Report

I-5 Existing Geometric Deficiency Analysis

Prepared for

Oregon Department of Transportation

Washington State Department of Transportation

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Prepared by

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Executive Summary

This Technical Report on existing geometric deficiencies for Interstate 5 (I-5) covers the Bridge Influence Area of the Columbia River Crossing project. The Bridge Influence Area is a five mile section of I-5, which extends from the Columbia Boulevard Interchange in Portland to the SR-500/E. 39th Street Interchange in Vancouver. The purpose of this study is to identify geometric deficiencies, but not to review the impacts of the deficiencies on traffic operations or safety. This report is for information only and does not make any recommendations to correct any of the deficiencies.

Eleven features were studied as part of this analysis, and the findings for each are summarized in the bullet points below:

1. Adequacy of Horizontal and Vertical Sight Distance for the Given Design Speed

- There are three vertical curves on or near the I-5 bridge that are substandard lengths

2. Insufficient superelevation on ramps, connectors, and main line freeway

- There is one horizontal curve on the mainline just north of the I-5 bridge that has a substandard superelevation rate

3. Available shoulder and lane widths for emergency access/incident response

- Many shoulders on the Oregon side of the river are substandard widths
- Only the I-5 bridge in Washington has substandard shoulders

4. Weaving lengths of collector-distributor/auxiliary lanes

- There are three weaving sections in Oregon and two in Washington with lengths less than 2000 feet. Weaving traffic counts were not available to determine the level of service for the weaving sections.

  Southbound I-5 from the Marine Drive onramp to the Denver Ave/Victory Blvd offramp

  Northbound I-5 from the Marine Drive onramp to the Hayden Island offramp

  Southbound I-5 from the Hayden Island onramp to the Marine Drive offramp

  Southbound I-5 from the SR-500 onramp to the Fourth Plain Blvd offramp

  Southbound I-5 from the Mill Plain Blvd onramp to the SR-14 offramp

- Five turning roadways on connecting ramps were substandard lengths in Washington
  - I-5 northbound from the SR-14 offramp to the 6th St/City Center offramp
  - E. 39th Street connector to SR-500
  - I-5 northbound offramp to Mill Plain Blvd to Fourth Plain Blvd connector

- SR-14 loop ramp to I-5 southbound where it merges with the 5th Street onramp
- I-5 northbound offramp to SR-500 to the E. 39th Street connector ramp

5. Acceleration/deceleration lane lengths

- Seven speed change lanes in Oregon and five in Washington are substandard length

  I-5 southbound Victory Blvd onramp

  I-5 southbound Marine Drive offramp

  I-5 northbound Marine Drive onramp

  I-5 northbound Hayden Island offramp

  I-5 northbound Hayden Island onramp

  I-5 southbound Hayden Island onramp

  I-5 southbound Hayden Island offramp

  I-5 northbound to SR-14 offramp

  I-5 northbound to 6th Street/City Center offramp

  SR-14 westbound to I-5 southbound loop ramp

  I-5 southbound to Mill Plain Blvd offramp (ramp grade greater than maximum allowable)

  I-5 southbound Fourth Plain Blvd onramp

6. Adequacy of guardrail, barriers, and crash cushions

- No needs identified in this study

7. Susceptibility to wrong-way moves

- The on and offramp connections to I-5 southbound from Fourth Plain Blvd present movements confusing to drivers that may lead to wrong-way movements

8. Deficient vertical clearances (under 17 feet)

- There were no vertical clearance issues found in this study

9. Pavement condition for rutting or abrupt edges

- Minor rutting exists on the Portland Cement Concrete sections of I-5 on the Oregon side of the river

10. Sufficient maintenance vehicle pull-out locations

- Discussions with WSDOT and ODOT maintenance personnel did not reveal the need for any additional pull-out locations for maintenance vehicles

11. Bicycle and pedestrian pathways for current ADA standards, bridge railing heights, exposure to traffic, tripping hazards, fixed objects in path, etc.

- A field trip along the bicycle and pedestrian pathways from Victory Blvd to 6th Street in Vancouver revealed many deficiencies detailed by photos in Appendix A. Some deficiencies found were as follows:

  Connectivity headed northbound from Victory Blvd through Delta Park is blocked by a raised median near the 76 gasoline station

  Pathway widths on the I-5 bridge are 3 to 5 feet

  Hand railings on the I-5 bridge are lower than OSHA standards

  Connectivity at Hayden Island is poor since the pathway crosses three streets and cyclists are forced to dismount and walk in the crosswalk

  Concrete barriers at bridge heads need fencing to protect pedestrians and cyclists from falling into I-5 traffic

  Large gaps in chain link fencing leave opportunity for pedestrians to cross the on and off ramps from I-5 northbound at Hayden Island

  Directional sign mounted in the path of bikes and pedestrians near the Hayden Island offramp from I-5 northbound

SECTION 1

Objective

The purpose of this study was to identify existing geometric deficiencies along the Interstate 5 mainline and interchange ramps from the N. Lombard Street Interchange in Portland to the State Route-500/E. 39th Street (Burnt Bridge Creek) Interchange in Vancouver. The deficiencies represent significant safety hazards for this section of I-5, which carries around 125,000 vehicles per day to and from Portland and Vancouver. This list was compiled as part of the environmental review process for the Columbia River Crossing Project and serves to inform the project owners of the existing freeway conditions. This review does not include an economic analysis of what it would cost to upgrade the freeway and its interchange components to today’s engineering standards, nor does it recommend that any of these deficiencies be fixed. This report is purely for information only and does not represent a comprehensive engineering analysis of the impacts that the deficiencies make on day to day traffic operations or safety.

SECTION 2

Introduction and Background

As part of the existing geometric deficiencies inventory for the Columbia River Crossing Project, data was collected for the I-5 mainline and all connecting ramps using the following sources of information:

Washington State Department of Transportation (WSDOT)

- Video log of I-5 between the Washington/Oregon State Line (MP 0.00) and the Main Street/Hwy 99 Interchange (MP 2.91)
- TRIPS System State Highway Log for I-5 from MP 0.00 to MP 2.91
- Interchange Viewer sheets from WSDOT website (link accessed 11/10/05): http://www.wsdot.wa.gov/mapsdata/tdo/interchange/
- As-constructed plans of the SR 14 Interchange project (Contract No. 2156) dated July 31, 1981
- As-constructed plans of the Mill Plain Interchange project (Contract No. 1193) dated May 12, 1978
- As-constructed plans of the Fourth Plain Interchange project (Contract No. 1978) dated October 3, 1980
- As-constructed plans of the Fourth Plain to Burnt Bridge Creek Interchange project (Contract No. 0694) March 4, 1977
- WSDOT Design Manual (English version with 2005 updates and supplements), Chapters 6, 9, and 10 (link accessed 11/10/05): http://www.wsdot.wa.gov/fasc/EngineeringPublications/Manuals/DesignManual.pdf

Oregon Department of Transportation (ODOT)

- Video log of I-5 between the Lombard Street Interchange (MP 305.22) and the Oregon/Washington State Line (MP 308.38)
- Straightline Chart (Highway Log) and Interchange Diagrams from ODOT website (link accessed 11/10/05): ftp://ftp.odot.state.or.us/tdb/trandata/maps/slchart/
- As-constructed plans of the Swift Interchange – Delta Park Interchange Section project (“V” No. 22V-89) dated October, 1992
- As-constructed plans of the North Unit Minnesota Freeway Section project (“V” No. 8V-56) dated February 3, 1966
- As-constructed plans of the Jantzen Beach Interchange project (“V” No. 10V-83) dated November 1, 1974
- As-constructed plans of the Minnesota Freeway Section project (“V” No. 7V-247) dated April 29, 1966
- ODOT Standard Drawings RD205 and RD210 (links accessed 11/10/05): http://www.oregon.gov/ODOT/HWY/ENGSERVICES/docs/dwgs/eng/erd205.pdf http://www.oregon.gov/ODOT/HWY/ENGSERVICES/docs/dwgs/eng/erd210.pdf

- ODOT Highway Design Manual (2003 English version), Chapters 5, 6, 9, and 11 (link accessed 11/10/05): http://egov.oregon.gov/ODOT/HWY/ENGSERVICES/hwy_manuals.shtml

The features listed in Table 2-1 were compared to the current standards as published by the Oregon and Washington Departments of Transportation and are presented in the analysis portion of this memo.

TABLE 2-1. GEOMETRIC FEATURES STUDIED

Geometric features evaluated in this study from Milepost (MP) 305.98 in Oregon to MP 2.42 in Washington

NUMBER	FEATURE
1	Adequacy of horizontal and vertical sight distance for the given design speed
2	Insufficient superelevation on ramps, connectors, and main line freeway
3	Available shoulder and lane widths for emergency access/incident response
4	Weaving lengths of collector-distributor/auxiliary lanes
5	Acceleration/deceleration lane lengths
6	Adequacy of guardrail, barriers, and crash cushions
7	Susceptibility to wrong-way moves
8	Deficient vertical clearances (under 17 feet)
9	Pavement condition for rutting or abrupt edges
10	Sufficient maintenance vehicle pull-out locations
11	Bicycle and pedestrian pathways for current ADA standards, bridge railing heights, exposure to traffic, tripping hazards, fixed objects in path, etc.

The features listed above represent the major components of an urban freeway that affect safety and traffic operations. Most of these features are governed by the design speed of the given highway. Oregon and Washington determine design speed in very different manners. In brief, Oregon takes the desired running speed on the highway during off-peak hours, but Washington designs urban freeways dependent on 10 mph greater than the posted speed limit. Due to the slight differences in standard-selecting policies, the two states have similar, but different criteria for what is considered “standard” in their respective jurisdictions. Also, Oregon and Washington horizontal alignments differ since Oregon chooses to use spiral transitions to connect the circular horizontal curves and Washington does not. The analysis section breaks each of the listed categories down and describes what resources and methods were used to obtain the results presented in each sub-section.

SECTION 3

Analysis

1. Adequacy of Horizontal and Vertical Sight Distance for the Given Design Speed

Horizontal and vertical stopping sight distance, or the distance one would take at a given design speed to avoid an object in the road, is one component of the project that governs the design of horizontal and vertical alignment. Crashes occur frequently in areas where long queues back up close to a short vertical or horizontal sight distance. The following tables outline the questionable horizontal and vertical curves in the corridor with those below standard in yellow.

TABLE 3-1. HORIZONTAL AND VERTICAL SIGHT DISTANCE EVALUATION FOR OREGON AND WASHINGTON

LOCATION (MILEPOST)	FEATURE DESCRIPTION	AS-BUILT EXISTING CURVE LENGTH (FT)	MIN. STAND-ARD LENGTH (FT)	MAIN-LINE DESIGN SPEED (MPH)	RAMP DESIGN SPEED (MPH)	SUPER-ELEVA-TION RATE (FT/FT)	CURVE RADIUS (FT)	SIGHT DIST. TYPE (VERT., HORIZ., OR STOPPING)
308.10 - 0.20	I-5 bridge crest vertical curve	531.4	3795.9	70	N/A	N/A	N/A	Vertical
0.34	Sag vertical curve	400	963.0	70	N/A	0.05	1890	Vertical
0.45	Sag vertical curve	400	532.8	70	N/A	0.05	3400	Vertical

2. Insufficient Superelevation on the Ramps, Connectors, and Mainline Highway

Superelevation governs the speed drivers can navigate horizontal curves at a given level of comfort. The following tables indicate where the superelevation is deficient for the given design speed.

TABLE 3-2. SUPERELEVATION DEFICIENCIES

LOCATION (STATION RANGE)	DIRECTION	FEATURE DESCRIPTION	LINE DESIGNATION	MAINLINE DESIGN SPEED (MPH)	CURVE RADIUS (FT)	CURVE SUPERELEVATION (FT/FT)	NOTES
102+80 to 105+37	Northbound	Mainline Horizontal Alignment	LR	60	1200	0.05	For a design speed of 60 mph and a radius of 1200 ft, a superelevation of 8% is required

3. Available Shoulder and Lane Widths for Emergency Access and/or Incident Response

Freeway shoulders provide space for vehicles to recover if they veer off the traveled way, a space for broken down vehicles to wait outside of the stream of traffic, and a pathway for emergency vehicle access/egress from a crash scene. The Highway Capacity Manual states that a lack of shoulder space actually inhibits the flow of traffic since drivers feel more comfortable driving at higher speeds if they have empty pavement beside them rather than guardrails, concrete barriers, or other fixed objects. Both ODOT and WSDOT require 10 to 12 foot outside shoulders and 10 foot inside shoulders for freeways with six lanes or more. The following tables outline where the shoulders are deficient along the corridor. It is clear that Oregon has many more locations with substandard shoulder widths. This hampers operations and safety of the highway and should be remedied if the highway were to be reconstructed.

TABLE 3-3. SHOULDER WIDTH DEFICIENCIES IN OREGON

LOCATION (MILEPOST RANGE)	DIR-EC-TION	FEATURE DESCRIPTION	EXISTING DIM (FT) TAKEN FROM ODOT VIDEO LOG (+/- 50 FT)	MINIMUM DIM (FT) (SEE CH. 9 ODOT HIGHWAY DESIGN MANUAL)	CONFIRMED WITH DIGITAL VIDEO LOG
305.22-305.78	both	Inside shoulder from Lombard Street to Columbia Blvd bridge	2	10	Yes
305.69-305.84	NB	Outside shoulder taper	0.5-10	10-12	Yes
305.69-305.84	NB	Inside shoulder taper	0.5-2	10	Yes
305.84-306.04	NB	Inside shoulder	0.5	10	Yes
306.04-306.09	NB	Outside shoulder	0.5-6	10-12	Yes
306.10-306.53	NB	Inside and outside shoulders	0.5-4	10-12	Yes
306.54-306.59	NB	Inside shoulder	0.5	10	Yes
306.59-307.45	NB	Inside shoulder	0.5-6	10	Yes
307.03-307.29	NB	Outside shoulder	1-4	10-12	Yes
307.69-308.38	NB	Inside shoulder	0.5-9.5	10	Yes
307.90-308.38	NB	Outside shoulder	0.5-2	10-12	Yes
307.86-308.38	SB	Inside and outside shoulders	0.5-9.5	10-12	Yes
307.31-307.74	SB	Inside and outside shoulders	0.5-6	10-12	Yes
305.22-307.31	SB	Inside shoulder	0.5-6	10	Yes
305.82-306.65	SB	Outside shoulder	0.5-9.5	10-12	Yes
305.22-305.47	SB	Outside shoulder	1-4	10-12	Yes

TABLE 3-4. SHOULDER WIDTH DEFICIENCIES IN WASHINGTON

LOCATION (MILEPOST RANGE)	DIR-EC-TION	FEATURE DESCRIPTION	EXISTING DIM (FT) TAKEN FROM ODOT VIDEO LOG (+/- 50 FT)	MINIMUM DIM (FT) (SEE CH. 9 ODOT HIGHWAY DESIGN MANUAL)	CONFIRMED WITH DIGITAL VIDEO LOG
0.00-0.38	both	Inside and outside shoulders	0.5-6	10-12	Yes

4. Weaving Lengths of Collector-Distributor and Auxiliary Lanes

Areas of a freeway where cars change lanes often in order to access connector ramps or auxiliary lanes need to be long enough for a given level of service (LOS) in order for the lanes to operate efficiently and safely. Weaving areas shall be evaluated for length deficiency when the projected traffic volumes are available from the Vissum Model. Without these projected numbers, it is impossible to know if the weaving areas are too short for a given LOS. However, Tables 3-5 and 3-6 list the weaving sections that are shorter than the required 2000 ft minimum in both states for a freeway to freeway connection.

TABLE 3-5. WEAVING LENGTH DEFICIENCIES OF AUXILIARY (AUX) LANES IN OREGON
(see Fig. 9-28 of the ODOT Highway Design Manual)

LOCATION (MILEPOST RANGE)	DIR-EC-TION	FEATURE DESCRIPTION	EXISTING DIM (FT) TAKEN FROM ODOT VIDEO LOG (+/- 50 FT)	EXISTING DIM (FT) TAKEN FROM 7/2005 MICROSTATION BASE-MAPS & AS-BUILTS	MINIMUM DIM (FT) (SEE CH. 9 ODOT HIGHWAY DESIGN MANUAL)	RAMP DESIGN SPEED (MPH)
307.06-306.90	SB	Marine Drive onramp terminal point to Victory Blvd/Denver Ave offramp terminal point	1214.4	1245	2000	55
307.45-307.77	NB	Marine Drive onramp terminal point to Hayden Island offramp terminal point	2059.2	1820.3	2000	50
307.68-307.36	SB	Hayden Island onramp terminal point to Marine Dr offramp terminal point	2059.2	1855.3	2000	50

TABLE 3-6. WEAVING LENGTH DEFICIENCIES OF AUX LANES IN WASHINGTON
(see Fig. 940-5 and 940-15 of the WSDOT Design Manual)

LOCATION (MILEPOST RANGE)	DIR-EC-TION	FEATURE DESCRIPTION	SPEED CHANGE LANE TYPE	AS-BUILT EXISTING DEMENSION (FT)	MINIMUM DIM (FT) (SEE CH. 940 WSDOT DESIGN MANUAL)
0.36-0.48	NB	005 P1 00028 offramp to 005 P5 00039 loop offramp	Off to off Free-way	633.6	1000
2.08-1.72	SB	005 S1 00198 onramp to 005 R1 00182 offramp	On to off (weaving)	1900.8	2000
0.94-0.70	SB	005 S1 00087 onramp to 005 R1 00079 offramp	On to off (weaving)	1267.2	2000
0.18-0.28	N/A	005 S1 00198 onramp to SR500 connector	System I/C turning rdwy	528	800
0.16-0.17	N/A	005 P1 00078 to 005 P2 00078 C/D road	System I/C turning rdwy	52.8	600
0.00-0.10	N/A	005 S5 00029 connector to 005 S6 00029 connector	System I/C turning rdwy	528	800
0.19-0.26	N/A	005 P1 00199 offramp to SR500 connector	System I/C turning rdwy	369.6	800

5. Speed Change (Acceleration/Deceleration) Lane Lengths

One of the most critical aspects of a freeway interchange ramp is the length of the speed change lane. This could be the distance for cars and trucks to accelerate onto the freeway or decelerate onto an offramp. Considerable time was spent on this one aspect of the deficiency list since so many factors are involved when determining the standard length. If this lane is too short for heavy traffic volumes typical in an urban area, traffic operations are likely to deteriorate and crashes could result from a lack of merge length. This is particularly true when high truck volumes are present. This corridor has a large percentage of trucks (8%), thus making the case for keeping to “desirable” level standards instead of “minimum” levels.

Oregon

The lengths of each existing speed change lane in Oregon were determined using the ODOT Standard Drawings RD205 and RD210. The entrance ramp adjusted acceleration lane lengths are determined using the existing degree of curve to find the turning highway design speed. A uniform value of 70 mph was used as the design speed for the mainline freeway to be conservative in the speed change lane lengths. An adjustment for grades was made where the ramp grade exceeded three percent. The exit ramp deceleration lane lengths were also adjusted for grade and for trucks where there are typically more than twenty per hour. The Lombard Street and Columbia Boulevard interchange ramp dimensions were taken from the as-constructed plans. The minimum dimensions for acceleration lanes listed in Table 3-7 below do not include the required 300 ft taper as shown on RD205. MicroStation was used to verify the as-constructed plan dimensions for all ramps. The maximum grade was checked against the maximum allowable grade for each state (5% for Oregon and 7% for Washington) and reported as well. The video logs were used to confirm lane drop and taper locations for the mainline freeway. The ramps are not available via video log, so a field trip confirmed questions regarding the ramps.

Washington

When determining the length of each existing speed change lane in Washington, ramp design speed was determined by the superelevation and horizontal curve radius. The mainline design speed was taken to be ten miles per hour greater than the posted speed, per the WSDOT Design Manual. Also, the standard lengths are corrected for grades greater than three percent. The posted speed from the Columbia River to approximately MP 0.75 is currently 50 mph. Outside of this area, the posted speed is 60 mph. Therefore, design speeds of 60 and 70 mph were used for the respective mainline freeway sections. Table 3-8 shows the results of the analysis. Four ramp locations were found to be deficient in the length of the speed change lane. Two of these are deceleration lanes at SR-14 and I-5 Northbound. One is the acceleration lane from SR-14 to I-5 Southbound. The last is an acceleration lane from Fourth Plain Blvd to I-5 Southbound. All other lanes appear to have sufficient length.

TABLE 3.7. SPEED CHANGE LANE DEFICIENCIES IN OREGON
(Acceleration and Deceleration Lane Length Deficiencies Shaded Gray)

LOCATION (MILEPOST RANGE)	DIR-EC-TION	FEATURE DESCRIPTION	EXISTING DIM (FT) TAKEN FROM ODOT VIDEO LOG (+/- 50 FT)	MINIMUM DIM (FT) (SEE CH. 9 ODOT HIGHWAY DESIGN MANUAL)	RAMP DESIGN SPEED (MPH)	CONFIRM-ED WITH DIGITAL VIDEO LOG
305.22	NB	Lombard St offramp heading EB	N/A			Yes
305.41	NB	Lombard St offramp heading WB	N/A			Yes
305.23	SB	Lombard St onramp from WB	N/A			Yes
305.4	SB	Lombard St onramp from EB	N/A			Yes
305.98	NB	Columbia Blvd offramp	N/A			Yes
305.93	SB	Columbia Blvd onramp	N/A			Yes
306.45	NB	Victory Blvd offramp	695	471	60	Yes
306.51	SB	Victory Blvd onramp	437	580 (750 desired)	60	Yes
306.7	NB	Marine Drive offramp	2100	520	60	Yes
306.97	SB	Victory Blvd/Denver Ave offramp	1390	550	25	Yes
307.19	NB	Victory Blvd/Denver Ave onramp	2900	580 (750 desired)	60	Yes
307.14	SB	Marine Drive onramp	1350	580 (750 desired)	30	Yes
307.47	SB	Marine Drive offramp	637	1228.5	30	Yes
307.49	NB	Marine Drive onramp	367 (not incl. aux lane)	1420	30	Yes
307.77	NB	Hayden Island offramp	289	520	30	Yes
307.97	NB	Hayden Island onramp	211	2201	25	Yes
307.99	SB	Hayden Island offramp	447	660	25	Yes
307.76	SB	Hayden Island onramp	367 (not incl. aux lane)	1420	25	Yes

TABLE 3-8. SPEED CHANGE LANE LENGTHS IN WASHINGTON
(Acceleration and Deceleration Lane Length Deficiencies Shaded Gray)

DIR-EC-TION	FEATURE DESCRIPTION	AS-BUILT EXISTING DIM-ENSION (FT)	MICRO-STATION EXISTING DIMEN-SION (FT)	MIN. STD. DIM. (FT)	MAIN-LINE DESIGN SPEED (MPH)	RAMP DESIGN SPEED (MPH)	AVG GRADE OF SPD CHANGE LANE	RAMP MAX GRADE (%)	RAMP RADIUS (FT)	RAMP SUPER-ELEVA-TION (FT/FT)
NB	I-5 to SR-14 EB	N/A	170	430	60	30	-2.54	+4.3	340	0.08
NB	I-5 to 7th St/Downtown	N/A	385	460	60	25	+1.77	+5.93	210	0.06
NB	SR-14 WB to I-5	1203.48	900	420	60	45	-1.29	+6.34	625	0.08
SB	SR-14 WB to I-5	600	450	1020	60	25	-1.52	-2.02	200	0.06
SB	I-5 to SR-14 WB	1601.16	1680	420	60	40	-3.23	-4.54	600	0.08
NB	I-5 to Mill Plain Blvd	1530	1500	390	70	45	+2.76	+3.05	700	0.06
NB	Mill Plain to I-5	4811.88	4300	2600	70	40	+5.23	+6.47	600	0.06
SB	I-5 to Mill Plain Blvd	1029.64	1500	830.25	70	0	-5.59	**-8.39**	2000	0.04
SB	Mill Plain to I-5	1887.12	1700	1620	70	0	+0.38	+2.84	1500	0.05
NB	I-5 to Fourth Plain Blvd	3207.84	3700	351	70	45	+3.96	+5.19	600	0.04
NB	I-5 to Fourth Plain Blvd	489.63	525	346.5	45	0	-1.45	+3.96	0	0.04
NB	Fourth Plain Blvd to I-5	2884.33	2400	1620	70	0	+1.71	+5.00	3000	0.04
SB	I-5 to Fourth Plain Blvd	1661.71	1400	490	70	35	-2.60	-2.60	350	0.09
SB	Fourth Plain Blvd to I-5	1830.68	1250	1420	70	25	-2.18	-2.29	200	0.06
NB	I-5 to SR-500 EB/E 39th St	117.06	875	290	70	55	-0.36	-0.80	1000	0.08
NB	I-5 to SR-500 EB/E 39th St	657.96	800	576	55	0	-4.60	-4.60	3500	0.02
NB	E 39th St to I-5	764.88	1600	348	70	50	-4.36	-5.96	800	0.08
SB	I-5 to E 39th St	N/A	2400	513	70	20	+4.10	+5.94	150	0.06
SB	E 39th St/SR500 to I-5	2037.73	2050	1000	70	40	+2.92	-3.82	550	0.07

6. Adequacy of Guardrail, Barriers, and Crash Cushions

Guardrail, concrete barriers, and impact attenuators such as a sand barrel type crash cushions all serve to keep traffic from hitting fixed objects, steep slopes, or head-on traffic. This analysis did not reveal any drastic need for different treatments to the roadside or median, however, in a reconstruction project, an engineering analysis of each feature named above should be completed to reveal any necessary improvements.

7. Susceptibility to Wrong-way Moves

Interchange ramps that take unconventional shapes or paths may confuse drivers enough where they may travel the wrong way on such a facility. This extremely hazardous scenario can be avoided through standard design of interchange ramps and proper signing and delineation. The analysis in this study identified the ramps in the following table as susceptible to wrong way movements due to the listed reasons.

TABLE 3-9. LOCATIONS SUSCEPTIBLE TO WRONGT WAY MOVEMENTS

LOCATION (MILEPOST RANGE)	DIRECTION	FEATURE DESCRIPTION	NOTES
Ramps “005R100182” & “005S500154”	SB	Fourth Plain Blvd on and off-ramps	Unconventional configuration of channelization could confuse drivers

8. Deficient Vertical Clearances (Under 17 Feet)

The Federal Highway Administration (FHWA) currently requires 17 feet vertical clearance for all bridge structures crossing over a freeway. The profile sheets of the as-constructed plans were used to find the vertical clearances on the existing structures in the corridor. There were no vertical clearance deficiencies in the corridor of study.

9. Pavement Rutting, Abrupt Edges, and Flat Spots in Superelevation Transitions

Pavement rutting can cause serious safety issues when heavy rains fall and standing water collects in the wheel paths of cars and trucks. To avoid hydroplaning, freeway pavements need to drain quickly and efficiently. Edge drops at the inside edge of a horizontal curve (especially on connector ramps) are hazardous if drivers overcorrect the steering wheel when the front wheels drop off the pavement. This can cause the vehicle to swerve into adjacent lanes and possibly lose control. Flat spots that occur between superelevation transitions if poorly constructed can collect concentrated flows of water and pose a hazard to the traffic traveling through the water. The Portland Cement Concrete pavement surfaces on the Oregon side of the river have minor rutting problems, but no edges, flat spots, or rutting was observed elsewhere.

10. Sufficient Maintenance Vehicle Parking Locations

The safety of State Employees is of great concern to the sponsoring agencies of this study. Safe areas for maintenance vehicles to park preferably off of the existing shoulder provide refuge for these vehicles, plus protection to their operators. When speaking with maintenance superintendents in Oregon and Washington about the need for additional pull-out locations, they said that there is not a need at this time for additional pull-outs. Therefore, this analysis will not recommend the addition of any more pull-out spaces.

11. Bicycle and Pedestrian Pathways

A field trip via bicycle on the Oregon and Washington bicycle and pedestrian pathways was made to survey the existing conditions in early September, 2005. The photos in Appendix A show the deficiencies noted on the field trip. Standards in the ODOT Highway Design Manual (Chapter 11) and the WSDOT Design Manual (Section 1020) were not noted in this study. Most of the bicycle and pedestrian pathways were in Oregon since Washington does not currently have any multi-use paths on the I-5 right of way within the corridor of study. Photos of the field trip appear at the end of this memo in Appendix A. Some of the deficiencies noted in the photos are as follows:

Connectivity headed northbound from Victory Blvd through Delta Park is blocked by a raised median near the 76 gasoline station

Pathway widths on the I-5 bridge are 3 to 5 feet

Hand railings on the I-5 bridge are lower than OSHA standards

Connectivity at Hayden Island is poor since the pathway crosses three streets and cyclists are forced to dismount and walk in the crosswalk

Concrete barriers at bridge heads need fencing to protect pedestrians and cyclists from falling into I-5 traffic

Large gaps in chain link fencing leave opportunity for pedestrians to cross the on and off ramps from I-5 northbound at Hayden Island

Directional sign mounted in the path of bikes and pedestrians near the Hayden Island offramp from I-5 northbound