	Diverge	B	13.0	A	8.0
Between Orange Street I/C Ramps	Mainline	A	5.6	A	3.0
Orange Street EB On-Ramp	Merge	A	9.5	A	8.2
Between Orange and Van Buren Street I/C	Mainline	A	7.1	A	5.9
Van Buren Street EB Off-Ramp	Diverge	B	10.7	A	9.1
Between Van Buren Street I/C Ramps	Mainline	A	3.6	A	5.2
Van Buren Street EB On-Ramp	Merge	A	6.8	B	10.7
Between Van Buren Street and East Missoula I/C	Mainline	A	4.5	A	8.4
Westbound					
Between Van Buren Street and East Missoula I/C	Mainline	A	9.5	A	5.0
Van Buren Street WB Off-Ramp	Diverge	B	14.8	A	9.1
Between Van Buren Street I/C Ramps	Mainline	A	5.4	A	4.1
Van Buren Street WB On-Ramp	Merge	A	8.9	B	10.7
Between Orange and Van Buren Street I/C	Mainline	A	7.1	A	7.9
Orange Street WB Off-Ramp	Diverge	B	11.7	B	12.8
Between Orange Street I/C Ramps	Mainline	A	3.2	A	5.0
Orange Street WB On-Ramp	Merge	A	5.4	B	10.1
Between Reserve and Orange Street I/C	Mainline	A	4.2	A	7.8

1 - Density reported in units of passenger cars per mile per lane (pc/mi/ln). Density thresholds vary depending if the segment is a mainline or merge/diverge. Refer to Appendix Exhibit 4 for Density to LOS thresholds.

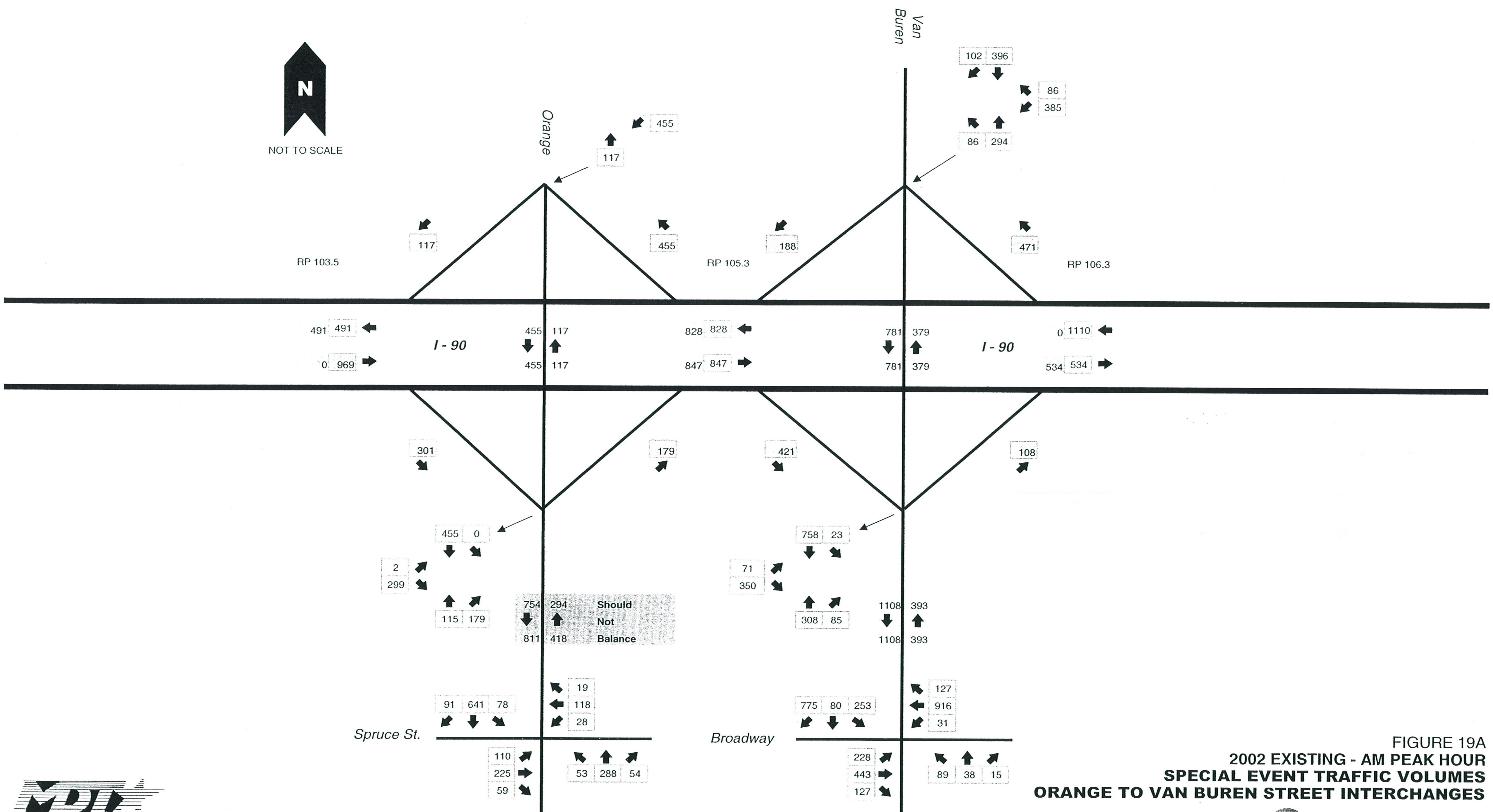


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FIGURE 19A
2002 EXISTING - AM PEAK HOUR
SPECIAL EVENT TRAFFIC VOLUMES
ORANGE TO VAN BUREN STREET INTERCHANGES

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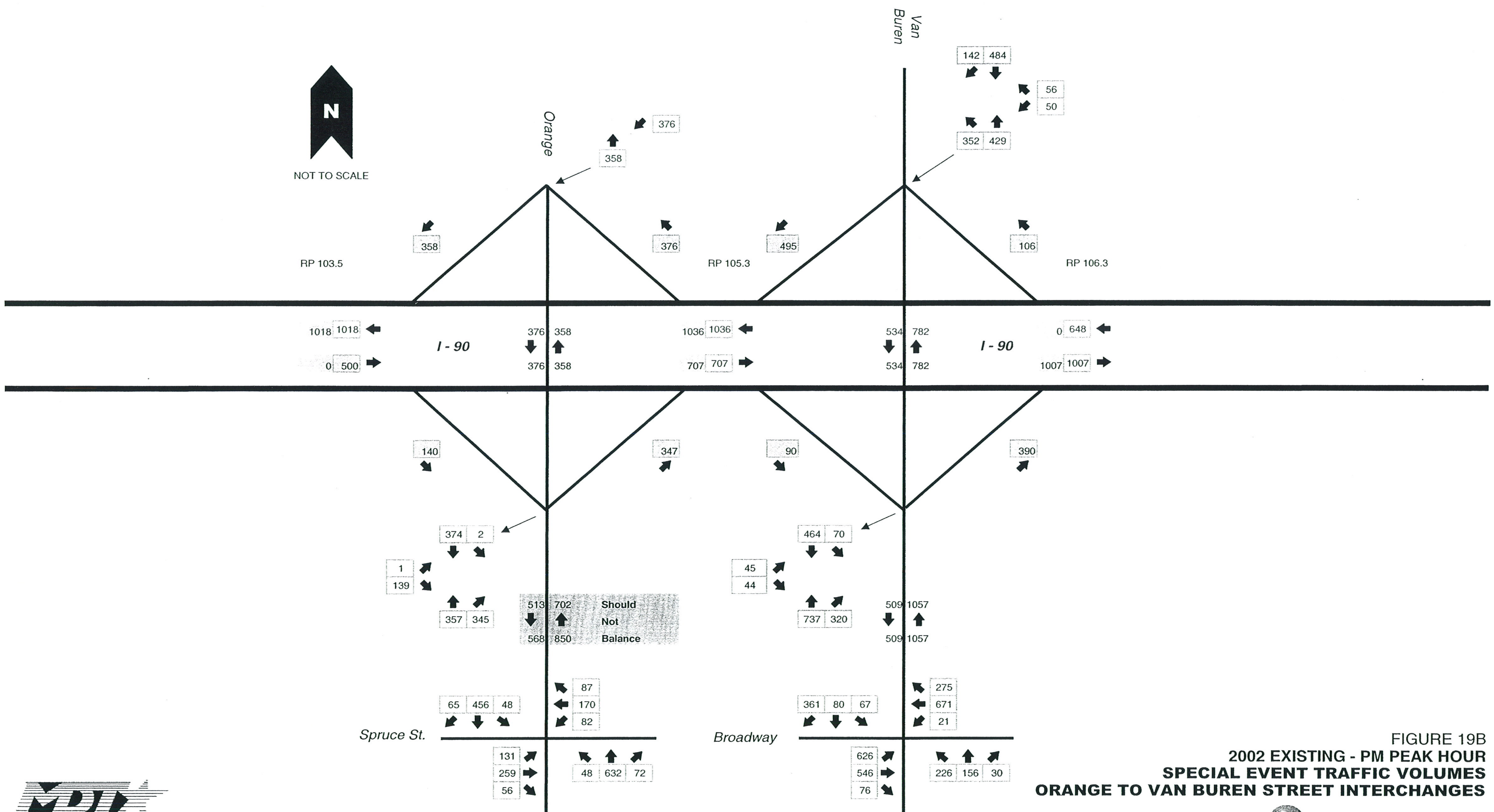

FIGURE 19B
2002 EXISTING - PM PEAK HOUR
SPECIAL EVENT TRAFFIC VOLUMES
ORANGE TO VAN BUREN STREET INTERCHANGES

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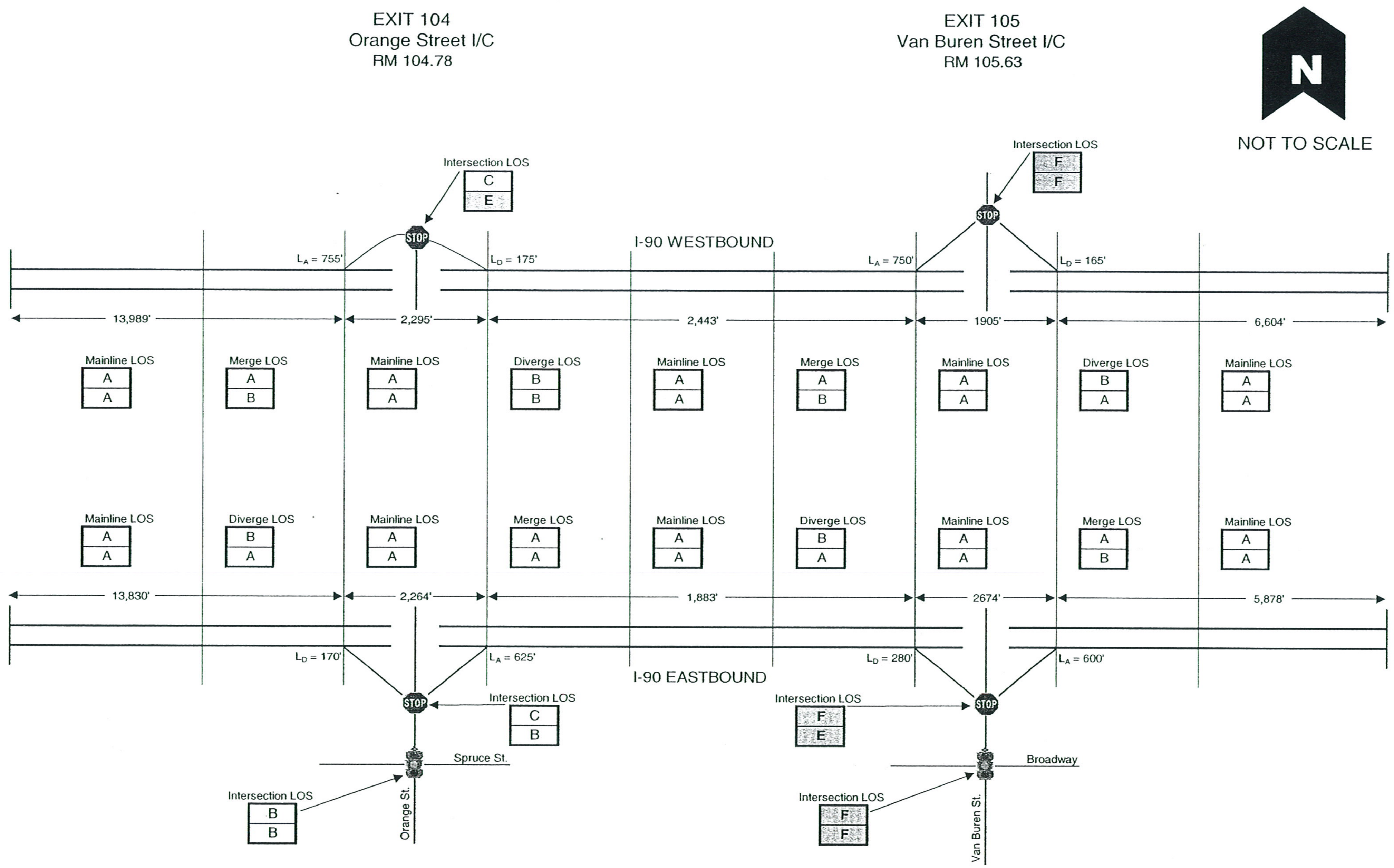
While the mainline theoretically operates acceptably, the influence of higher traffic volumes on-ramp intersection operations with local streets was found to result in unacceptable levels of service at four of the five intersections in the study area. The results are shown in Table 10. While the results indicate unacceptable LOS at the ramps, the actual impacts on the I-90 appear to be most significant for the pre-game morning arrivals where vehicle queues on the Van Buren Street eastbound off-ramp extend onto the mainline itself. After the game, exiting traffic volumes experience excessive delays as drivers attempt to turn left onto the westbound on-ramp. Finally, the signalized intersection of Van Buren Street and East Broadway is perhaps the most delayed intersection, with the eastbound lefts onto Van Buren Street experiencing queues far in excess of the available left-turn storage length.

TABLE 10
Summary of Existing Special Event, Saturday, November 23, 2002 – AM and PM Peak Hour Intersection Operations

	2002 AM Existing – Event		2002 PM Existing – Event	
Intersection	**LOS**	**Delay[1]**	**LOS**	**Delay[1]**
I-90 Orange Street WB Ramps and Orange Street	C	15.8	**E**	**35.6**
I-90 Orange Street EB Ramps and Orange Street	C	21.2	B	14.3
Orange Street and Spruce Street[2]	*B*	*11.3*	*B*	*17.5*
I-90 Van Buren Street WB Ramps and Van Buren Street	**F**	**585.0**	**F**	**571.4**
I-90 Van Buren Street EB Ramps and Van Buren Street	**F**	**87.4**	**E**	**35.2**
Van Buren Street and East Broadway	***F***	***197.1***	***F***	***94.0***

[1]Delay indicated for stop controlled intersections reflects the critical movement.
[2]Italicized results indicate signalized intersections.

A summary of the special event analysis is illustrated in Figure 20.



LEGEND

Level-of-Service
2002-Event AM
2002-Event PM

- Special event occurs on Saturday, November, 23, 2002 at the University of Montana.
- Freeway segments operating worse than threshold LOS B are highlighted in **bold** text.
- Local intersections operating worse than threshold LOS C are highlighted in **bold** text.

\- Study signalized intersection

STOP - Study stop-controlled intersection

- ←— 1,100' —→ Segment length in units of feet.
- L_A is acceleration lane length (HCM 2000, Exhibit 13-18) for on-ramp.
- L_D is deceleration lane length (HCM 2000, Exhibit 13-19) for off-ramp.

FIGURE 20
2002 EXISTING, SPECIAL EVENT - AM & PM PEAK
I-90 FREEWAY & LOCAL INTERSECTION LEVEL-OF-SERVICE RESULTS
ORANGE AND VAN BUREN STREET INTERCHANGES

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Forecast Traffic Conditions

Traffic Volumes (MDT Traffic Demand Model)

The Montana Department of Transportation has provided transportation demand modeling for the Missoula Transportation Plan Update. This county-wide model was used to develop macro-level arterial corridor-level traffic projections for alternative land use scenarios and alternative transportation network improvements. The scope of work for the Phase I I-90 East-West Corridor Study included the continued use of this tool in order to maintain continuity in methodology as well as a common basis for future alternatives development and evaluation.

In order to use the model for the purposes of the I-90 East-West Corridor Study, it was necessary to perform adjustments. These adjustments were due to the differing intents and purposes of the Transportation Plan Study and this corridor study. Adjustments were made to zonal connectors as it related to definition of the network in vicinity of the I-90 corridor. The adjustments yielded better results in movement forecasting as well as impacts on local street forecasts. The analysis network assumed as the future year base scenario is typically known as the existing plus committed network (E+C). For this study, only one modification to the known future year network was made. That modification involved the connection of a local road from the Airport Boulevard interchange, to and from the east, connecting Gooden Keil Road/Keil Loop Road area. The information provided by the modeling results was used as a starting point for the development of future volume projections.

After reviewing the model growth rates based on ADT volumes and turning movement assignments, mainline and ramp projections were developed and validated. Some outlying growth rates were found at study intersections away from the freeway core. These outlying rates were modified to balance the main arterials that connected to the freeway corridor.

Validation of Model Forecasts

Each freeway segment where historical traffic data was available was evaluated to see how well modeled future forecasted rates compared to historical (straight line) growth rates. As an example, an annual rate of two percent applied over 25 years creates an overall growth rate of 50 percent. The overall growth rate is used as the guideline for validating the model forecasts. Table 11 shows the comparison between the historical annual growth rate projected over 25 years and the raw and balanced overall growth rate forecasted by the MDT model.

As the table indicates, trends within the urban area (Orange Street-Van Buren Street) yielded differing results. This is considered to be normal based on the level of model prediction accuracy where the impacts of traffic congestion, as well as localized traffic growth, could be expected to change travel patterns and routing in the future.

The general corridor and cross arterial growth trends are shown as Figures 21A through 21D (see Figures appendix).

TABLE 11
Summary of I-90 Forecasted Growth Rates

Freeway Segment	Historical Annual Growth Rate[1] (1993 to 2000)	MDT Model Overall Growth (2000 to 2025)	Balanced Volume Overall Growth (2000 to 2025)	Comparison Notes
Between Airport & Reserve St. interchanges	4.7% (118% over 25 years)	95% to 125%	94% to 124%	Model matches closely with historical growth.
Between Reserve St. & Orange St. interchanges	4.1% (103% over 25 years)	65% to 75%	65% to 82%	Model is lower than historical growth.
Between Orange St. & Van Buren St. interchanges	3.3% (83% over 25 years)	38% to 65%	64% to 68%	Model is lower than historical growth.
Between Van Buren St. & E. Missoula interchanges	-1.3% (-33% over 25 years)	48% to 58%	48% to 57%	Model is higher than historical growth.
Between E. Missoula & Bonner interchanges	2.3% (56% over 25 years)	56% to 57%	55% to 56%	Model matches closely with historical growth.

1 - See Appendix Exhibit 8 for values used to determine annual growth rate.

Notes: The MDT model growth rates were validated and have approximately a 2% annual growth rate or higher throughout the corridor. As a final check, the balanced volume growth rates were compared to the model results and provided equal or higher growth rates in all cases.

Balancing Future Forecasted Volumes

The process of developing the future forecasted volumes followed a seven-step process described below.

1) Existing volumes: The distribution of turning movements for the future volumes at ramp termini were based on the distribution of balanced turning movement volumes from the existing conditions analysis.
2) Forecasted growth projections: Growth projections developed were used to obtain growth of an area and were not used directly for turning movement projections.
3) Validation: This process was described in the previous section.
4) Area growth projections were applied to balanced existing volumes.
5) Review peak period directional flows: As one of the steps in balancing the network for AM and PM volumes, peak period flows were reviewed for each interchange to see if any flaws existed in the corridor projections. No mainline flaws were found in the corridor. AM inflows were compared to PM outflows for each interchange and balanced throughout the study intersections.
6) Balanced future projected volumes: Volumes for the freeway, ramps, arterial corridors, and intersections were adjusted according to a priority-based balancing order. The freeway mainline had the highest balancing priority, which then filtered down to the lowest priority of balancing each individual local intersection.
7) Review: A review of the final forecasted volumes was conducted in comparison with initial model projections. Projected growth rates from historical counts had a high correlation to the model with the exception of outlying growth rates at two intersections (West Broadway /Pulp Mills Road and Airway Blvd./Expressway) away from the freeway corridor.

Balanced freeway, ramp, arterial corridor and intersection volumes for 2025 AM and PM peak hours are presented in Figures 22A and 22D.

Traffic Operations

Traffic operations for the 2025 forecast year were projected for the AM and PM peak hours for the study area freeway segments and intersections. The SYNCHRO and HCS2000 analysis methodologies which were used for analyzing the existing conditions were also used for the future year operations scenario. However, at signalized intersections, the signal timing parameters were assumed to be optimized or upgraded to meet future year conditions. This assumption is based on the premise that traffic signal timing adjustments would be made (likely more than once) to respond to traffic demand changes over the course of the next 25 years. Cycle lengths and splits of the four signalized intersections were optimized with SYNCHRO to represent normal traffic signal operations maintenance techniques. After verifying and summarizing the results, the results were compared to MDT acceptable operating criteria. That criteria remains the same as under the existing conditions analysis. Acceptable levels-of-service include LOS B for all freeway segments and LOS C for stop-controlled and signalized intersections.

The forecast levels-of-service for freeway mainline and ramps and intersections are discussed below.

Mainline and Ramps

Table 12 summarizes the results of the analysis for both eastbound and westbound directions on the mainline, merge, and diverge segments of I-90. The results of the previously performed existing conditions analysis is reproduced here for comparison purposes. Two eastbound diverge segments, at the Airport and Reserve Street interchanges, resulted in and increase to LOS C in the AM peak hour. It must be pointed out that the increase in density for ramp diverge analysis is just over the threshold level, between LOS Band LOS C, which is 20.0 pc/mi/ln. All other segments were LOS A or B in both AM and PM peak hours.

As Table 12 indicates, all segments and ramps operate acceptably for the studied peak hour periods with the two LOS C segments noted above in the AM peak hour. Similar to the existing conditions analysis, the methodology does not take into account a few key factors for the projected operations of the I-90 corridor. These factors include truck traffic being restricted in its lane usage, truck traffic traveling at a reduced speed compared to passenger cars, and the methodology assumes a maximum free flow speed of 60 km/h (35 mph) for the ramps. Through a sensitivity analysis, the influences of these three factors were found to be negligible and thus they did not affect the outcome or conclusions of the analysis.

TABLE 12
Summary of Existing and Forecast Year – AM and PM Peak Hour Freeway Operations

	Segment Type	2002 AM		2002 PM		2025 AM		2025 PM	
I-90 Segment	**Mainline/ Merge/Diverge**	**LOS**	**Density[1]**	**LOS**	**Density[1]**	**LOS**	**Density[1]**	**LOS**	**Density[1]**
Eastbound									
West of DeSmet I/C[2]	Mainline	A	5.7	A	3.5	B	11.6	A	7.8
DeSmet EB Off-Ramp	Diverge	A	9.0	A	6.6	B	15.6	B	11.4
Between DeSmet I/C Ramps	Mainline	A	3.8	A	2.4	A	7.0	A	4.5
DeSmet EB On-Ramp	Merge	A	8.1	A	6.2	B	16.3	B	12.4
Between DeSmet and Airport I/C	Mainline	A	6.5	A	4.6	B	14.2	A	10.0
Airport EB Off-Ramp	Diverge	B	10.5	A	8.0	**C**	**20.4**	B	15.0
Between Airport I/C Ramps	Mainline	A	5.6	A	4.2	B	12.1	A	9.0
Airport EB On-Ramp	Merge	A	8.9	A	7.4	B	18.6	B	15.0
Between Airport and Reserve St. I/C	Mainline	A	6.2	A	5.3	B	13.9	B	11.9
Reserve St. EB Off-Ramp	Diverge	B	10.7	A	9.5	**C**	**20.7**	B	18.0
Between Reserve St. I/C Ramps	Mainline	A	3.8	A	3.3	A	7.2	A	6.8
Reserve St. EB On-Ramp	Merge	A	8.9	A	8.7	B	13.9	B	14.2
Between Reserve and Orange St. I/C	Mainline	A	6.6	A	6.9	A	10.9	B	11.8
Orange St. EB Off-Ramp	Diverge	B	11.0	B	11.3	B	16.4	B	17.5
Between Orange St. I/C Ramps	Mainline	A	3.3	A	4.7	A	6.0	A	7.9
Orange St. EB On-Ramp	Merge	A	6.4	A	9.7	A	9.7	B	13.6
Between Orange and Van Buren St. I/C	Mainline	A	4.2	A	7.6	A	7.1	B	11.0
Van Buren St. EB Off-Ramp	Diverge	A	7.0	B	11.3	B	10.7	B	15.6
Between Van Buren St. I/C Ramps	Mainline	A	2.6	A	5.9	A	3.7	A	8.8
Van Buren St. EB On-Ramp	Merge	A	5.6	B	10.3	A	7.4	B	15.0
Between Van Buren St. and East Missoula I/C	Mainline	A	3.6	A	7.5	A	5.3	B	11.5
East Missoula EB Off-Ramp	Diverge	A	6.8	B	11.6	A	9.0	B	16.8
Between East Missoula I/C Ramps	Mainline	A	2.9	A	5.7	A	4.4	A	9.4
East Missoula EB On-Ramp	Merge	A	5.0	A	8.7	A	7.0	B	13.0
Between East Missoula and Bonner I/C[2]	Mainline	A	3.0	A	6.2	A	4.7	A	10.1
Bonner EB Off-Ramp	Diverge	A	6.5	B	10.8	A	8.7	B	15.5
Between Bonner I/C Ramps	Mainline	A	1.2	A	2.7	A	2.3	A	5.2
Bonner EB On-Ramp	Merge	A	1.7	A	4.2	A	3.2	A	7.9
East of Bonner I/C	Mainline	A	1.7	A	3.8	A	3.0	A	7.1

TABLE 12 (Continued)
Summary of Existing and Forecast Year – AM and PM Peak Hour Freeway Operations

	Segment Type	2002 AM		2002 PM		2025 AM		2025 PM	
I-90 Segment	**Mainline/ Merge/Diverge**	**LOS**	**Density[1]**	**LOS**	**Density[1]**	**LOS**	**Density[1]**	**LOS**	**Density[1]**
Westbound									
East of Bonner I/C	Mainline	A	3.6	A	3.2	A	6.3	A	5.5
Bonner WB Off-Ramp	Diverge	A	6.9	A	6.4	B	10.3	A	9.4
Between Bonner I/C Ramps	Mainline	A	3.3	A	2.8	A	5.7	A	4.9
Bonner WB On-Ramp	Merge	A	9.0	A	7.5	B	13.3	B	10.9
Between East Missoula and Bonner I/C[2]	Mainline	A	6.7	A	5.2	A	10.4	A	8.2
East Missoula WB Off-Ramp	Diverge	B	11.1	A	9.2	B	15.8	B	13.0
Between East Missoula I/C Ramps	Mainline	A	6.3	A	4.8	A	9.8	A	7.6
East Missoula WB On-Ramp	Merge	B	10.0	A	7.6	B	15.1	B	11.4
Between Van Buren St. and East Missoula I/C	Mainline	A	7.8	A	5.8	B	12.2	A	9.1
Van Buren St. WB Off-Ramp	Diverge	B	12.6	B	10.1	B	18.3	B	14.4
Between Van Buren St. I/C Ramps	Mainline	A	6.1	A	4.5	A	9.9	A	7.4
Van Buren St. WB On-Ramp	Merge	A	9.2	A	7.6	B	14.7	B	12.0
Between Orange and Van Buren St. I/C	Mainline	A	7.3	A	5.9	B	12.0	A	9.7
Orange St. WB Off-Ramp	Diverge	B	12.0	B	10.1	B	18.0	B	15.0
Between Orange St. I/C Ramps	Mainline	A	3.5	A	3.3	A	6.7	A	6.1
Orange St. WB On-Ramp	Merge	A	5.8	A	7.2	A	9.9	B	12.1
Between Reserve and Orange St. I/C	Mainline	A	4.4	A	5.8	A	8.0	A	10.1
Reserve St. WB Off-Ramp	Diverge	A	8.2	A	10.0	B	12.9	B	15.5
Between Reserve St. I/C Ramps	Mainline	A	1.8	A	3.0	A	4.0	A	6.0
Reserve St. WB On-Ramp	Merge	A	5.9	A	7.9	B	10.4	B	14.4
Between Airport and Reserve St. I/C	Mainline	A	4.1	A	6.1	A	7.9	B	11.9
Airport WB Off-Ramp	Diverge	A	7.6	B	10.2	B	12.6	B	17.8
Between Airport I/C Ramps	Mainline	A	3.1	A	5.6	A	5.1	A	10.3
Airport WB On-Ramp	Merge	A	5.4	A	9.1	A	8.9	B	16.7
Between DeSmet and Airport I/C	Mainline	A	3.4	A	6.4	A	6.1	B	12.5
DeSmet WB Off-Ramp	Diverge	A	7.0	B	10.9	B	10.5	B	18.8
Between DeSmet I/C Ramps	Mainline	A	1.9	A	3.4	A	3.4	A	6.8
DeSmet WB On-Ramp	Merge	A	4.3	A	6.4	A	7.6	B	12.4
West of DeSmet I/C[2]	Mainline	A	2.9	A	5.0	A	6.0	A	10.7

1 - Density reported in units of passenger cars per mile per lane (pc/mi/ln). Density thresholds vary depending if the segment is a mainline or merge/diverge. Refer to Appendix Exhibit 4 for Density to LOS thresholds.

2 - The segment was also analyzed with grade-specific terrain. Between the general terrain and grade-specific terrain, the worst results were reported.

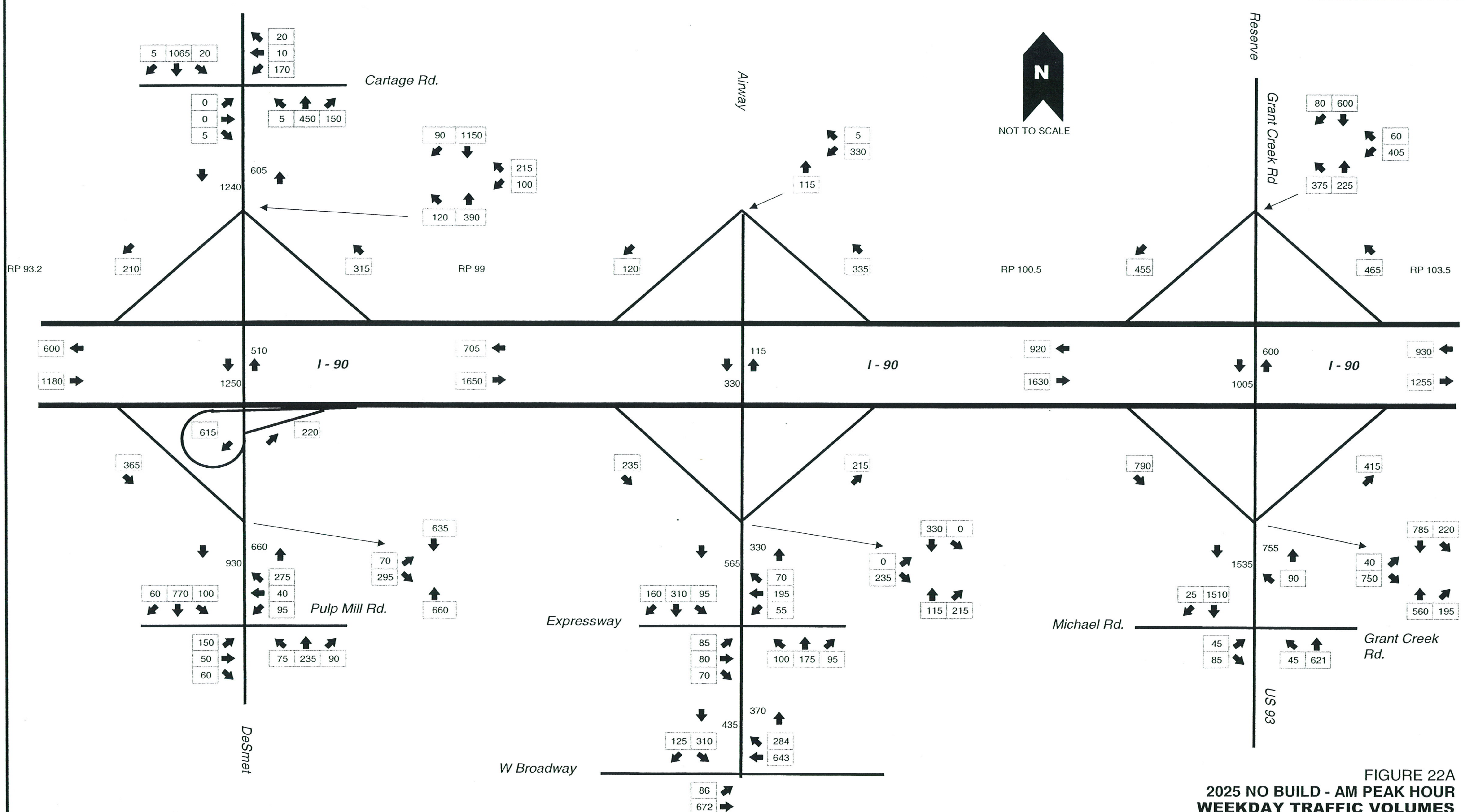

FIGURE 22A
2025 NO BUILD - AM PEAK HOUR
WEEKDAY TRAFFIC VOLUMES
DESMET TO RESERVE STREET INTERCHANGES

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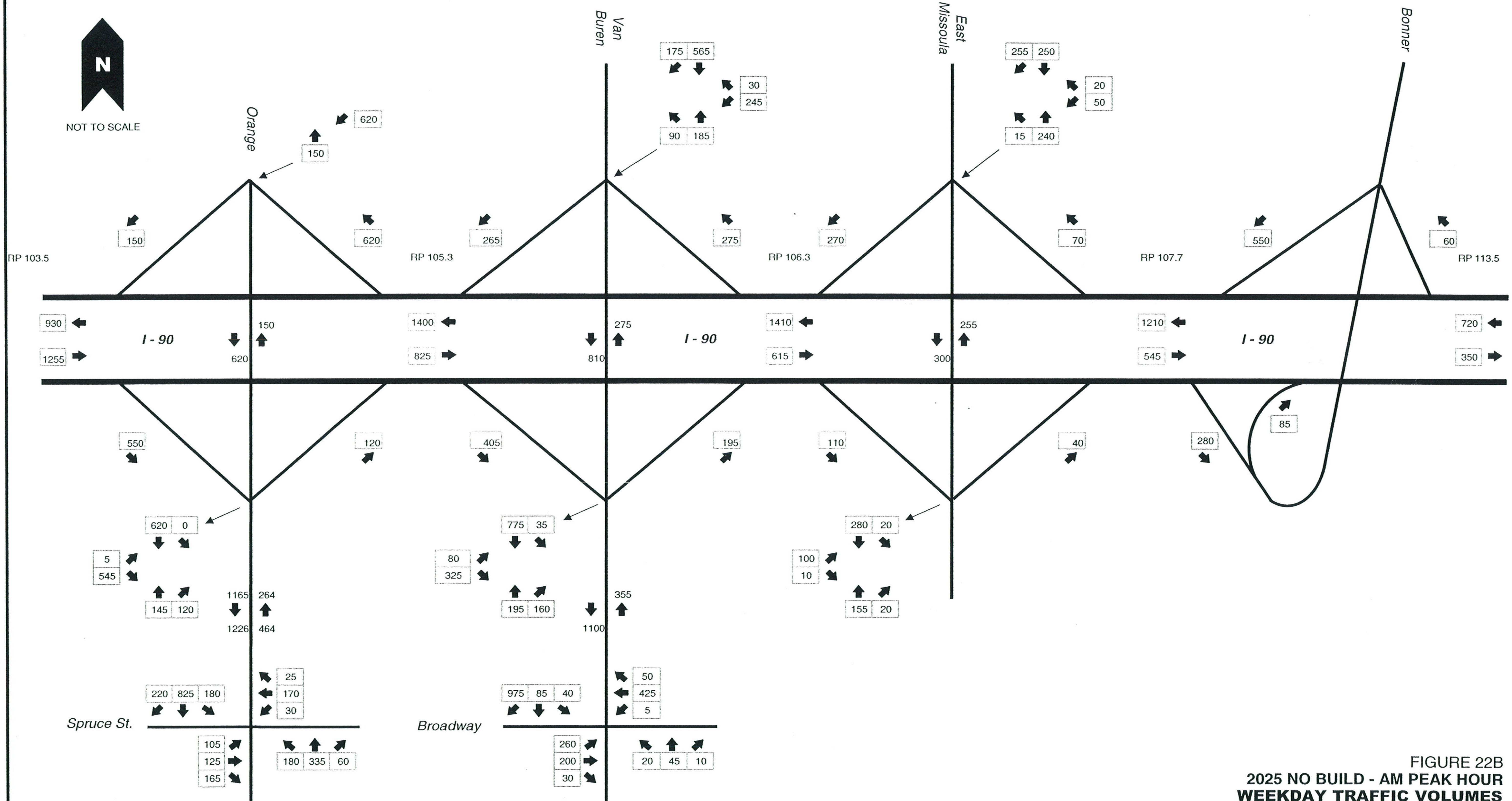

FIGURE 22B
2025 NO BUILD - AM PEAK HOUR
WEEKDAY TRAFFIC VOLUMES
ORANGE STREET TO BONNER INTERCHANGES

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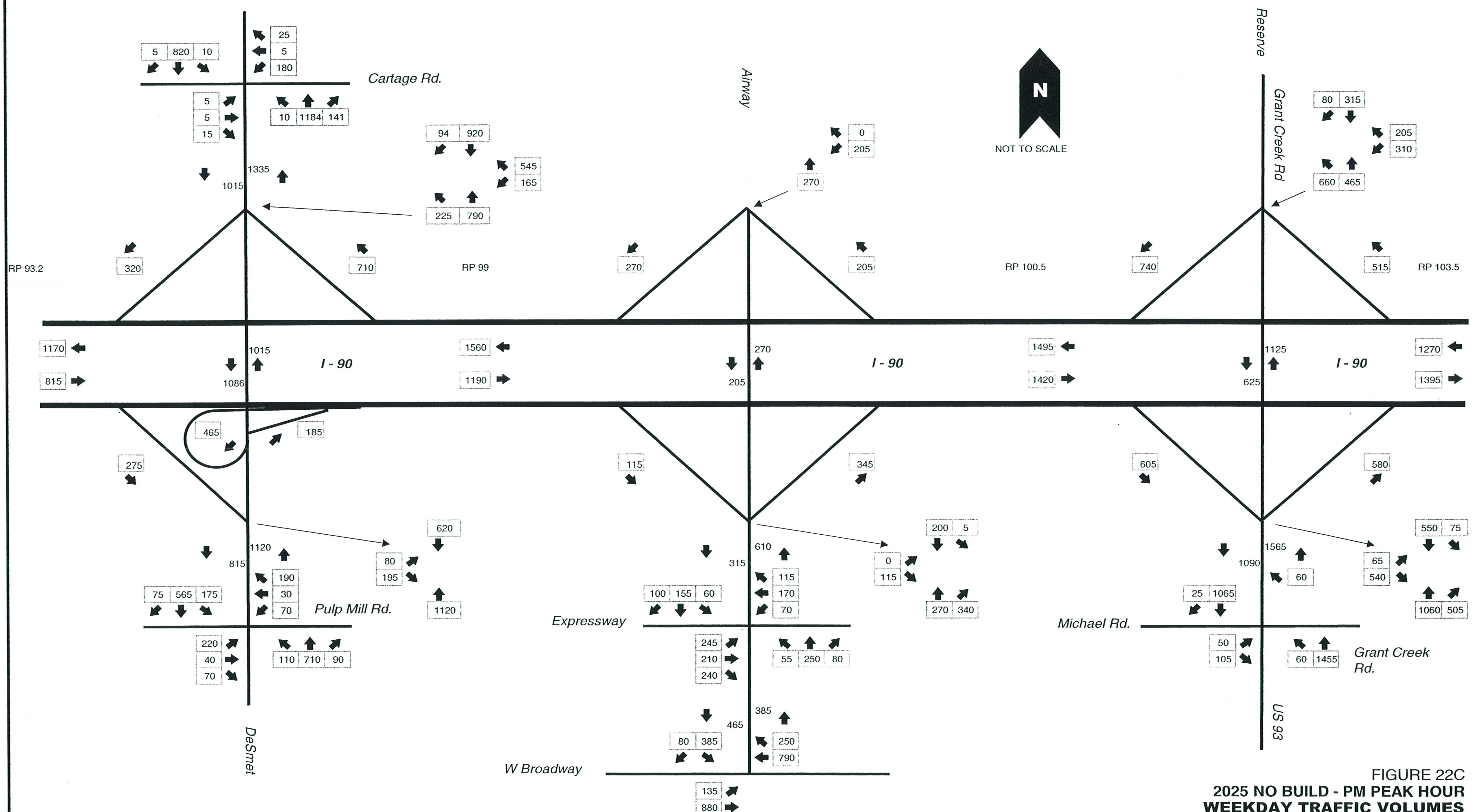

FIGURE 22C
2025 NO BUILD - PM PEAK HOUR
WEEKDAY TRAFFIC VOLUMES
DESMET TO RESERVE STREET INTERCHANGES

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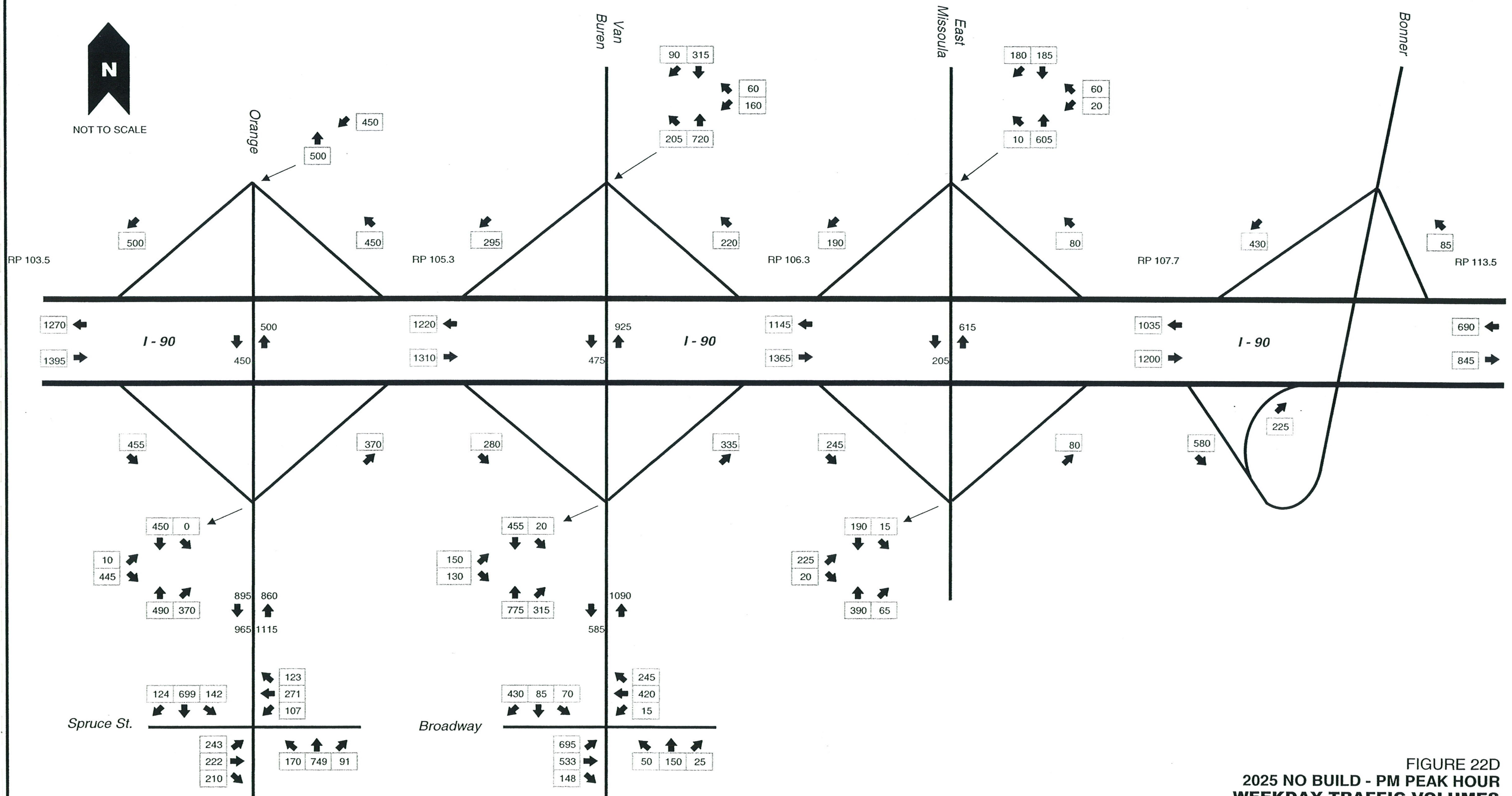

FIGURE 22D

2025 NO BUILD - PM PEAK HOUR

WEEKDAY TRAFFIC VOLUMES

ORANGE STREET TO BONNER INTERCHANGES

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Intersections

The forecasted freeway operations were indicative of mostly acceptable freeway operations, but these results do not present the interactions between ramp junctions and the adjacent streets. Similar to the existing conditions, these local intersections were evaluated to determine the impact on freeway operations and are typically projected as queue lengths from the ramp termini.

Table 13 presents a summary of the LOS analysis for the study intersections. The existing conditions analysis is reproduced here for comparison purposes. For the forecasted year, the analysis results for signalized intersections were based on optimized signal timing to reflect the high probability that cycle lengths and splits would be modified as necessary in the future.

Table 13 indicates that forecasted intersection operations will worsen beyond existing conditions, particularly the ramp termini at the stop sign and yield controlled DeSmet, Orange Street, and Van Buren Street interchanges. The growth in ramp and major street volumes at these unsignalized intersections will cause the stop-controlled approaches to significantly exceed their capacity. When this occurs, drivers will seek alternative routes. Many of the volume to capacity ratios and 95th percentile queue lengths for these and other stop-controlled approaches were not computed (as indicated by the asterisks in the table) because the limits of the HCM analysis equations were exceeded. Although unreported, it is reasonable to assume that these queues would extend back to the freeway mainline or at least extend far enough to affect the diverge operation and deceleration areas of the ramps.

TABLE 13
Summary of Existing and Forecast Year – AM and PM Peak Hour Intersection Operations

	2002 AM		2002 PM		2025 AM		2025 PM	
Intersection[2, 3, 4]	LOS	Delay[1]	LOS	Delay[1]	LOS	Delay[1]	LOS	Delay[1]
US 93 & Cartage Rd.	**D**	**26.7**	**E**	**45.3**	**F**	*	**F**	*
I-90 DeSmet WB Ramps & US 93	B	12.5	C	20.4	**F**	**137.4**	**F**	*
I-90 DeSmet EB Off-Ramp & US 93	B	14.7	C	17.3	**F**	*	**F**	*
West Broadway & Pulp Mill Rd.	**D**	**32.6**	**F**	**69.4**	**F**	*	**F**	*
I-90 Airport WB Ramps & Airway Blvd.	A	9.5	B	10.0	B	14.1	C	18.6
I-90 Airport EB Ramps & Airway Blvd.	A	9.7	A	8.9	C	15.3	B	10.7
Airway Blvd. & Expressway	B	14.8	B	13.3	**F**	*	**F**	*
Airway Blvd. & West Broadway	C	20.6	**E**	**35.6**	**F**	*	**F**	*
I-90 Reserve St. WB Ramps & Grant Creek Rd.	*C*	*34.2*	***D***	***38.0***	***F***	***96.6***	***D***	***42.8***
I-90 Reserve St. EB Ramps & US 93	*C*	*32.2*	***E***	***68.5***	***D***	***35.0***	***D***	***53.9***
US 93 & Michael Rd./Grant Creek Rd.	C	17.5	C	17.3	**F**	*	**F**	*
I-90 Orange St. WB Ramps & Orange St.	C	15.3	C	16.0	**E**	**39.4**	**F**	**60.0**
I-90 Orange St. EB Ramps & Orange St.	**F**	**68.4**	B	13.9	**F**	*	**F**	**51.7**
Orange St. & Spruce St.	*A*	*9.4*	*B*	*19.4*	*C*	*27.2*	***D***	***48.5***
I-90 Van Buren St. WB Ramps & Van Buren St.	**F**	**274.1**	**F**	**189.0**	**F**	*	**F**	*
I-90 Van Buren St. EB Ramps & Van Buren St.	C	23.8	**D**	**25.7**	**F**	**241.3**	**F**	**86.8**
Van Buren St. & East Broadway	***D***	***39.0***	***D***	***45.8***	***D***	***45.0***	*C*	*28.6*
I-90 East Missoula WB Ramps & East Missoula Hwy.	B	14.1	C	15.1	C	18.2	C	19.2
I-90 East Missoula EB Ramps & East Broadway	B	14.6	C	23.9	C	19.6	**F**	**66.9**

TABLE 13 (Continued)
Summary of Existing and Forecast Year – AM and PM Peak Hour Intersection Operations

* - Delay is greater than 300 seconds per vehicle.

1 - Delay reported in units of seconds per vehicle. Delay thresholds vary depending if the intersection is signalized or unsignalized. Refer to Appendix Exhibit 4 for Delay to LOS thresholds.

2 - Signalized intersection results are in *italic* type.

3 - Worst stop-controlled approach LOS and Delay reported for unsignalized intersections.

4 - Intersections operating worse than threshold LOS C are in **bold** type.

The CORSIM model provides a simulated model view of average and 95th percentile queues. Examples of these are shown in the screen captures shown as Figures 23A through 23I (see Figures appendix). The operational issues are discussed by interchange in the summary that follows:

DeSmet Interchange

AM

- WB off-ramp becomes congested when left turn vehicles heading SB conflict with NB left turns to on-ramp and SB through vehicles on US 93.
- EB vehicles on Pulp Mill Rd get stuck in a queue approximately 1000 ft.

PM

- WB off-ramp becomes congested when left turn vehicles heading SB conflict with NB left turns to on-ramp and SB through vehicles on US 93. Off-ramp backs up from ramp terminus to just onto mainline. Queue approximately 1400 feet.
- EB vehicles on Pulp Mill Rd subject to potential significant queue (extending outside the network).

Airport Boulevard Interchange

AM

- SB Airway Blvd becomes congested at W. Broadway and backs up to Expressway. Left turn vehicles can not find gap in traffic, can not make left onto EB W. Broadway.

PM

- SB Airway Blvd becomes congested at W. Broadway and backs up to Expressway. Left turn vehicles can not find gap in traffic, can not make left onto EB W. Broadway. Expressway becomes congested also because vehicles can not move SB on Airway Blvd.

Reserve Street Interchange

AM

- No major issues.

PM

- Grant Creek becomes slightly congested when there are no gaps for left turns onto Reserve Street.

Orange Street Interchange

AM

- EB off-ramp backs up from ramp terminus to just onto mainline. Queue approximately 1200 feet.

PM

- EB off-ramp backs up from ramp terminus almost onto mainline. Queue approximately 1000 feet.

Van Buren Street

AM

- EB off-ramp backs up from ramp terminus to just onto mainline. Queue approximately 1650 feet.

PM

- EB off-ramp backs up from ramp terminus almost onto mainline. Queue approximately 1400 feet.

East Missoula Interchange

AM

- EB off-ramp backs up from ramp terminus to just onto mainline. Queue approximately 600 feet.

PM

- No major issues.

Bonner Interchange

AM

- No major issues.

PM

- No major issues.

Figures 24A and 24B summarize the analysis results for the study network. For comparison purposes, both existing year (2002) and future year (2025) results are shown. Figures 25A through 25F (see Figures appendix) show the intersection specific-lane movement designations and the performance measures for the controlling approach or lanes.

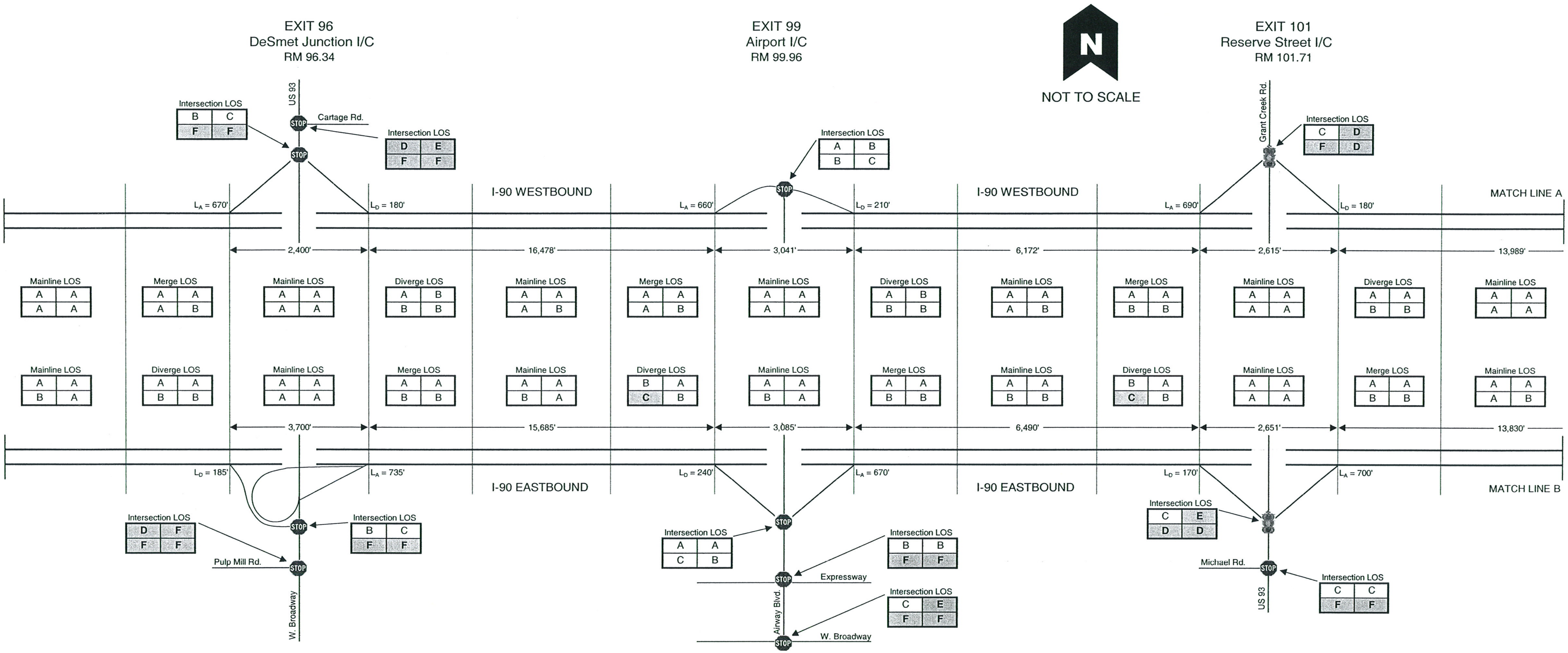
CORSIM Model Measures of Effectiveness

The CORSIM model provides a wide range of simulation based computations for the corridor. These measures of effectiveness (MOE) may be used to establish baseline conditions from which future conditions and alternatives may be evaluated for their potential benefits. Tables 14A and 14B illustrate the relevant MOEs for the I-90 corridor under the existing and projected future traffic demands. While a useful tool, simulation based models yield results based on the simulations performed. For each simulation run, the results will differ to a certain degree. The results presented in the table reflect what was observed to be the most reasonable simulation run for the corridor.

TABLE 14A
CORSIM Measures of Effectiveness – Future (2025) AM Peak Traffic Conditions

	Total Travel Time (sec/veh)	Total Delay Time (sec/veh)	Distance (mi)	Average Speed (mi/hr)	Average Density (veh/ln-mi)	Average Lane Volume (veh/lane/hr)
EASTBOUND						
West of DeSmet	84.5	4.7	1.57	66.8	8.7	585.4
Between DeSmet and Airport Interchanges	162.7	9.9	2.99	65.9	11.9	790.9
Between Airport and Reserve Interchanges	66.4	3.8	1.21	65.0	11.0	725.0
Between Reserve and Orange Interchanges	156.4	18.0	2.61	60.3	10.3	587.3
Between Orange and Van Buren Interchanges	37.3	17.1	0.35	45.3*	11.9	412.2
Between Van Buren and East Missoula Interchanges	63.7	2.1	1.11	62.3	5.8	361.7
Between East Missoula and Bonner Interchanges	77.5	1.5	1.38	64.0	3.3	212.9
East of Bonner	52.2	1.5	0.99	67.3	2.2	146.3
WESTBOUND						
East of Bonner	32.3	0.5	0.62	68.7	5.1	350.4
Between Bonner and East Missoula Interchanges	87.3	3.8	1.51	60.8	9.2	563.8
Between East Missoula and Van Buren Interchanges	75.0	3.0	1.29	61.7	10.7	668.0
Between Van Buren and Orange Interchanges	27.0	1.7	0.45	60.0	10.2	615.6
Between Orange and Reserve Interchanges	143.0	3.4	2.63	65.1	6.1	398.2
Between Reserve and Airport Interchanges	65.4	3.3	1.20	64.5	6.1	396.2
Between Airport and DeSmet Interchanges	165.1	3.5	3.14	68.1	4.1	280.1
West of DeSmet	90.4	3.0	1.71	67.8	3.7	254.4

*: Note significant decrease in average speed (45.3 mph). See discussion that follows.



LEGEND

Level-of-Service	
2002 AM	2002 PM
2025 AM	2025 PM

- Freeway segments operating worse than threshold LOS B are highlighted in **bold** text.
- Local intersections operating worse than threshold LOS C are highlighted in **bold** text.

- Study signalized intersection

- Study stop-controlled intersection

- ← 1,100' → Segment length in units of feet.
- L_A is acceleration lane length (per HCM 2000, Exhibit 13-18) for on-ramp.
- L_D is deceleration lane length (per HCM 2000, Exhibit 13-19) for off-ramp.

Methods of determining L_A and L_D are based on HCM 2000 and is not the same as that determined by AASHTO Criteria

FIGURE 24A

2002 EXISTING & 2025 NO BUILD - AM & PM PEAK

I-90 FREEWAY & LOCAL INTERSECTION LEVEL-OF-SERVICE RESULTS

DESMET TO RESERVE STREET INTERCHANGES

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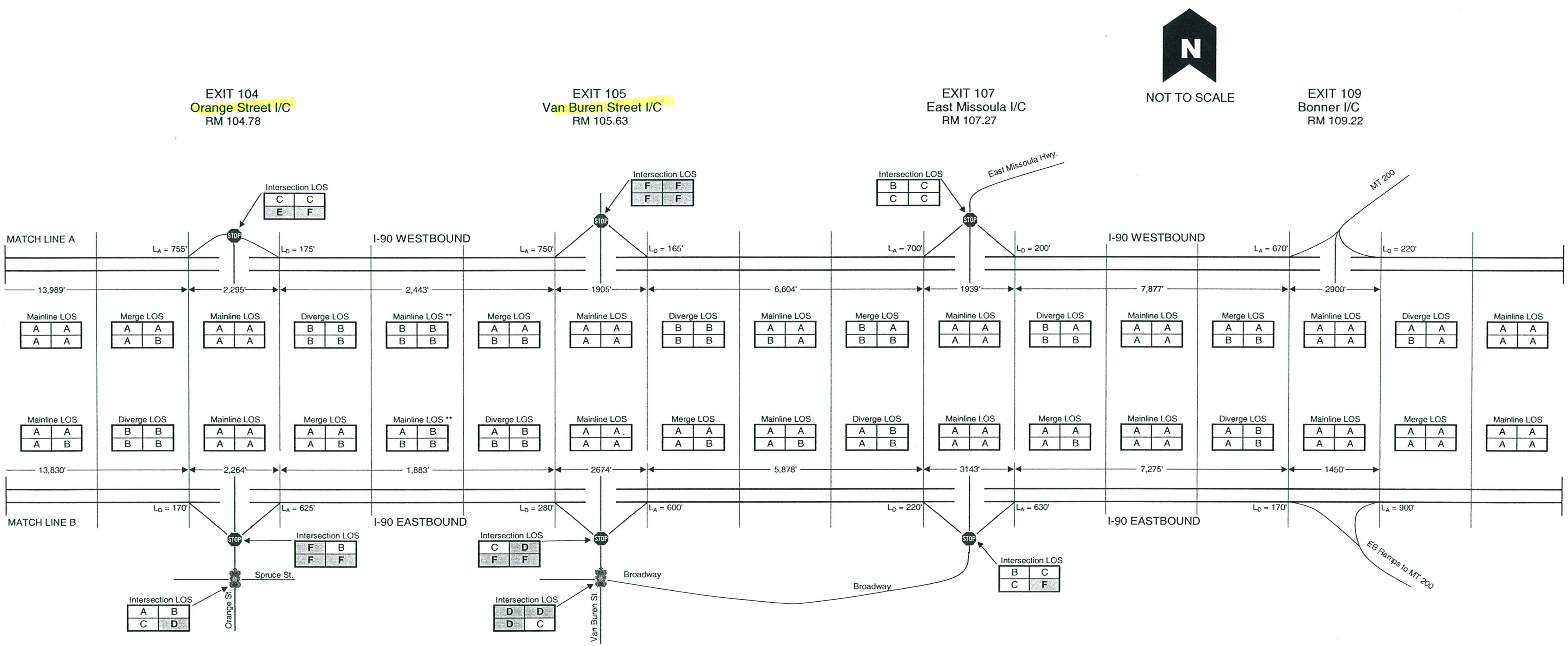

LEGEND

Level-of-Service

2002 AM	2002 PM
2025 AM	2025 PM

- Freeway segments operating worse than threshold LOS B are highlighted in **bold** text.
- Local intersections operating worse than threshold LOS C are highlighted in **bold** text.

- Study signalized intersectio

- Study stop-controlled intersection

- ◄—— 1,100' ——► Segment length in units of feet.
- L_A is acceleration lane length (HCM 2000, Exhibit 13-18) for on-ramp.
- L_D is deceleration lane length (HCM 2000, Exhibit 13-19) for off-ramp.

Methods of determining L_A and L_D are based on HCM 2000 and is not the same as that determined by AASHTO Criteria

** The Orange Street Interchange and VanBuren Street Interchange are closer than 3000 ft. Because of this, there is an overlap between the on-ramp merge movement and off-ramp diverge movement. The mainline operation between these two junctions is dictated by the worst operations of the merge or diverge movements.

FIGURE 24B

2002 EXISTING & 2025 NO BUILD - AM & PM PEAK
I-90 FREEWAY & LOCAL INTERSECTION LEVEL-OF-SERVICE RESULTS
ORANGE STREET TO BONNER INTERCHANGES

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MISSOULA, MT, I-90 EAST WEST, CORRIDOR STUDY PHASE 1

TABLE 14B
CORSIM Measures of Effectiveness Future Year (2025) PM Peak Conditions

	Total Travel Time (sec/veh)	Total Delay Time (sec/veh)	Distance (mi)	Average Speed (mi/hr)	Average Density (veh/ln-mi)	Average Lane Volume (veh/lane/hr)
EASTBOUND						
West of DeSmet	84.2	3.8	1.57	67.0	6.0	403.8
Between DeSmet and Airport Interchanges	161.0	7.6	2.98	66.6	7.8	522.5
Between Airport and Reserve Interchanges	66.1	3.6	1.21	65.3	9.2	603.2
Between Reserve and Orange Interchanges	145.2	6.4	2.61	64.0	9.4	606.0
Between Orange and Van Buren Interchanges	21.4	1.9	0.35	59.0	8.8	521.2
Between Van Buren and East Missoula Interchanges	64.2	2.2	1.11	62.0	8.9	554.4
Between East Missoula and Bonner Interchanges	78.9	2.3	1.39	63.0	7.4	466.5
East of Bonner	53.1	2.1	0.99	66.3	5.3	357.2
WESTBOUND						
East of Bonner	32.2	0.4	0.62	68.7	4.9	335.7
Between Bonner and East Missoula Interchanges	86.9	3.4	1.51	61.0	7.8	481.5
Between East Missoula and Van Buren Interchanges	74.7	2.6	1.30	62.0	8.6	538.8
Between Van Buren and Orange Interchanges	27.0	1.7	0.45	60.0	9.2	556.4
Between Orange and Reserve Interchanges	144.9	5.5	2.63	64.2	8.9	575.1
Between Reserve and Airport Interchanges	65.4	3.4	1.20	64.5	9.5	612.1
Between Airport and DeSmet Interchanges	168.2	5.6	3.14	66.7	9.5	640.1
West of DeSmet	90.4	2.9	1.70	67.5	7.4	501.6

As Table 14A indicates, a significant decrease in operating speed resulted in the eastbound direction between the Orange Street and Van Buren Street interchanges during the AM peak hour. This decrease can be attributed to the high number of lane changes and exit ramp volumes, which were found to queue back to the mainline. This was not found to be significant during the PM peak hour. However, it does confirm the potential need for auxiliary lanes between those interchanges.

Geometrics and Features

Future year traffic projections were used to determine potential future year queue lengths with and without operational improvements, determined essentially to be newly signalized intersections. No other improvements were assumed for the purposes of this analysis. The analysis performed under the existing conditions scenario and discussed under the Existing Conditions section of this report was reviewed for changes that would result relative to the impacts of vehicle queue distances on each interchange ramp along the study corridor. Table 15 presents a summary of the I-90 ramp lengths and the modeled 2025 95th percentile queue lengths for those ramps impacted by unacceptable intersection operations. This table is a summary of a detailed analysis of the sufficiency of each ramp's geometry that is provided in Appendix Exhibit 1.2. Only those ramps that were expected to be impacted in the freeway diverge or deceleration area by queues were included in the summary.

TABLE 15
Summary of I-90 Ramp Queue Impacts[1]

Ramp	All Geometric Requirements Met?	Queue Impacts?	Impact Assessment of 95th Percentile Queues
DeSmet WB Off-Ramp	Yes	Yes	2025 PM queues must not exceed 428 feet. (*95th percentile queue not computed for 2025 PM peak due to limits of HCM equations.*)
Reserve St. WB Off-Ramp	No	Yes	Projected 2025 AM and PM peak queues would impact deceleration length.
Orange St. WB Off-Ramp	No	Yes	Projected 2025 AM and PM peak queues would impact deceleration length.
Orange St. EB Off-Ramp	Yes	Yes	Projected 2025 AM and PM peak queues would impact deceleration length.
Van Buren St. WB Off-Ramp	Yes	Yes	Existing and projected 2025 AM and PM peak queues would impact deceleration length.
Van Buren St. EB Off-Ramp	Yes	Yes	Projected 2025 AM peak queues would impact deceleration length.

1 – See Exhibit 1.2 in Appendix for details of each interchange.

The above data indicates that for the projected 2025 AM and PM peak periods, 95th percentile queue lengths will impact both directions of freeway diverge operations at the DeSmet (WB only), Reserve Street (WB only), Orange Street, and Van Buren Street interchanges. Both the Reserve Street and Orange Street WB off-ramps do not have adequate deceleration lengths at the present time. The deficient deceleration lengths contribute to the queue impacts and should be evaluated further.

DeSmet Interchange

- EB Off Ramp-Meets geometric guidelines, 2025 queues accommodated
- EB On Ramp (Loop)- Meets geometric guidelines
- EB On Ramp (Direct)- Meets geometric guidelines
- WB Off Ramp-Meets geometric standards, 2025 queues can not exceed 428 feet
- WB On Ramp- Meets geometric guidelines

Airport Boulevard Interchange

- EB Off Ramp- Meets geometric guidelines, 2025 queues accommodated
- EB On Ramp- Meets acceleration geometric guidelines but taper rate is less than recommended.
- WB Off Ramp- Meets geometric guidelines, 2025 queues accommodated
- WB On Ramp- Meets acceleration geometric guidelines but taper rate is less than recommended

Reserve Street Interchange

- EB Off Ramp- Meets geometric guidelines, 2025 queues accommodated
- EB On Ramp- Does not meet geometric guidelines
- WB Off Ramp- Projected 2025 queue lengths impact Ld
- WB On Ramp- Does not meet geometric guidelines

Orange Street Interchange

- EB Off Ramp- Projected 2025 queue lengths impact Ld
- EB On Ramp- Does not meet geometric guidelines
- WB Off Ramp- Projected 2025 queue lengths impact Ld
- WB On Ramp- Does not meet geometric guidelines

Van Buren Street Interchange

- EB Off Ramp- Projected 2025 queue lengths impact Ld
- EB On Ramp- Does not meet geometric guidelines
- WB Off Ramp- Both existing and projected 2025 queue lengths impact Ld
- WB On Ramp- Does not meet geometric guidelines

East Missoula Interchange

- EB Off Ramp- Meets geometric guidelines, 2025 queues accommodated
- EB On Ramp- Does not meet geometric guidelines
- WB Off Ramp- Meets geometric guidelines, 2025 queues accommodated
- WB On Ramp- Does not meet geometric guidelines

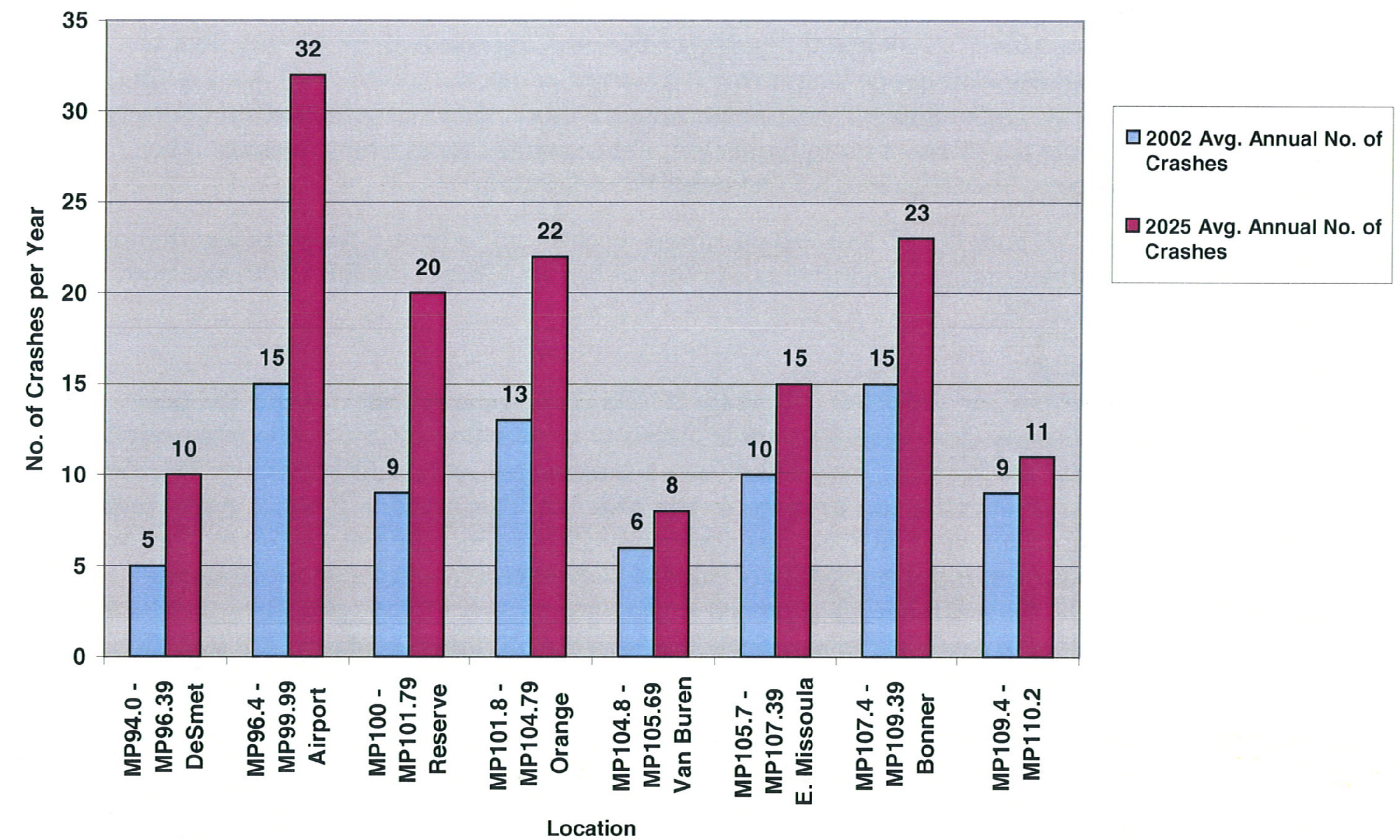
Bonner Interchange

- EB Off Ramp- Does not meet geometric guidelines
- EB On Ramp- Does not meet geometric guidelines
- WB Off Ramp- Does not meet geometric guidelines
- WB On Ramp- Meets geometric guidelines

Safety

The Montana Department of Transportation, like all state departments of transportation, invests significant resources into the area of traffic safety statistics and analysis. Improvements in computer data base processing, digital mapping, global positioning, as well as communications, have all contributed to the increased accuracy, and thus reliability of crash data. These improvements have resulted in advanced analysis techniques and understanding. However, unfortunately the ability to reliably predict future crash potential for a highway has yet to be developed. The general reason for this is the lack of predictability of the variables such as driver demographics, weather, road surface conditions, etc. As a result, predictions have been based on existing and past statistics and trends which are modified based on predicted traffic growth rates. Overall, this methodology assumes that without safety countermeasure improvements the average crash rate would remain relatively the same over the next 20 years. Even so, it is recognized that on freeways, as traffic volumes increase, the number of crashes will increase. However, as congestion increases the severity of crashes may decrease, as vehicle speeds decrease. For this corridor, application of the anticipated growth rates by critical segment, shown in Figure 26, yields the following projected future number of crashes:

Figure 26
Average Annual Crash Projections



As Figure 26 indicates, the greatest increase in the number of crashes is expected to occur west of the Orange Street interchange. The supporting data for Figure 26 is included in Appendix Exhibit 5.

Deficiencies

The results of the forecast year (2025) analyses show potentially significant deficiencies along the I-90 mainline and at numerous ramp terminal and local intersections. These are discussed below separately by interchange. The information in Appendix Exhibit 1.2 is referenced for geometric deficiencies throughout the following discussion.

DeSmet Interchange

The stop sign-controlled ramp termini and both local intersections are expected to achieve LOS F in both peak periods with volume to capacity ratios well over 1.00. As shown in Exhibit 1.2.1, there were no deficient geometric properties identified with any of the ramps. MDT staff has indicated, however, that sight distance at the termini of the WB off-ramp is restricted to/from the south approach. MDT staff further believe that this condition may be resulting in a diversion of truck traffic to the Airport Boulevard Interchange, and West Broadway. The scope of this study did not allow validation of this issue and MDT has initiated a safety enhancement project (JCT I-90-NORTH, NH 5-1(29)0 CN 4778) to address this as well as issues associated with the Pulp Mill Road and Cartage Road intersections.

Airport Interchange

The stop sign-controlled ramp termini are projected to operate acceptably in both peak periods. The I-90 EB off-ramp diverge movement was anticipated to operate at LOS C in the AM peak. Both local intersections along Airway Blvd are projected to operate at LOS F in both peak periods with volume-to-capacity ratios well over 4.00. The link length for the southbound approach along Airway Blvd is nearly 1200 feet. Because the 95th queue length was not computed for the southbound Airway Blvd approach at W Broadway, it is unknown whether the queue would extend to the upstream intersection. It is reasonable to assume the queue, although not computed, would extend a long distance. The CORSIM simulation screen shot (Figure 23C) illustrates this condition.

As shown in Exhibit 1.2.2, both the EB and WB on-ramps were found to have taper rates that do not meet current design guidelines. The desirable rate is 50:1 to 70:1 (AASHTO Exhibit 10-69) and both ramps have taper rates of 25:1.

Reserve Street Interchange

The signalized ramp termini are projected to operate at LOS D or worse in both AM and PM peak periods. The I-90 EB off-ramp diverge movement is projected to operate at LOS C in the AM peak. The Southbound approach to the Reserve Street WB off-ramp intersection in the AM period was shown to reach a 95th percentile queue in the SB direction of over 1000 feet. This queue will result in blockage of the nearest intersecting driveways which are approximately 350 feet and 850 feet upstream. The local street stop sign-controlled intersection at Michael Road is LOS F in both periods with volume-to-capacity ratios over 2.00. The northbound approach to the Reserve Street EB off-ramp intersection in the PM period was shown to reach a 95th percentile queue in the SB direction of over 470 feet. This exceeds the distance to the upstream intersection at Michael Rd which is less than 350 feet away.

The geometric analysis results illustrated in Exhibit 1.2.3 indicate that both the EB and WB on-ramps have deficient acceleration lengths and the WB off-ramp has a deficient deceleration length.

Orange Street Interchange

The ramp termini will operate at LOS E or worse in both periods with the 95th percentile queue length at the EB off-ramp in the AM peak period exceeding the ramp length. As indicated in Exhibit 1.2.4, both the acceleration and gap-acceptance lengths are deficient for both the EB and WB on-ramps; the deceleration length is deficient for the WB off-ramp due to the impacts of queues from the stop sign-controlled ramp intersection.

The Spruce Street intersection operates at LOS C in the AM peak and LOS D in the PM peak period. No turn pocket lengths are exceeded by the 95th percentile queue lengths in the AM peak, but the SB through lane queue extends into the upstream intersection. The EB and SB left-turn pocket storage lengths are exceeded by the 95th percentile queue lengths in the PM peak. The westbound, northbound, and southbound through-lane queues extend into the upstream intersection in the PM peak.

Van Buren Street Interchange

Based on the future year traffic demand, the ramp termini intersections can be expected to operate at LOS F in both peak periods with volume to capacity ratios exceeding 3.00 at the WB ramp terminal and at least 1.00 at the EB ramp terminal. As shown in Exhibit 1.2.5, the EB and WB on-ramps have deficient acceleration lengths.

At the East Broadway intersection, the 95th percentile queue length for the SB right-turn is over 1200 feet, well beyond the 500 feet to the upstream intersection. The queue for the EB left-turn pocket would extend into the two-way left-turn lane (TWLTL) during the PM peak, but would still be able to queue the full distance in that lane.

East Missoula Interchange

The stop sign-controlled East Missoula EB off-ramp is anticipated to operate at LOS F in the PM peak based on future year traffic projections. The ramp termini operate acceptably in all other peak periods.

According to Exhibit 1.2.6, both the EB and WB on-ramps have deficient acceleration lengths.

Bonner Interchange

The ramp termini are uncontrolled and have no operational or queue deficiencies.

According to Exhibit 1.2.7, the EB and WB off-ramps have deficient deceleration lengths and the EB on-ramp has a deficient acceleration length.

Environmental

Traffic Noise

The City of Missoula has expressed concerns about traffic noise to the MDT based on inquiries from residents. In particular, the residents of the Rattlesnake Canyon neighborhood have expressed the concern that their geographic area provides an "amphitheater effect" relative to highway noise. As a result, MDT authorized a preliminary noise study as part of the Phase I Corridor Study.

According to 23 CFR 772 and MDT's Policy and Procedure Manual, traffic noise impacts occur at single-family residences, mobile homes, apartments, hotels, parks, and medical receptors if L_{eq}(h) traffic noise levels for a roadway are 66 dBA or greater in the Design Year, or if the predicted L_{eq}(h) noise levels in the Design Year are 13 dBA or greater than those in the Present Year. For reconstruction projects, if either criterion is met, then an impact occurs and traffic noise abatement measures need to be considered to determine if they are reasonable and feasible.

Thirteen (13) ambient noise level measurements were taken in July 2003 in areas adjacent to I-90 and predicted traffic noise levels at 71 receptor locations, including groups of receptors. FHWA's Traffic Noise Model (TNM) Version 2.0 computer program was used to predict the traffic noise levels due to the existing highway configuration. The measurement and receptor locations are shown on Figures 1 through 8 of Appendix Exhibit 6.

Based on the existing I-90 highway configuration, the traffic noise impact criteria were met or exceeded in the Present Year and Design Year of the project (Section 5.2). Of the 71 Category B receptors identified for the baseline noise study, the predicted traffic noise levels equal or exceed the traffic noise impact criteria (66 dBA) in the Present Year of the project at 28 receptors, and at 48 receptors in the Design Year. Receptors that meet or exceed the criteria are generally located throughout the corridor. However, the predicted noise levels are less than the criteria in the Northside neighborhood, where I-90 is approximately 3 to 4 stories above the ground level of the neighborhood. This condition shields the receptors. In addition, the railroad grade blocks the line of sight and shields the apartment buildings located between the Rattlesnake neighborhood and the East Missoula Interchange, and the predicted noise levels are less than the criteria.

Since the criteria is predicted to be met or exceeded at some of the I-90 receptors, then traffic noise abatement measures may need to be considered and evaluated during Phase II of this project.

Summary

The Phase I Interstate 90 Missoula East-West Corridor Study has identified the potential need for corridor-based improvements based on anticipated future year traffic growth. By the year 2025 it is anticipated that new traffic signals may be required at 14 current stop sign-controlled intersections. In addition, the existing signalized diamond interchange at Reserve Street may require operational and physical improvements to provide additional capacity to meet the LOS C requirements. Two other local intersections (Van Buren St. at East Broadway and Orange St. at Spruce St.) may also require operational improvements.

The mainline study segments of Interstate 90 were found to operate acceptably from a traffic flow perspective. Relative high operating speeds appear to be maintainable, although the high speeds may be a contributing factor in the relatively poor safety record east of the Bonner Interchange. The 85th percentile speed was found to be greater than the posted speeds along most of the segments.

The most significant observation relates to the geometric characteristics of the interchange ramps. Queuing impacts from non-signalized ramp intersections reduce the available amounts of deceleration lane lengths for exit ramp traffic. This factor, coupled with the potential for queues extending onto the mainline, was found to negatively impact the closely spaced Orange Street and Van Buren Street interchanges. Queues were also found to potentially impact two (2) additional off-ramps by the year 2025.

Thirteen (13) of the twenty-nine (29) interchange ramps were found to not meet current design guidelines. Generally this was due to inadequate deceleration or acceleration lane lengths or rapid taper rates.

The noise analysis performed confirmed the potential for a future noise abatement analyses as part of the Phase II study effort as well as any potential corridor improvement projects. Of the 71 noise receptors studied, 28 were found to exceed the 66 dBA noise criteria today and an additional 20 might do so in the future, based on the year 2025 traffic projections.

The net result of this Phase 1 Study is the identified need to plan for congestion mitigation measures, traffic operational improvements, as well as detailed geometric review and improvements to the Interstate 90 mainline and its interchanges with local Missoula streets. This includes the need to develop potential interchange modifications, including possible reconfigurations, as well as addition of traffic signals at the ramp/local street intersections.

The following areas are considered to be recommended focus areas for further study by MDT:

RAMP GEOMETRY AND SIGHT DISTANCE

A review of the existing ramp geometry indicates that several of the interchange ramps can be termed to be non-compliant with the current geometric guidelines for ramp taper rates, deceleration, acceleration, and queue storage distances. These interchanges warrant detailed evaluation of ramp geometry and approach sight distances.

The appropriateness of existing taper rates and deceleration and acceleration lane lengths should be evaluated in the following areas:

- **Exit 96 DeSmet Interchange**
- **Exit 101 Reserve St. Interchange**
- **Exit 104 Orange St. Interchange**
- **Exit 105 VanBuren St. Interchange**
- **Exit 107 East Missoula Interchange**
- **Exit 110 Bonner Interchange**

MAINLINE GEOMETRY

A number of alignment and cross-section issues were identified for the I-90 mainline. These included:

- **MP 95.3 – MP 95.8, EB I-90** – The extended grade of 4% for 0.5 miles results in a speed reduction for large heavy vehicles.
- **MP 103.2 – MP 105.5, EB and WB I-90** – Superelevation does not meet AASHTO criteria. Median barrier reduces shoulder width to less than 4 feet.
- **MP 107.1 – MP 107.6, EB and WB I-90** – Superelevation does not meet AASHTO criteria.
- **MP 108.3, EB and WB I-90** – Shoulder widths on bridges over Clark Fork River do not meet AASHTO criteria.
- **MP 108.7 – MP 109.2, EB and WB I-90** – Mainline stopping sight distance is negatively impacted by the short crest vertical curve.
- **MP 109.4, EB and WB I-90** – Shoulder widths on bridges over Clark Fork River do not meet AASHTO criteria.
- **MP 109.5 – MP 109.8, EB and WB I-90** – Superelevation does not meet AASHTO criteria.
- **MP 110.0 – MP 109.8, EB and WB I-90** – Sight distance is restricted by a short crest vertical curve at the bridge over the railroad.

TRAFFIC OPERATIONS

As previously noted, the Phase 1 Study analysis identified the potential need for traffic signals at 14 non-signalized intersections by the year 2025. Immediate needs for traffic signals were identified at the following interchange locations:

- **Orange Street Eastbound Ramps** – was found to be deficient during the AM peak hour.
- **VanBuren Street Westbound Ramps** – was found to be deficient during both the AM and PM peak hours.
- **VanBuren Street Eastbound Ramps** – was found to be deficient during the PM peak hour.

It is recommended that traffic signal warrants analyses should be performed at the above locations to validate the conclusions prior to design.

By the year 2025, the analysis indicates the potential need for traffic signals at four (4) other interchange ramp intersections and seven (7) local intersections in the study area. The interchange locations are:

- **DeSmet Interchange Westbound Ramps** - was found to be deficient during both the AM and PM peak hours.
- **DeSmet Interchange Eastbound Off-Ramp** - was found to be deficient during both the AM and PM peak hours.
- **Orange Street Interchange Westbound Ramps** - was found to be deficient during both the AM and PM peak hours.
- **East Missoula Interchange Eastbound Ramps** - was found to be deficient during the PM peak hour.

The seven local intersections are identified in Table 13 of the report. It is recommended that traffic volumes and operations be monitored on a regular basis for all intersections anticipated to require signals by the year 2025.

INTERCHANGE MODIFICATIONS

Based on the outcome of the Phase 1 Study which identified the needs for ramp and ramp junction improvements, predominantly at the Orange Street and VanBuren Street Interchanges, it is recommended that MDT consider the potential reconfiguration of those interchanges. As previously identified, the addition of an auxiliary lane between the two may be warranted and should be considered as one of several possible solutions. Other alternatives, such as reconfiguration of one or both interchanges, or their linkage via a collector–distributor (CD) road system should also be evaluated.

NOISE

The Phase 1 Study provided conclusive evidence of potential impacts of I-90 noise on residential areas, particularly the Rattlesnake Canyon area, of Missoula. As a result, it is recommended that any significant improvement scenarios for I-90 should consider noise abatement as part of the project scope.

Next Steps

Based on the outcome of the Phase I study, a prioritized workplan should be developed by MDT that includes the following efforts:

- Development of geometric alternatives relative to the interrelationship and joint operations of closely spaced Orange Street and Van Buren Street Interchanges.
- Evaluate in detail the geometry of all identified potentially deficient interchanges and determine the nature of improvements necessary to meet current design guidelines.
- Evaluate signal warrants for non-signalized intersections in order to determine remaining service life and prioritize a traffic signal installation and operations improvement program.
- Develop detailed planning for improved traffic operations at the Reserve Street interchange, with consideration of increased access control on Reserve Street. Coordinate this effort with the results and planning activities associated with the Missoula Transportation Plan Update.
- Evaluate in detail the Bonner Interchange area relative to geometric and sight distance issues.
- Evaluate all bridge approaches and cross sections for safety-related widening. Coordinate with bridge condition ratings.
- Evaluate the potential for a uniform speed limit and/or speed limit reductions and enforcement along the corridor, particularly east of the Bonner Interchange.
- Verify the effectiveness of recent animal control fencing projects and consider additional projects where necessary.

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