

3.0 DEFICIENCY ANALYSIS

The deficiency analysis is arranged to evaluate each of the five project interchanges in relation to each of the categories below:

- Geometric Elements – intersection configurations, lane (and shoulder) widths, truck turns, intersection sight distance, vertical clearance, and access management.
- Traffic Control – signs, pavement markings, traffic signal operation, and signal warrants
- Capacity – intersection levels of service and capacity issues such as auxiliary lanes (and lengths), and I-90 ramp merge / diverge.
- Safety – review of available accident data, observed safety issues.
- Bicycles and Pedestrians – existing facilities, review of City of Billings Bike & Pedestrian plans, existing deficiencies.
- Street and Highway Lighting – streetlight inventory, spot lumen measurements, potential deficiencies using MDT volume guidelines

A. Geometric Elements

Most geometric element deficiencies are defined as Existing. However, some current deficiencies may not create significant problems until future years when traffic increases. Two examples are truck opposing left turn overlaps and access management. Under low volume conditions, it is relatively infrequent that opposing trucks arrive simultaneously, and when they do they can easily avoid each other. Under congested conditions, and particularly at signalized intersections when they receive green indications or are given simultaneous protected left turn arrows, this overlap problem becomes more frequent and less avoidable. Similarly, access management deficiencies may be acceptable under current low volume conditions, but they become more significant problems as traffic levels grow. An initial judgment regarding when these geometric deficiencies become “significant” has been included in this report, so some geometric elements are defined as short term or long term.

Many deficiencies related to congestion and future traffic growth are included in other sections of this report. The need for future traffic signals is in the *Traffic Control* sub-section, and thru / auxiliary lane deficiencies are analyzed in the *Capacity* sub-section.

This report illustrates existing bridge cross-sections and identifies “critical failures” when the width of these bridges will be inadequate to provide needed auxiliary lanes and capacity. These bridge deficiencies are a critical part of this analysis, as their impact is larger than most other deficiencies. Inadequate lane widths, shoulder widths, and pedestrian / bicycle facilities have also been identified.

B. Traffic Control

Signs are schematically illustrated on aerial based graphics, and most pavement markings are visible on these aerials. Existing signs and pavement markings are reviewed in this sub-section, so all identified deficiencies are considered “existing”.

The evaluation of future traffic signal needs is primarily based on Manual of Uniform Traffic Control Devices (MUTCD) traffic signal volume warrant analyses. 2003 existing volumes (factored 24 hour tube count data) was increased by link growth factors to estimate 2008 and 2023 future volumes. At a few locations where 24 hour tube count data was not available, 24 hour forecasts were estimated or 8 hour turning movement count data was utilized.

Future side streets do not currently exist at Zoo Drive / Gabel Road, Zoo Drive / future entrance, and South Billings / Midland Road (west leg). MUTCD volume warrant analyses were not performed at these two intersections along Zoo Drive, and the analysis did not include the Midland Boulevard leg on South Billings Boulevard.

Traffic control deficiencies are summarized and illustrated on aerial based graphics. If our analyses indicates that future traffic signals may be warranted, these are noted in this report as “deficiencies” in the estimated time frame they become warranted.

C. Capacity

The following capacity analyses were performed at each of the five project interchange areas:

Both of these analyses were performed using 2000 Highway Capacity Manual (HCM-2000) methodologies. Intersection capacity analyses were performed with Synchro (version 5) software, based on HCM-2000 methodology for estimating intersection Level of Service (LOS). Ramp merge / diverge analyses were performed with the HCS-2000 (version 4.1d) software. These capacity analyses worksheets are included in **Appendices O thru S** of the *Worksheets* volume.

Intersection capacity analyses assume current lane configuration and method of traffic control (stop sign or traffic signal) unless signal warrants are anticipated to be met in the future, in which case stop sign control was changed to traffic signal control. At these stop sign

controlled intersections where future signal warrants are met, the summary LOS tables only include the signalized analyses results.

These capacity deficiencies are based on a target LOS C for the overall signalized intersection and LOS D for individual approaches to signalized intersections. LOS D was considered adequate for stop-controlled approaches. When marginally deficient poor LOS is achieved, a “potential inadequate capacity” deficiency is identified. When significant capacity needs are identified, an “inadequate capacity” deficiency is identified. Inadequate auxiliary lane storage length deficiencies have also been identified in a few locations.

A saturation flow rate of 1700 vehicles per hour per lane (vphpl) was utilized for all existing, short-term, and long-term capacity analysis to identify *potential* capacity issues. While this rate is below the standard 1900 vphpl flow rate typically used for these calculations, it is more representative of area driving conditions today (less aggressive than nationwide averages). This also represents a more conservative analysis for identifying potential capacity issues. However, when analyzing future long-term improvement options (discussed later in this report), 1900 vphpl was used as saturation flow rates will be expected to rise with congestion.

Ramp merge / diverge capacity analyses were only performed for the future 2023 (long term) time frame. All year 2023 results indicate adequate ramp merge / diverge capacity, so existing 2003 and short term 2008 analyses with lower volumes were not performed. Actual percentages from project count data was used for percent trucks along the ramps. I-90 mainline percentages were conservatively assumed to be 15 percent; MDT automatic traffic counter data at two I-90 permanent count stations indicate that there were about 9 percent trucks on I-90 in the year 2002. Similarly, actual peak hour factors (PHF) were assumed along ramps, and the I-90 mainline PHF was assumed to be 0.85 (no actual data available).

All ramp LOS analyses assumed that the current I-90 lane configuration remains the same in 2023. MDT indicated that there could potentially be a third thru lane on mainline I-90 through the project study area within this long term 2023 time frame. However, this I-90 mainline widening was not included in any ramp analyses.

The HCM-2000 ramp analysis methodology does not consider platoon effects along on-ramps due to a traffic signal at the ramp / crossroad intersection. A traffic signal at the ramp / crossroad intersection can increase the platoon effect for vehicles turning onto the I-90 on-ramps. When a new traffic signal appears to be needed at a ramp / crossroad intersection, a “potential platoon deficiency due to new traffic signal” was identified for the on-ramp intersection.

These ramp platoon impacts are often greatest when there is a double left turn movement onto the on-ramp under signal control. These high left turn volumes enter the on-ramp during their signal phase, and these double left turn movements often have a protected only phase. These double left platoons either merge into one lane on the ramp before entering the freeway or a two lane ramp merge must be added. When there is inadequate intersection capacity at a ramp / crossroad signalized intersection, and a heavy left turn movement suggests that a double left turn lane is a potential mitigation improvement, a “potential platoon deficiency due to signalized double left turn” was identified for the on-ramp intersection. These potential platoon deficiencies in relation to recommended improvements are discussed later in this report.

D. Safety

Accident history was obtained from MDT for each of the five interchange study areas for a three year period. The majority of data was for the period between July 2000 and June 2003, although the dates varied. This data contained information related to number of vehicles involved, type of crash, general location, date of accident, time of day, roadway conditions, traffic control, and number of injuries / fatalities. Using this information, SEH performed safety review of each interchange to identify any documented problem areas that may be corrected by operational or other improvements.

Table 12 summarizes the accident data received from MDT for each of the interchange study areas. The data is first divided by mainline I-90 accidents near the interchange and “intersection/interchange” related accident based on milepost readings. Since only milepost data was provided by MDT to locate these accidents, these were not grouped with the second set. The second set of accidents is divided up by crossroad segment and by intersection (as more specific information was provided for these). It is believed the discrepancy between location designations in the accident reports is due to some of the ramp terminal intersection accidents being identified by I-90 milepost, while others are referenced by a crossroads milepost or other means.

Night-to-day accident ratios for the interchange areas were calculated for use in determining highway lighting needs and are discussed in upcoming Section F.

E. Bicycles and Pedestrians

Analysis of existing and future bicycle and pedestrian deficiencies was performed by reviewing the existing bicycle and pedestrian facility network, existing bicycle and pedestrian volumes, and comparing existing facilities to the Yellowstone County BikeNet plan.

Existing bicycle and pedestrian volumes were collected with turning movement counts at major intersections within the five interchange study areas. These turning movement counts were collected during the following times of the day:

- AM peak (7:00 am - 9:00 am)
- Noon Peak (10:00 am – 2:00 pm)
- PM peak (4:00 pm – 6:00 pm)

Figures 3 thru 7 illustrate existing 2003 bicycle and pedestrian volumes collected at each intersection. As shown on these figures, the bicycle and pedestrian volumes are relatively low at most intersections within each interchange study area. During many peak periods, no bicycles and pedestrians were observed.

The Billings area BikeNet plan provides the following classifications for roadways and off-street paths that are applicable for this project:

- *Principal Vehicular Arterial*: Bicyclists are encouraged to use an alternate route to these roadways. I-90 and all ramps in the study area are classified this way.
- *Arterial District Connector*: These routes are not encouraged for bicycle use, but will be designed with wide outside lanes or paved shoulders to accommodate them.
- *Primary and Secondary District Connectors*: These routes are the basis of the on-street network and will be developed and managed to encourage bicycle use. Bicycles are accommodated in shared vehicle/auto lanes, designated parallel bicycle lanes, or on wide outside lanes depending upon the roadway characteristics and volumes.
- *Bike Paths*: These are improved, continuous, off-street routes developed and managed to complement and connect with on-street District and other connectors.

There are no bicycle paths or marked bicycle lanes across any of the five project interchanges. There is one marked (but unsigned) path along northbound South Billings Boulevard which appears to be designed for pedestrians but can be used by bicycles traveling in that direction. Based on the Billings BikeNet plan, four of the five interchange crossroads are categorized as *Arterial District Connectors* on which bicycle use is not encouraged but some level of accommodation should be provided. The exception is 27th Street, which is a *Principal Vehicular Arterial*, where bike use is discouraged and accommodations are not made. Bicycle deficiencies identified in this sub-section are based on a comparison of existing facilities with

goals contained in the BikeNet plan. While 27th Street may not adequately accommodate bicycles, it was not noted as a bicycle deficiency because of its BikeNet designation. At other interchanges, wide outside lanes or paved shoulders are considered adequate for bicycles.

The City and County are currently exploring alternatives for off-street, grade-separated crossings of I-90 through the Billings corridor (using existing culverts and other structures). However, these interchanges will continue to serve as an important element of the Billings area bikeway network. As bridge structures are replaced or lane configurations are changed in the future, implementation of bicycle improvements should be considered. Phase 2 recommendations in this study will include bicycle related improvements which will meet City of Billings BikeNet guidelines.



Shiloh EB off-ramp streetlights

F. Street and Highway Lighting

Existing street and highway lighting at each interchange study area were compared to design guidelines contained in Section 13 of the MDT Traffic Engineering Manual to identify existing and future lighting deficiencies. In addition, SEH performed site examinations at each interchange during nighttime conditions and recorded spot foot-candle measurements.

Inventory and Data Collection

An inventory of the existing street and highway lighting system was performed by SEH. The following information was collected:

- Existing light pole locations
- Approximate pole height
- Approximate luminaire arm length
- Luminaire type
- Luminaire wattage
- Spot foot-candle readings near ramp terminals and in intersections



Partial Interchange Lighting (PIL) at 27th St. EB off-ramp gore area

Figures G-1 thru G-5 (Appendix G) show the above information for each interchange location. Existing I-90 mainline and underpass lighting was not reviewed.

MDT provides general descriptions for two types of interchange lighting configurations that are applicable for this project: *Complete Interchange Lighting* (CIL) and *Partial Interchange Lighting* (PIL). In addition, Section 13 gives guidelines for conditions in which CIL and

PIL should be considered (based on ramp volumes, crossroads volumes, adjacent land use & lighting, nighttime accident data, and local agency needs). This information was used to define existing lighting at each interchange and help identify existing and future deficiencies.

With the exception of the Shiloh Road interchange, all study area interchanges have existing lighting layouts that meet or almost meet the MDT description for PIL: there is some level of lighting provided at gore areas and ramp terminals. In most cases, there is also some lighting along the crossroads and at adjacent intersections.

The Shiloh interchange is continuously lit along the traffic lanes of all ramps, at all ramp terminals, and along the crossroad extending from the south ramp terminal to roughly 1000' north of the north ramp terminal. This closely fits the MDT description for CIL, although I-90 mainline through lanes are not continuously lit as described for CIL in Section 13. The intersection of Zoo Drive and Gabel Road, Zoo Drive S Frontage Road, and Zoo Drive / Shiloh Road also all have lighting.

Existing and Future Deficiencies

Using the MDT guidelines for Highway Lighting, field inventories, spot foot-candle measurements taken during site examinations, and computer modeling using Lighting Analysts AGI32 software, existing and future deficiencies were identified.

Evaluation of existing lighting included comparing PIL guidelines in Sections 13.2.2.4, 13.2.3 and Figure 13.6J to the inventory at each interchange. CIL evaluations were made with respect to three criteria: ramp volume, crossroad volume, and night-to-day accident ratios. Night-to-day ratios were calculated based on accident data provided by MDT. Statewide night-to-day accident ratio averages for similar sections were not available from MDT to make a comparison (per MDT guidelines). However, these ratios were used to provide a relative context for nighttime accidents at each interchange. CIL evaluations were performed for existing, short term (2008) and long term (2023) traffic conditions.

Lighting Analysts AGI32 computer modeling was performed at all ramp terminal intersections at all interchanges with the exception of Shiloh Rd. (since Shiloh currently has CIL along the crossroad). This information was used to further define deficiencies and to analyze existing light spacing and luminaire performance. The AGI32 lighting displays are shown in **Figures G-6 thru G-9** (Appendix G).

Table 13 summarizes the evaluation of interchange lighting for existing and future conditions.

All of the interchanges, at a minimum, have traffic conditions that meet the volume criteria for PIL in both the existing, short, and long-term scenarios. Based on our evaluation, the PIL recommendations for the lighting of through lanes and speed change lanes at merging and diverging locations have been met at all interchanges. For future conditions, all interchanges meet the criteria for CIL based crossroad volume, and all interchanges meet CIL criteria based on ramp volumes with the exception of 27th Street. Relative night-to-day accident ratios (excluding Shiloh, which did not have a large enough number of accidents to make a relevant calculation) do not seem to indicate that any interchanges have a significantly higher overall ratio of nighttime accidents than another, although the lower rate at US 87 Lockwood may be indicative of the more consistent lighting at that location.

Nevertheless, there are some higher night/day accident ratios at the four interchanges at non-junction locations (mainline). Those ratios are: South Billings = .52; 27th St = .86; US 87 Lockwood = .58; and Johnson Lane = .67. Without an in-depth analysis of the mainline traffic accident reports (which is beyond the scope of this project), it would be difficult to identify the causal factors behinds these higher ratios, and determine whether lack of lighting is really the root cause of the problem, compared to other conditions such as icy roads, etc. It is suggested that MDT consider such an in-depth analysis subsequent to this project. If the results of such an analysis indicate that lack of mainline lighting is indeed a problem, the time frames for implementing Complete Interchange Lighting, or other remedial lighting countermeasures, at the interchanges may need to be accelerated.

Since MDT CIL criteria are guidelines for when to “consider” complete interchange lighting (rather than a “hard” rule), lack of CIL at each interchange was only considered a deficiency for time frames when *both* ramp and crossroad volumes meet thresholds, rather than either/or.

The existing, short and long term lighting deficiencies for each interchange are summarized within the individual interchange examinations to follow.

3.1 SHILOH INTERCHANGE

A. Shiloh Interchange Geometric Elements

This interchange area is relatively undeveloped at the present time, but significant development growth is anticipated. The zoo is south of the Zoo Drive / Shiloh Road intersection.

This entire interchange study area was recently constructed by MDT, so geometric elements generally conform to current MDT standards.

All intersections are designed to accommodate existing traffic, some future traffic growth, and two new intersections along Zoo Drive north of I-90 for future development.

Zoo Drive is currently striped for one thru lane in each direction. However, it was designed so that it could be widened to two thru lanes plus auxiliary lanes in each direction. The existing bridge structure over I-90 can be reconfigured to accommodate two thru lanes plus auxiliary lanes.

During the course of this study, the Gabel Road connection was constructed NE of Zoo Drive. This Gabel Road extension aligns with Pierce Parkway. This new road is not shown on our aerial photos.

Intersection configurations

All intersections are well designed to MDT standards, so there are no deficiencies identified in this category.

Lane widths / taper lengths

Figure C-1 (Appendix C) shows lane widths, taper lengths, and shoulder widths. All thru and auxiliary lane widths are 12' or more. Adequate taper lengths are present for all auxiliary lanes. All rural sections have adequate paved shoulder widths

Truck turns

Figures D-1 (Appendix D) illustrate truck turn movements at study area intersections along Zoo Drive. There are some opposing left turn overlaps along Zoo Drive at the future driveway, Gabel Road and South Frontage Road intersections to avoid painted median areas and stop bars. At Zoo Drive / Shiloh Road, the southbound truck left turn path extends into the southbound through lane and runs over a painted right turn channelization island. Otherwise, there are no truck turn issues.

Intersection sight distance

There are no intersection sight distance issues at any study area intersections along Zoo Drive.

Vertical clearance

There are no vertical clearance issues.

Access Management

When constructed by MDT, an access resolution was developed for Zoo Drive, designating an area of "limited access control" throughout

the study area. There will be no additional access points along Zoo Drive beyond those currently constructed.

Shiloh Interchange Geometric Deficiencies

- Opposing left turn overlap for trucks at Zoo Drive / future driveway west of Gabel Road [Existing]
- Opposing left turn overlap for trucks at Zoo Drive / Gabel Road [Existing]
- Opposing left turn overlap for trucks at Zoo Drive / S Frontage Road [Short or Long term, after south leg of Zoo Drive is open and used by truck traffic

B. Shiloh Interchange Traffic Control

Signs and Pavement Markings

Figure F-1 (Appendix F) illustrates existing traffic control signs and pavement markings.

Following are sign and pavement marking deficiencies within this interchange study area:

- There is no posted speed limit on Zoo Drive between Shiloh Road and South Frontage Road [existing]
- This interchange does not have any advance directional I-90 guide signs [existing]
- There are no end of road markers or type 3 barricade with a Road Closed sign at the end of pavement on Zoo Drive south of the South Frontage Road behind the existing type 3 barricade at the Zoo Drive / South Frontage Road intersection [existing]
- There are no end of road markers or type 3 barricades at the end of pavement on the future entrance legs between Gabel Road and Shiloh Road on Zoo Drive; there is a small coffee hut retail use on one of these legs. [existing]
- The advance street name signs on the South Frontage Road prior to Zoo Drive indicate that Shiloh Road is the upcoming cross street [existing]
- There are stop lines across right turn lanes with striped channelization islands and, for three of four locations, yield signs: northbound Shiloh at Zoo, westbound Zoo at Gabel Road, northbound South Frontage at Zoo, westbound South Frontage at Zoo [existing]

Traffic Signals

There are no existing traffic signals in the Shiloh interchange study area. Streetlight poles at all intersections have mounting brackets and were designed for future traffic signal mast arm installation.

Table 1 summarizes signal warrant analysis results for major intersections along Zoo Drive. These signal warrant analyses were performed assuming both MUTCD speed assumptions (above 40 mph, and 40 mph or less), as speed limits are not currently posted along Zoo Drive.



Signal-ready pole on Zoo Drive

At Zoo Drive / Shiloh Road intersection, hourly volumes on the south leg of Shiloh Road were estimated by factoring the north leg hourly volumes to the average daily traffic volume for the south leg (obtained from a traffic study by Engineering Inc., Jan, 2001). If 45 mph speed is assumed on Shiloh Road, a traffic signal is already warranted at Zoo Drive / Shiloh Road in 2003; with 40 mph speeds, this traffic signal will be warranted after 2008. Most side street traffic on Zoo Drive are channelized right turn movements, and newly constructed Gabel Road will divert some traffic away from this intersection. Therefore, this traffic signal installation has been identified as long term, though short term adjacent development could move this up to short term (2008) time frame. A combination of heavy southbound Shiloh Road left turn volumes, difficult westbound left turn movement on Zoo Drive, and a potential future fourth (west) intersection leg with future development traffic will likely create the need for this future traffic signal.

Based on forecasts from this study and the Shiloh Interchange – North Side Properties study (Engineering Inc., Jan, 2001), traffic signal volume warrants will be probably be met by 2023 at the Zoo Drive / future entrance intersection.

Based on forecasts from this study and the Shiloh Interchange – North Side Properties study (Engineering Inc., Jan, 2001), traffic signal volume warrants will be probably be met by 2008 at the Zoo Drive / Gabel Road intersection. Project daily forecasts indicate that Gabel Road will have about 6,000 vehicles per day and Zoo Drive will have about 10,000 to 11,000 vehicles per day, and a significant portion of this Gabel Road traffic is the difficult left turn movement onto Zoo Drive heading towards I-90.

The westbound and eastbound I-90 ramp intersections will both meet signal warrants by 2023 under project traffic forecasts and any assumed travel speed along Zoo Drive. Assuming 45 mph travel speed on Zoo Drive, the westbound ramp intersection will meet warrants and the eastbound ramp intersection will meet the four hour volume warrant by 2008. Assuming 40 mph, neither of these ramp intersections will meet any signal warrants. These ramp traffic signals

have been identified as long term deficiencies, but they may be needed soon after 2008.

The traffic forecasts for the Zoo Drive / South Frontage Road intersection will meet traffic signal warrants by 2023.

If all of these signals are installed, there will be six traffic signals within about 5,000 feet distance. The largest distance between signals will be about 1900' between the I-90 westbound ramps and Gabel Road. A coordinated traffic signal system would significantly improve traffic flow along Zoo Drive.

The following *traffic signal* deficiencies have been identified:

- New traffic signal at Zoo Drive / Shiloh Road [long term]
- New traffic signal at Zoo Drive / future entrance [long term]
- New traffic signal at Zoo Drive / Gabel Road [short term]
- New traffic signal at Zoo Drive / I-90 westbound ramps [long term]
- New traffic signal at Zoo Drive / I-90 eastbound ramps [long term]
- New traffic signal at Zoo Drive / South Frontage Road [long term with development to south)
- Coordinated signal system along Zoo Drive [long term]

C. Shiloh Interchange Capacity

The Shiloh interchange study area is projected to have the highest growth levels of all five interchange being evaluated in this study, as much of this area has not yet developed.

At the Shiloh interchange, the long term year 2023 analysis included additional traffic from future development south of the South Frontage Road beyond traffic growth included in the MDT travel demand model for Billings. These forecasts assume very high annual growth rates for the entire twenty year period. These high growth rates may be difficult to achieve, so these forecasts more likely represent growth over a longer period of time than twenty years.

This capacity analysis assumed cycle lengths calculated by Synchro network optimization. Coordination was desired along the entire length of Zoo Drive, but at times Synchro did not coordinate the Gabel Road and Zoo Drive intersections.

Intersection Capacity

Table 7 summarizes the HCM-2000 LOS analyses for intersections in this interchange study area. **Appendix O** (*Worksheets* volume) contains these LOS analysis worksheets.

At Zoo Drive / Shiloh Road, daily traffic forecasts suggest that a traffic signal will be warranted by 2023. The westbound left turn movement currently operates at LOS E in 2003 PM Peak and will operate at LOS F in 2008 PM Peak under stop control. All other movements operate at LOS C or better during other peak periods in 2003 and 2008. In 2023, by which time signal warrants will be met, this signalized intersection will operate at an overall LOS A or B during all peak periods. Individual turning movements will operate at LOS C or better except for the westbound left turn movement, which will operate at LOS D under our assumed signal timing.

The westbound right turn and opposite southbound left turn movement will have the highest volume at this intersection. The westbound right turn movement has an acceleration lane along northbound Shiloh Road which extends about 650' north from the end of the right turn channelization island. This right turn movement currently operates as a free right turn, but future entrances along Shiloh Road could restrict this right turn in the future. There is an unimproved entrance on Shiloh Road about 530' north of this right turn channelization island.

The southbound left turn movement will have up to 600 vph during peak periods. Double left turn lanes are frequently needed at these volume levels. However, our capacity analysis indicates that this movement will operate at LOS B or better with long-term conditions. This heavy left turn movement has the benefit of a relatively low opposing northbound thru and right turn movements. A southbound double left turn lane would have the drawback of probably requiring protected only signal phasing, which would eliminate the permissive left turn. It would be beneficial to maintain this single left turn operation as long as possible. There is currently a 550' southbound left turn lane.

This analysis did not consider impacts of a fourth west leg at Zoo Drive / Shiloh Road intersection. If significant peak period traffic is generated by future development on this potential future west leg, additional improvements may be needed on these three existing intersection approaches to achieve an acceptable level of service. If this fourth leg creates additional signal phases and reduces green time for the southbound left turn, improvements such as earlier traffic signal installation, a southbound double left turn lane, or an extended northbound to eastbound right turn acceleration lane to separate this right turn from the southbound left turn may need to be considered.

At Zoo Drive / Gabel Road – Pierce Parkway, daily traffic forecasts suggest that a traffic signal will be warranted by 2008. In 2008, the overall signalized intersection and each movement will operate at LOS C or better in all peak periods. If unsignalized, the northbound and southbound left turn movements will operate at a poor LOS during peak periods.

In 2023, the overall intersection will operate at LOS C / B / F during the AM / Noon / PM peak periods. PM peak volumes are high, especially on Zoo Drive and the southbound Gabel Road left turn movement.

At Zoo Drive / I-90 WB ramps, daily traffic forecasts suggest that a traffic signal will be warranted before 2023. In 2003, all movements at this unsignalized intersection currently operate at LOS B or better during all peak periods. In 2008, all movements at this unsignalized intersection will operate at LOS C or better during all peak periods. In 2023, the overall intersection will operate at LOS F during all peak periods, as traffic movements to and from the south significantly increase.

At Zoo Drive / I-90 EB ramps, daily traffic forecasts suggest that a traffic signal will be warranted before 2023. In 2003, the unsignalized eastbound ramp approach currently operates at LOS C or better during all peak periods. However, in 2008 the unsignalized eastbound ramp approach will operate at LOS F / C / E during the AM / Noon / PM peak periods. This suggests that capacity improvements or a traffic signal installation may be needed by 2008. In 2023, the overall intersection will operate at LOS F / D / F during the AM / Noon / PM peak periods as traffic volumes at this intersection increase significantly.

At Zoo Drive / South Frontage Road, in 2003, all movements currently operate at LOS B or better during all peak periods. In 2008, all unsignalized movements will operate at LOS C or better during all peak periods. In 2023, the southbound left turn movement will operate at LOS C during all peak periods under stop sign control, though some movements will operate at LOS D-F. This suggests that capacity improvements or a traffic signal installation may be needed by 2023.

The following *intersection capacity* deficiencies have been identified within the Shiloh interchange study area:

- Potential inadequate capacity at Zoo Drive / Shiloh Road until signalized [short term]
- Evaluate impacts of future entrances along Shiloh Road on free WB to NB right turn movement [short or long term, depending on time of development]

- Evaluate capacity impacts of potential fourth west leg at Zoo Drive / Shiloh Road intersection [short or long term, depending on time of development]
- Inadequate capacity at Zoo Drive / Gabel Road [long term]
- Inadequate capacity at Zoo Drive / I-90 WB ramps [long term]
- Potential inadequate capacity at Zoo Drive / I-90 EB ramps [long term], inadequate capacity [long term]
- Potential inadequate capacity at Zoo Drive / South Frontage Road without signalization [long term], potential inadequate capacity with signalization [long term]

Ramp Capacity

Table 6 summarizes the HCM-2000 LOS analyses for I-90 ramp merge / diverge operation with estimated 2023 traffic forecasts. All ramps will merge and diverge at HCM-2000 LOS A or B with 2023 volumes.

The Shiloh interchange on-ramps will have relatively high volumes by the year 2023. Based on project forecasts, the westbound on-ramp will have up to 1,203 vph in the 2023 scenario. Most of these westbound on-ramp volumes will be right turns from Zoo Drive. This heavy right turn movement may require consideration of a free right turn or overlap signal phasing from Zoo Drive when this intersection is signalized.

The eastbound on-ramp is projected to have similar volume levels, with up to 1,047 vph with 2023 conditions. These on-ramp volumes will consist of almost equal left and right turn movements from Zoo Drive. A double left turn lane and right turn overlap phase may be needed with signalization.

Both of these on-ramps were identified as having the potential for ramp merge deficiencies.

The following ramp capacity deficiencies have been identified within the Shiloh interchange study area:

- Potential platoon deficiency due to new traffic signal at Zoo Drive / I-90 westbound ramps [long term]
- Potential platoon deficiency due to signalized double left turn at Zoo Drive / I-90 westbound ramps [long term]

- Potential need for right turn overlap phase or “free” right turn from Zoo Drive at Zoo Drive / I-90 westbound ramps [long term]
- Potential platoon deficiency due to new traffic signal and signalized double left turn at Zoo Drive / I-90 eastbound ramps [long term]
- Potential need for right turn overlap phase from Zoo Drive at Zoo Drive / I-90 eastbound ramps [long term]

D. Shiloh Interchange Safety

- The severity of right-angle accidents for southbound vehicles at the Zoo Drive / South Frontage Road intersection indicates that additional and/or more visible display of the stop condition may be needed [existing].

E. Shiloh Interchange Bicycles & Pedestrians



Shoulder on Zoo Dr.
north of I-90

The Shiloh Road interchange currently has a 10’ wide attached sidewalk located along the east side of Zoo Drive. This sidewalk extends from the South Frontage Road to roughly 1000’ north of the westbound I-90 ramp terminal intersection. There is a crosswalk marked (for this sidewalk) only at the eastbound ramp terminal intersection, and there are curb ramps located along the east side at each of the ramp terminal intersections. There are no other pedestrian facilities in the Shiloh Road interchange study area.

The BikeNet plan identifies Zoo Drive and Shiloh Road as Arterial District Connectors, and South Frontage Road as a Primary District Connector through the study area. A potential future off-street bicycle path is shown along the existing railroad corridor paralleling I-90 on the north side through the study area. Adequate width and shoulders exist on these roadways to meet BikeNet standards for District Connectors.

A future Billings West End Bike Trail is also being proposed along Gabel Road, which would connect to Zoo Drive and continue west to Shiloh Road. Although the BikeNet plan identifies this trail along the BBWA canal north of this study area, current plans involve the trail aligning along Gabel Road and Zoo Drive to ultimately connect ZooMontana to downtown Billings.



Complete Interchange Lighting (CIL) at Shiloh Rd interchange

Shiloh Interchange Bicycle and Pedestrian Deficiencies

- Lack of sidewalks (and supporting crosswalk markings) within the study interchange area, with the exception of along the I-90 bridge, but only on the east side [short term w/development]
- No bicycle deficiencies.

F. Shiloh Interchange Lighting Deficiencies

- I-90 mainline highway lighting does not meet CIL standards [long term]

3.2 SOUTH BILLINGS BLVD. INTERCHANGE

A. South Billings Blvd. Interchange Geometric Elements

There are mixture of industrial, commercial and residential uses along King Avenue and north along South Billings Boulevard. There is an elementary school on the east side of South Billings Boulevard about 1,200 feet north of King Avenue. The new Midland Boulevard extension south of I-90 will serve the future Billings Operations Center and other hotel and industrial uses.

There were two local roadway improvement projects underway in this interchange area during Phase 1 of this study. King Avenue was improved on the west side of South Billings Boulevard during the summer of 2003; these improvements are shown in the project aerial photos. Another project currently being constructed is the Midland Boulevard connection on the west side of South Billings Boulevard. This Midland Boulevard extension will align with the South Frontage Road, and South Billings Boulevard will be improved in this vicinity with auxiliary lanes. A future traffic signal may be installed with opening of City Operations Center as early as summer of 2004. Project aerial photos and counts do not include this Midland Boulevard extension.



Recent improvements on King Ave west of S. Billings Blvd

There is also a future planned improvement project for South Billings Boulevard between King Avenue and Laurel Road. This improvement is planned to include curb, gutter, sidewalk and streetlights on both sides of the road.

Intersection configurations

All intersections are well aligned, and there were no configuration deficiencies identified.

Lane widths / taper lengths

Figure C-2 (Appendix C) shows lane widths, taper lengths, and shoulder widths. All thru and auxiliary lanes have minimum 12'

width. Taper lengths along South Billings Boulevard are adequate. Some taper lengths along King Avenue are slightly shorter than MDT recommended length, allowing longer full width storage in the westbound left turn lanes at the signalized South Billings Boulevard and unsignalized Southgate Drive intersections. All rural sections have adequate paved shoulder widths.

Truck turns

Figure D-2 (Appendix D) illustrates truck turn movements at study area intersections along South Billings Boulevard. There are right turn constraints and opposing left turn overlaps at the South Billings Boulevard / King Avenue intersection.

There are no truck turn issues at other intersections at this time. We have not reviewed truck movements to / from the new Midland Road west leg across from the South Frontage Road.

Intersection sight distance

There are no intersection sight distance issues at any study area intersections along South Billings Boulevard.

Vertical clearance

There are no vertical clearance issues.

Access Management

South Billings Boulevard has no private access points between King Avenue and South Frontage Road.

There are several access points near the South Billings Boulevard / King Avenue intersection. There is a gas station entrance about 200' north of King Avenue, and a residential neighborhood entrance about 320' north of King Avenue. A raised median on South Billings Boulevard restricts left turn movements at both of these entrances. The gas station has an alternate full access entrance about 300' further to the north. This same gas station also has a full movement entrance on King Avenue about 240' west of South Billings Boulevard. The King Avenue / Southgate Drive intersection is about 440' west of South Billings Boulevard. Newman Lane is about 450' east of South Billings Boulevard, and the entrance to Burger King and other future development parcels is about 650' east of South Billings Boulevard.

The only existing access management deficiency identified near this intersection is the full movement entrance on King Avenue about 240' west of South Billings Boulevard.

Potential future access management deficiencies with the development of the Billings Operations Center should be avoided with the planned raised median along Midland Boulevard.

South Billings Boulevard Interchange Geometric Deficiencies

- Truck turn movements at South Billings Boulevard / King Avenue [Existing]
- Access management for gas station entrance on King Avenue about 240’ west of South Billings Boulevard [Short term, becomes a more serious problem with future traffic growth]

B. South Billings Blvd. Interchange Traffic Control

Signs and Pavement Markings

Figure F-2 (Appendix F) illustrates existing traffic control signs and pavement markings. The future roadway improvement project along South Billings Boulevard north of King Avenue may include signing and striping improvements.

Following are sign and pavement marking deficiencies within this interchange study area:

- There are Jct I-90 signs on southbound South Billings Boulevard north of King Avenue and northbound South Billings Boulevard south of South Frontage Road – Midland Road [existing]
- Southbound South Billings Boulevard does not have an advance I-90 East directional guide sign after the westbound I-90 ramp intersection; the other three ramp approaches have this advance sign [existing]
- South Billings Boulevard speed limit is not posted in the southbound direction within the interchange study area [existing]
- There is no thru-right intersection lane control sign on mast arm for southbound approach at South Billings Boulevard / King Avenue; this southbound thru-right lane is 21’ wide, which can appear wide enough for two travel lanes [existing]
- There is no intersection lane control signs for thru and right turn movements on mast arm for eastbound approach at South Billings Boulevard / King Avenue [existing]
- There are no end of guardrail object markers on northbound and southbound South Billings Boulevard overpass [existing]



Wide thru/right lane on SB S Billings Blvd. at King Ave.

Traffic Signals

There are existing traffic signals along South Billings Boulevard at King Avenue, I-90 westbound ramps, and I-90 eastbound ramps. **Table 2** summarizes a signal volume warrant analysis for unsignalized intersections at South Billings Boulevard / Southgate Drive and King Avenue / Southgate Drive.

A future traffic signal is planned at the South Frontage Road – Midland Road intersection, perhaps in conjunction with the opening of the Billings Operations Center in summer of 2004. A signal volume warrant analysis without Midland Road (with only west South Frontage Road volumes) indicates that this signal would be warranted by 2023.

At King Avenue / Southgate Drive, a traffic signal will not be warranted by 2023 with project traffic forecasts.

After the new Midland Boulevard traffic signal is installed there will be four traffic signals on South Billings Boulevard within about 2,300'. Signal spacing will be about 530' (King to I-90 westbound), 1,350' (I-90 westbound ramps to I-90 eastbound ramps), and about 400' (I-90 eastbound ramps to South Frontage-Midland Road). A coordinated traffic signal system throughout this study area will be beneficial to traffic flow along South Billings Boulevard, particularly as volumes continue to increase with development growth to the south. It is especially important to coordinate the two pairs of close traffic signals to minimize impacts of their close proximity.

The following traffic signal deficiencies have been identified:

- New traffic signal at South Billings Boulevard / Midland – South Frontage Road [short term with Billings Operation Center or long term]
- Coordinated signal system along South Billings Boulevard [short term]

C. South Billings Blvd. Interchange Capacity

The South Billings interchange study area will have a moderate rate of growth north of I-90 and a high rate of growth south of I-90. The traffic growth south of I-90 is due to the Midland Road connection and significant development growth further to the south.

This analysis assumed that Midland Boulevard PM peak projections from the Billings Operations Center Subdivision traffic study (Engineering Inc.) occur during all three peak periods (AM, Noon, and PM).

The three current traffic signals operate at 70 second cycles during much of the day. These cycle lengths were assumed to remain in the year 2008, though splits were optimized in each peak period. In 2023, the network cycle length was optimized with Synchro software, and different cycle lengths were recommended during each peak period (90 sec - AM, 104 sec - Noon, 130 sec - PM). These long cycle lengths are indicative of inadequate capacity at some intersections in this interchange study area during peak periods.

Intersection Capacity

Table 8 summarizes the HCM-2000 LOS analyses for intersections in this interchange study area. **Appendix P** (*Worksheets* volume) contains these LOS analysis worksheets.

At King Avenue / Southgate Drive, daily traffic forecasts suggest that a traffic signal will not be warranted by traffic volume levels. The northbound approach under stop control operates at an overall LOS A / B / B during the AM / Noon / PM peak periods, and the northbound left turn movement operates at LOS C during all peak periods. In 2008, the same northbound levels of service were calculated. In 2023, the northbound approach under stop control operates at an overall LOS B during all peak periods, and the northbound left turn movement operates at LOS F during all peak periods.

At this intersection, the north leg currently serves minimal traffic from the gas station on the corner of South Billings Blvd / King Avenue. If the undeveloped land west of this gas station develops, southbound traffic could significantly increase. This could increase the potential need for a traffic signal at this intersection. Southgate Drive is about 450 feet from South Billings Boulevard.

At South Billings Boulevard / King Avenue, the overall signalized intersection currently operates at LOS B during all peak periods. Some eastbound movements currently operate at LOS D-E. There are similar LOS results in 2008, with the overall signalized intersection continuing to operate at LOS B during all peak periods. In 2023, the overall intersection will operate at LOS C / C / E during the AM / Noon / PM peak periods.

At South Billings Boulevard / I-90 WB ramps, the overall signalized intersection currently operates at LOS B / A / B during the AM / Noon / PM peak periods. In 2008, the overall signalized intersection will operate at LOS B during all peak periods. In 2023, the overall intersection will operate at LOS B / B / C during the AM / Noon / PM peak periods. Westbound ramp movements operate at LOS D-F during all peak periods.

At South Billings Boulevard / I-90 EB ramps, the overall signalized intersection currently operates at LOS A / B / B during the AM / Noon / PM peak periods. In 2008, the overall signalized intersection will operate at LOS B during all peak periods. In 2023, the overall intersection will operate at LOS D / D / E during the AM / Noon / PM peak periods.

At South Billings Boulevard / South Frontage Road, a traffic signal is planned with the opening of the City of Billings Operations Center. The unsignalized “T” intersection currently operates at LOS A during all peak periods. In 2008 after the Midland Boulevard connection is open, the overall signalized intersection will operate at LOS B during all peak periods. In 2023, the overall intersection will operate at LOS F / E / F during the AM / Noon / PM peak periods.

The following intersection capacity deficiencies have been identified within the South Billings Boulevard interchange study area:

- Inadequate capacity at King Avenue / Southgate Drive for side street left and thru movements under stop control [long term]
- Monitor need for traffic signal as adjacent development occurs at King Avenue / Southgate Drive [long term]
- Inadequate capacity at South Billings Boulevard / King Avenue [long term]
- Potential inadequate capacity at South Billings Boulevard / I-90 westbound ramps [long term]
- Inadequate capacity at South Billings Boulevard / I-90 eastbound ramps [long term]
- Inadequate capacity at South Billings Boulevard / South Frontage Road – Midland Road [long term]

Ramp Capacity

Table 6 summarizes the HCM-2000 LOS analyses for I-90 ramp merge / diverge operation with estimated 2023 traffic forecasts. All ramps will merge and diverge at HCM-2000 LOS A or B under the 2023 scenario.

The South Billings Boulevard interchange on-ramps will have moderate volumes by the year 2023. Based on project 2023 forecasts, the westbound and eastbound on-ramps will have up to 590 vph and 512 vph in the westbound and eastbound directions respectively. About 60 percent of these year 2023 westbound on-ramp volumes will be left turns from South Billings Boulevard; a double left turn lane may need to be considered as over 300 left turns are projected during

each peak period. At the eastbound on-ramp, the highest left turn volume onto the eastbound on-ramp is projected to be 260 vph in 2023, so a double left turn lane will probably not be needed.

The westbound on-ramp was identified as having a potential ramp merge deficiency related to a signalized double left turn lane.

The following *ramp capacity* deficiencies have been identified within the South Billings Boulevard interchange study area:

- Potential platoon deficiency due to signalized double left turn at South Billings Boulevard / I-90 westbound ramps [long term]

D. South Billings Blvd. Interchange Safety

- No deficiencies identified

There have been 93 crashes within the study period, of which 59 are rear end crashes. The majority of the rear end accidents are at the ramp terminals. Both ramp terminal intersections are signalized. Rear end accidents are typical at traffic signals. The analysis of the interchange yielded no identifiable deficiencies due to sight distance or geometric deficiencies (lack of proper taper lengths, ramp lengths, etc) at these ramps. The capacity analysis for existing (2003) conditions showed that these ramp terminal intersections operate at a good LOS (B's and one C), so traffic congestion does not seem to be a problem.

This type of accident pattern (rear end collisions at a signalized intersection) is most often due to congestion at a signalized intersection, or some sight distance or related geometric deficiency problem. With those conditions not appearing to be causal at the interchange ramp terminals, a more detailed accident analysis, including a review of the individual traffic reports (which is beyond the scope of this project) is suggested to determine whether other causal factors are at play.



Detached sidewalk along south side of King Ave east of South Billings Blvd.

E. South Billings Blvd. Interchange Bicycle and Pedestrian Facilities

The South Billings Boulevard interchange currently has a marked, attached path located on the paved shoulder along the east side of South Billings Road through the interchange. The path is separated by a concrete divider and railing over the I-90 bridge structure. The width of this path is variable, but narrows to a few feet at each end of the bridge structure where the guardrail protrudes into it. This marked path extends from the South Frontage Road to King Avenue where it connects to the existing sidewalk network. Crosswalk markings are present along this path at intersections with both ramp terminals and at

South Frontage Road. Pedestrian push buttons / signal indications exist at both ramp terminal intersections. Attached sidewalks (variable width) exist along King Avenue to the west of South Billings Boulevard, and a detached sidewalk extends east along the south side. Signal indications exist on the east legs of the ramp intersections. All four legs of the South Billings / King Avenue intersection have crosswalks and pedestrian push buttons / signal indications.



Push button (left side of pole out of view) inaccessible on SW corner of S Billings / King

The BikeNet plan identifies South Billings Boulevard as an Arterial District Connector, and South Frontage Road and King Avenue as a Primary District Connectors through the study area. A Secondary District Connector (off-street path) is shown on the south side of King Avenue. This would connect to the existing path which currently only exists for roughly 300' to the east of South Billings Boulevard. In addition, there is currently a project being planned to improve South Billings Boulevard north of King Avenue that will upgrade the pedestrian facilities north of the study area. Adequate width and shoulders exist on each of these roadways to meet BikeNet standards for District Connectors.



Marked path along NB shoulder of S. Billings Blvd.

South Billings Interchange Bicycle and Pedestrian Deficiencies

- Pedestrian push button on southwest corner of South Billings Boulevard / King Avenue intersection (for the south leg crossing) is not adequately accessible [existing]
- Inadequate width where guard rail causes narrowing of marked path (pedestrian / bicycle) along northbound South Billings Boulevard on I-90 bridge [existing]
- Lack of sidewalks along South Billings Boulevard with the exception of the I-90 bridge [short term with development]
- No other bicycle deficiencies identified

F. South Billings Blvd. Interchange Street and Highway Lighting

South Billings Boulevard Interchange Lighting Deficiencies

- Crossroad and ramp lighting does not meet CIL standards [existing]
- I-90 mainline highway lighting does not meet CIL standards [existing]

3.3 27th STREET INTERCHANGE

A. 27th Street Interchange Geometric Elements

This interchange was built in the early 1960s. 27th Street is a designated NHS (National Highway System) route from I-90 to the

Billings airport and beyond, and is the major north/south roadway through downtown Billings. There are industrial uses along State Avenue (sugar refinery) and Belnap Drive. Garden Avenue serves residential neighborhoods and two campgrounds.

Intersection configurations

State Avenue and Belnap Avenue approaches have about a 35 degree skew relative to 27th Street. 12th Street is one-way southbound and acts as a local bypass to partially relieve the southbound 27th Street to westbound State Avenue acute right turn movement.

Relative to 27th Street, the I-90 westbound on ramp has about a 12 degree skew angle and the I-90 eastbound on-ramp has about a 15 degree skew angle.

Lane widths / taper lengths

Figure C-3 (Appendix C) shows lane widths, taper lengths, and shoulder widths. All thru and auxiliary lanes have minimum 12' width except at the 27th Street / State Avenue intersection, where 27th Street and State Avenue have some lane widths less than 12' wide.

Taper lengths in the study area meet MDT standards except for the 80' northbound left turn taper on 27th Street at State Avenue, which is only slightly less than the recommended 8:1 taper ratio (approximately 96' recommended length).

All rural sections along 27th Street and the ramps have adequate paved shoulder widths. Garden Avenue has 26' to 28' cross section, which is adequate to serve the relatively low traffic volumes.

Truck turns

Figure D-3 (Appendix D) illustrates truck turn movements at study area intersections along 27th Street. There are left and right turn constraints and opposing left turn overlaps at the 27th Street / State Avenue – Belnap Avenue intersection.

There was guardrail damage at several locations on the eastbound on-ramp near 27th Street, likely caused by truck traffic. Our truck turn figures show that WB-20 trucks can barely make the turning maneuvers onto the eastbound and WB on-ramps without hitting the guardrails. These ramp truck turns were identified as deficiencies.

Trucks can more easily make turns at 27th Street / Garden Avenue.

Intersection sight distance

There are some intersection sight distance limitations for both I-90 ramp intersections due to the jersey barrier and railing that protect



Narrow EB I-90 on-ramp at 27th Street



Guardrail damage along EB I-90 on-ramp at 27th Street



I-90 EB off-ramp @
27th St. Interchange
sight limitations



I-90 WB off-ramp @
27th St. Interchange
sight limitations

pedestrians along the sidewalks on the bridge structure. The jersey barrier blocks visibility, and the railing partially blocks visibility. These sight distance issues apply to passenger vehicles, as the driver in single unit and larger trucks sit high enough to see over these jersey barrier / railing obstructions. **Figure E-1** in Appendix E shows the available and suggested intersection sight distance for minor street approaches on 27th Street. This suggested ISD is calculated as 415' for passenger cars making a left turn across two travel lanes at 35 mph posted speed limit. As shown, the jersey barrier / railing limits visibility within the ISD, but the railing does not completely block sight distance for passenger cars. Field observations confirm that passenger cars have some difficulty seeing over / around these jersey barriers, as one car on the eastbound ramp pulled out in front of us at night and cars on these ramps regularly pull up close to the travel way to improve visibility. Both of these approaches have been identified as having sight distance deficiencies. However, an analysis of the three year accident history (as discussed later in this report) did not identify accident trends related to the poor sight distance at these intersections.

No other sight distance deficiencies were identified.

Vertical clearance

There are no vertical clearance issues.

Access Management

27th Street has no private access points between State Avenue and Garden Avenue. Garden Avenue only has private residential driveways.

There are several access points near the 27th Street / State Avenue intersection. A raised median restricts left turns at entrances along 27th Street north of State Avenue. There are right-in / right-out entrances about 220' to 240' north of State Avenue on both sides of 27th Street.

Erie Drive is about 150' east of 27th Street on the north side of Belknap Avenue. However, Belknap Avenue only serves an auto parts distribution center and a few other small traffic uses and has very low volumes.

There are several full movement entrances on both sides of State Avenue, with the closest being a gas station entrance on the north side about 230 feet west of 27th Street. The State Avenue / Sugar Avenue - 12th Avenue S intersection is about 640' west of 27th Street.

The only existing access management deficiency identified near this intersection are the number of full movement entrances on State Avenue west of 27th Street, and the proximity of those entrances closest to 27th Street.

27th Street Interchange Geometric Deficiencies

- Skewed intersection at 27th Street / State Avenue – Belknap Avenue [Existing]
- Truck turn movements at 27th Street / State Avenue – Belknap Avenue [Existing]
- Truck turn movements at 27th Street / I-90 westbound on-ramp [Existing]
- Truck turn movements at 27th Street / I-90 eastbound on-ramp [Existing]
- Intersection sight distance for I-90 eastbound off-ramp at 27th Street [Existing]
- Intersection sight distance for I-90 WB off-ramp at 27th Street [Existing]
- Access management deficiencies on State Avenue west of 27th Street [Short Term]

B. 27th Street Interchange Traffic Control

Signs and Pavement Markings

Figure F-3 (Appendix F) illustrates existing traffic control signs and pavement markings.

Following are sign and pavement marking deficiencies within this interchange study area:

- There are no advance I-90 guide signs in either direction on the 27th Street bridge structure between the ramps [existing]
- 27th Street has no posted speed limit northbound (or westbound) through the interchange area [existing]
- There are no intersection lane control signs on mast arm for eastbound State Avenue approach at 27th Street [existing]
- There is no guardrail object marker on southbound 27th Street north of westbound ramp intersection [existing]
- There are no signs or pavement markings showing transition from two lanes to one lane on southbound 27th Street immediately south of the I-90 eastbound ramp intersection; [existing]