Washington State
Department of Transportation

I-90 DATA VAULT APPROVAL

Corridor Analysis

I-90 Snoqualmie Pass East

MP 55.1 to MP 70.3

The corridor analysis has been prepared under my direct supervision and in accordance with WSDOT policy.

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☒ Corridor Analysis Recommended ☐

George R. Helsinger
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Assistant State Design Engineer for South Central Region — 9-7-07 Date

☑ Corridor Analysis Approved

Federal Highway Administration – Area Engineer — 13 SEPT 2007 Date

Corridor Analysis
I-90 Snoqualmie Pass East
(MP 55.1 to MP 70.3)

Introduction

This corridor analysis is for the I-90 Snoqualmie Pass East project. The Project corridor is located in Kittitas County along a 15-mile stretch of I-90 that passes through the Wenatchee National Forest between the unincorporated communities of Hyak and Easton (see Figure 1). The corridor begins three miles east of Snoqualmie Pass Summit at the existing Coal Creek bridges near MP 55.1 and ends at the West Easton Interchange near MP 70.3. The corridor is located in a rural / forested area and the local topography is mountainous. The limits of the corridor were selected as part of the NEPA documentation process and were determined based on topography, operational and maintenance characteristics of the freeway, existing geometry, and problems to be addressed by the project.[1]

Interstate 90 has a roadway classification of Rural Interstate and the proposed work is classified as New/Reconstruction. Two Design Matrices will be used to determine the appropriate design level of the various design elements within the corridor. Line 12 of Design Matrix 1: Interstate Routes (Main Line), Figure 325-3, will be used for all mainline work. Line 12 of Design Matrix 2: Interstate Interchange Areas, Figure 325-4, will be used for ramps and crossroads within the corridor.

This analysis provides justification for design speed selection and maximum superelevation rate selection

Corridor Overview

As stated in the Draft Environmental Impact Statement, "The purpose of this project is to meet projected traffic demands, improve public safety, and meet identified needs along this 15-mile stretch of I-90."

Improvements will be made within the corridor to:

- **Reduce the risk of closures due to avalanches.** Corrective measures will be constructed to reduce the existing delays caused by avalanche impacts.

- **Increase capacity.** The corridor will be widened from an existing 4-lane facility to a 6-lane facility. This will improve mobility and allow for future growth.

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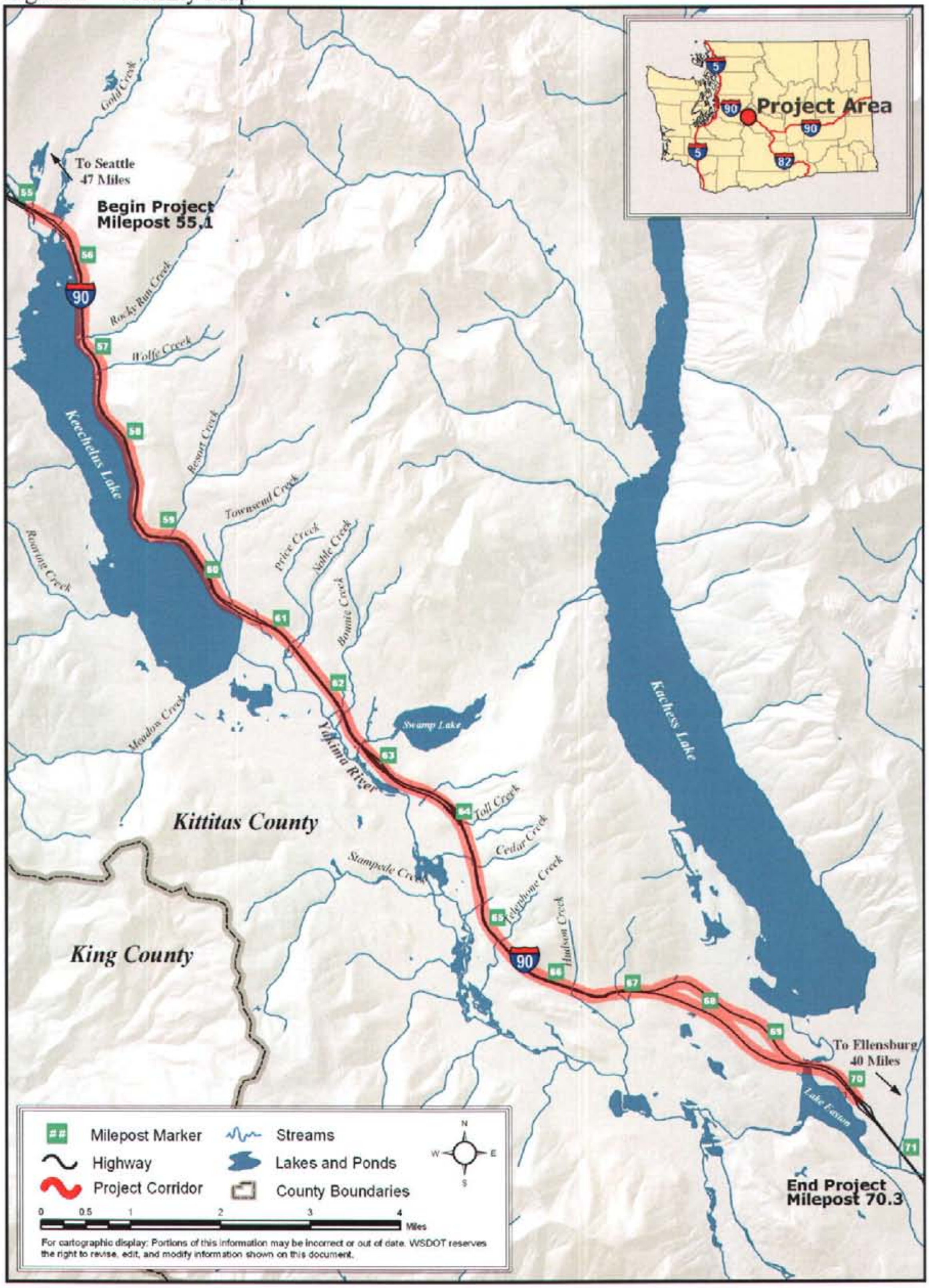
[1] Washington State Department of Transportation (WSDOT). 2005. I-90 Snoqualmie Pass East Draft Environmental Impact Statement.

Figure 1 – Vicinity Map



- **Stabilize slopes.** Rock fall protective measures will be constructed to reduce the risk of falling debris reaching the Interstate.

- **Improve safety.** In addition to the previously mentioned improvements, which also improve safety. The corridor will be enhanced with lengthened chain on and off areas, straightening of the existing alignment, replacing the existing deteriorating pavement, and the installation of advanced warning signs.

- **Connect habitats.** The corridor will be improved by providing new and enhancing current highway crossings to provide habitat connections within the corridor.

- **Replace deficient pavements.** The corridor will be replacing the existing roadway surface with a new Portland Concrete Cement Pavement (PCCP).

Improvements to the corridor will be made in phases. The first five mile segment of the corridor constitutes the first phase and design work is currently under way. This phase, titled "Hyak to Keechelus Dam", is a 2005 Transportation Partnership Fund project currently scheduled for advertisement during the winter of 2009. The project will construct a third traffic lane in each direction, new creek crossing bridges, expanded chain on/off areas, and wildlife crossings. Furthermore, geometric improvements will be made in the alignment, snow retention structures will be installed, several slopes will be stabilized, and new pavement will be placed. Subsequent phases (currently unfunded) will provide similar benefits in the remaining ten miles of the corridor.

Traffic Data

The corridor currently has an Annual Average Daily Traffic (AADT) of approximately 27,000 with 18% trucks. The truck percentage varies depending on day of the week and decreases on weekends, especially during the summer months when heavier recreational traffic is present. Based on field counts, weekend truck and RV percentages are 3% and 9% respectively.

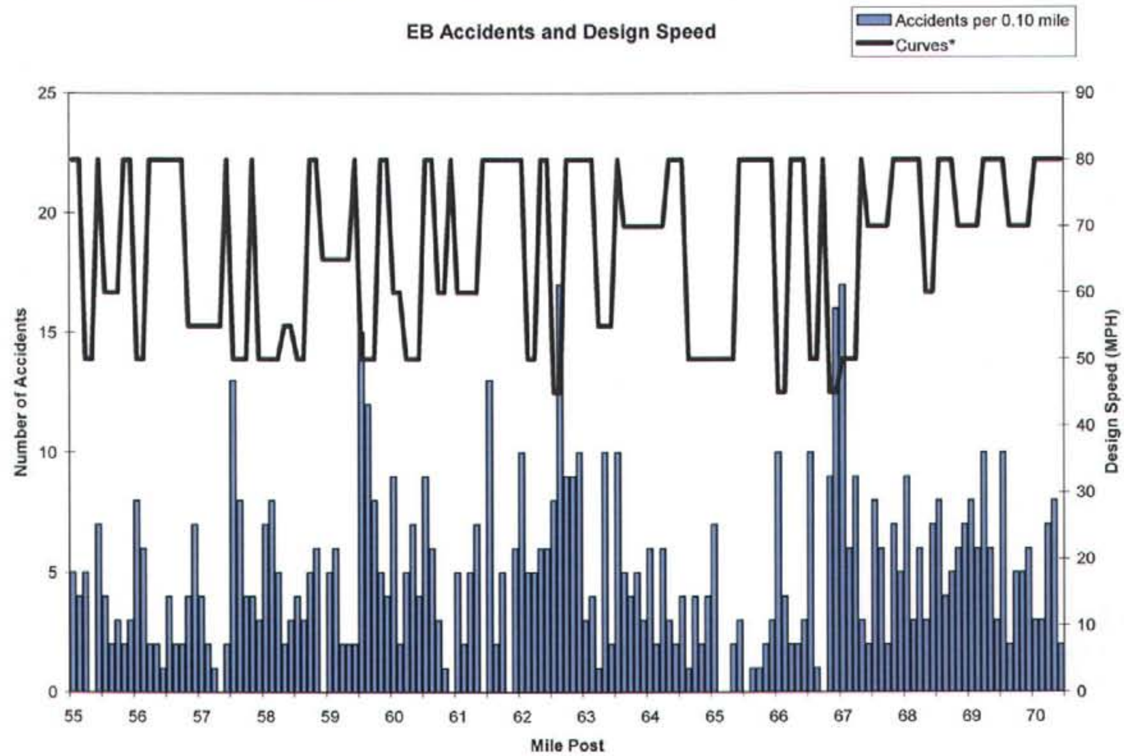
An analysis of past growth was used to determine a trend line for future growth at approximately 2.11%. Utilizing the 2.11% linear rate for growth, future traffic volumes are projected to be approximately 41,300 AADT in the phase 1 design year of 2030. The DDHV is projected at 3780 vehicles per hour.

Accident Analysis

The corridor had 72 accidents over a three year period (2003 to 2006). The majority of these accidents (51 or 70%) occurred during periods of poor roadway conditions (e.g. ice or snow). Of the 51 accidents that occurred during poor roadway conditions, 35 had "Exceeding Reasonable Safe Speed" listed as a contributing factor by the WSP (14 had no contributing factors, 1 was listed as inattention and 1 had 'Driving Under Influence of Alcohol').

In addition to the 3 year accident history, accidents from 1991 to present were also analyzed to determine if any accident trends could be recognized. In examining the extended accident history, there appears to be some correlation between geometry and accident rates. Figures 2 and 3 show the extended accident history through the corridor for WB and EB directions respectively. Accidents were plotted by number of accidents (left vertical axis of graph) per 0.10 mile section (x-axis) and compared to the calculated design speed of curves (right vertical axis of graph) represented by the solid dark line.

Figure 2 – Eastbound Accident Distribution (1991 to 2006)



* Tangents and curves with design speed > 80 mph are shown as 80 mph design speed segments

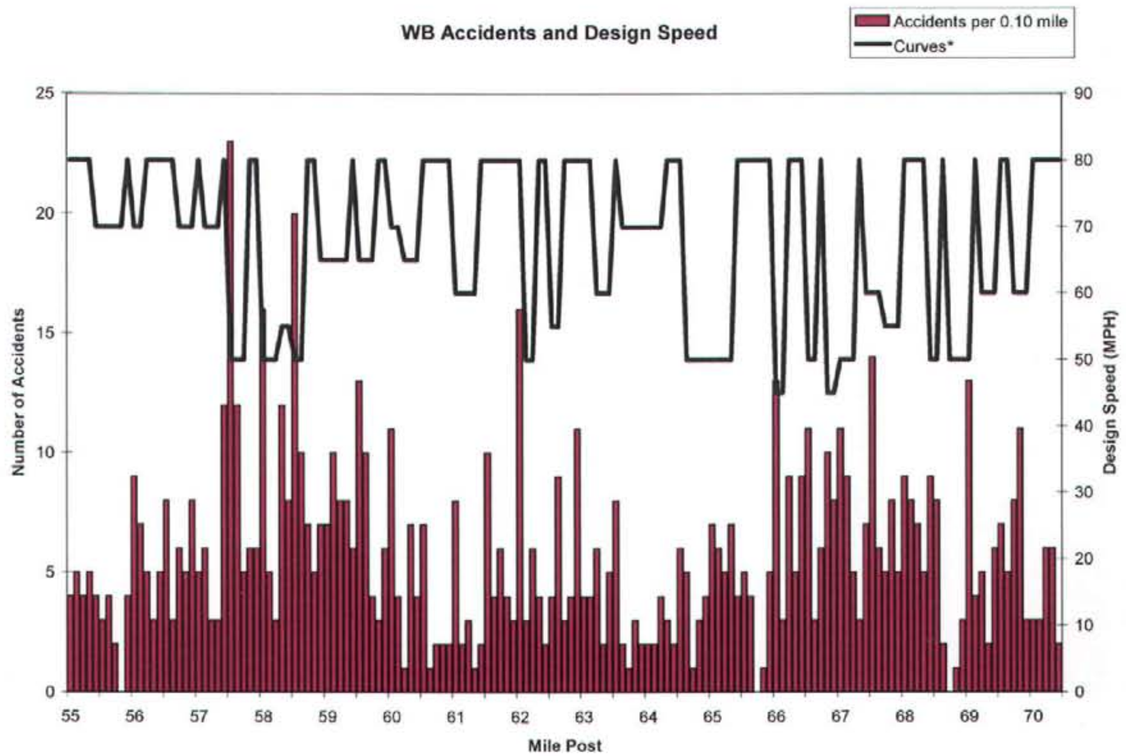
Accident locations are fairly evenly distributed throughout the corridor with accidents occurring at an average of 113 accidents per year (7.5 per year per mile). There are 3 general segments of the corridor where accidents occurred at a rate slightly above the corridor average. These 3 segments range from 1.5 to 4 miles in length and are listed below:

- Wolfe Creek to Resort Creek (MP 57.5 to 60.0): This segment is immediately adjacent to Keechelus Lake and is characterized by several reverse curves and limited sight distance.

- Bonnie Creek to Swamp Creek (MP 61.5 to 63.0): This segment is just west of the Stampede Pass interchange and has 2 lower speed reverse curves.

- Telephone Creek to Kachess River (MP 66.0 to 70.0): This relatively long segment is characterized by fairly steep grades (4-5%) coupled with a mix of low to higher speed horizontal curves.

Figure 3 – Westbound Accident Distribution (1991 to 2006)



* Tangents and curves with design speed > 80 mph are shown as 80 mph design speed segments

Figures 2 and 3 show some correlation between several lower design speed curves (60 mph and less) and the corresponding accident rates, as seen near mileposts 57.5, 58.0, 58.5, 62.0, and 66.0 in the westbound direction and near mileposts 57.5, 59.5, 62.5, and 67 for the eastbound. (It should be noted that these mileposts all are at even half mile increments indicating that the exact location of accidents might be rounded when WSP reports are filed.)

Even though there appears to be some correlation between curve design speed and accident rate, it is difficult to determine the extent that horizontal alignment may have contributed to the accidents as there are many variables to consider (e.g. weather and road conditions, visibility, traffic volume, driver behavior, etc.). Furthermore, not all curves with lower design speeds have a corresponding increase in accident rate, while some areas with higher accident rates have relative good geometry.

Design Speed Selection

WSDOT Design Manual Standard

Figure 440-4 refers to Interstate projects and recommends an 80 mph design speed for rural interstates.

Proposed Design Speed Standard

A 65 mph design speed will be used in the first section of the corridor (Coal Creek MP 55.1 to the Keechelus Lake Dam MP 60.1) due to terrain constraints. A design speed of 70 mph will be used for the remaining section of the corridor (Keechelus Lake Dam MP 60.1 to the end of the corridor MP 70.3) due to slightly more favorable terrain.

Existing Conditions

The project corridor is located on a mountain pass in restrictive terrain with the Keechelus Ridge and Amabilis Mountain to the north of the roadway and Keechelus Lake or the Yakima River to the south of the roadway.

There are six segments in the corridor (three in each direction) with differing speed controlling devices. Both variable message speed signs and posted speed limit signs exist within the 15 mile corridor.

- Eastbound, a variable speed limit controlled by a variable message sign exists between Coal Creek (MP 55.1) and Price Creek vicinity (MP 61.1). A posted speed limit of 65 mph for cars and 60 mph for trucks is in effect from Price Creek (MP 61.1) to the Kachess River Bridge (MP 69.5). A posted speed limit of 70 mph for cars and 60 mph for trucks controls speed between the Kachess River Bridge (MP 69.5) and the end of the corridor (MP 70.3).
- Westbound, a variable message sign controls speed between Coal Creek (MP 55.1) to the west Price Creek rest area (MP 61.0). A posted speed limit of 65 mph for cars and 60 mph for trucks exists from the Price Creek rest area vicinity (MP 61.0) to the Kachess River Bridge (MP 69.5). A posted speed limit of 70 mph for cars and 60 mph for trucks controls speed between the Kachess River Bridge (MP 69.5) and the end of the corridor (MP 70.3).

The highest posted speed on the variable speed limit signs is 65 mph for cars and 60 mph for trucks. During times of poor road conditions, the posted speed is reduced.

Speed studies were conducted in June and July of 2004 at four locations inside the project corridor. The weather and traffic conditions during the speed study were conductive to unimpaired operating speeds and the posted speed during this study was 65 mph. Speeds were measured for both directions of travel, the results are listed in Table 1.The results show that the 85th percentile speed, often referred to as the operating speed, exceeds the posted speed limit of 65 mph. The operating speed was also found to be higher than the calculated design speed of curves found at Slide Curve and on Easton Hill (see following discussion).

Table 1: Speed Study Results

Location	Posted Speed (mph)	85th Percentile Speed Eastbound (mph)	85th Percentile Speed Westbound (mph)
Gold Creek Vicinity (MP 56.1)	65	69.81	70.2
Slide Curve Vicinity (MP 58.8)	65	71.25	69.7
Price Creek Vicinity (MP 61.1)	65	70.81	68.2
Easton Hill (MP 67.9)	65	69.69	67.18

While the operating speed is fairly constant throughout the corridor, the design speed of existing curves is not, and in several locations does not meet current geometric design standards. The project team evaluated existing curves within the corridor to determine their corresponding design speeds. We broke up the analysis into two sections due to the natural terrain constraints. The first section (W. Summit Interchange MP 52.0 to the Lake Keechelus Dam MP 60.7) we analyzed 30 curves and calculated a minimum design speed for a curve to be 51 mph and a maximum of 79 mph.

The second section (the Lake Keechelus Dam MP 60.7 to the W. Easton Interchange MP 70.3) we analyzed 27 curves and calculated a minimum design speed of a curve at 49 mph and a maximum of 104 mph. Table 2 shows all the curves analyzed and their corresponding design speeds per Design Manual section 642.06, solving for V.

Table 2: Existing Curves

Direction & MP	Existing Radius	Existing Superelevation	Calculated Design Speed
LE 52.01	1100’	8%	51 mph
LW 51.86	2000’	8%	69 mph
LW 52.63	1910’	7%	65 mph
LW 53.19	1900’	7%	65 mph

LW 53.53	1200’	9%	55 mph
LW 53.88	1400’	8%	58 mph
LW 54.22	1100’	10%	54 mph
LW 54.50	1432.5’	8%	59 mph
LW 54.74	1432.5’	8%	59 mph
LW 55.17	2292’	7%	72 mph
LE 55.28	3820’	3%	79 mph
LW 55.57	2800’	7%	79 mph
LE 55.66	1637.1’	7%	61 mph
LE 56.09	2865’	4%	72 mph
LW 56.08	3000’	6%	79 mph
LW 56.82	2000’	8%	69 mph
LE 56.86	1146’	8%	52 mph
LE 57.16	1790.6’	6%	61 mph
LW 57.19	2000’	8%	69 mph
L 57.65	1432.5’	6%	55 mph
L 58.09	2046.4’	5%	63 mph
L 58.35	2292’	5%	67 mph
L 58.57	1432.5’	6%	55 mph
L 59.21	1500’	10%	64 mph
LE 59.50	1433’	6%	55 mph
LW 59.50	1500’	10%	64 mph
LE 60.10	2865’	6%	77 mph
LW 60.10	3000’	6%	79 mph
LE 60.40	1433’	6%	55 mph
LW 60.40	1500’	10%	64 mph
Section 2			
LE 60.80	2865’	6%	77 mph
LW 62.30	2865’	4%	72 mph
LE 62.24	2865’	4%	72 mph
LW 62.60	2000’	6%	65 mph
LE 62.58	1146’	6%	49 mph
LW 63.30	2300’	7%	72 mph
LE 63.40	1910’	6%	63 mph
LW 63.60	3870’	5%	87 mph
LE 63.97	3820’	5%	86 mph
L 64.64	1910’	5%	61 mph
L 64.84	1910’	5%	61 mph
L 65.05	1910’	5%	61 mph
L 65.31	1507.9’	6%	56 mph
L 66.08	1146’	6%	49 mph
L 66.62	5730’	2%	93 mph
L 66.89	1146’	6%	49 mph
L 67.16	1432.5’	6%	55 mph

LE 67.50	6000'	4%	104 mph
LW 67.50	1433'	8%	59 mph
LW 67.80	1433'	7%	57 mph
LE 68.50	5000'	3%	91 mph
LW 68.50	2865'	4%	72 mph
LW 68.80	2865'	4%	72 mph
LE 69.10	3000'	6%	79 mph
LW 69.30	1636'	7%	61 mph
LE 69.70	2600'	7%	76 mph
LW 69.70	1636'	7%	61 mph

Justification for an Alternative Design Standard

The WSDOT Design Manual recommends a design speed for a divided multilane Interstate per Figure 440-4 of 80 mph, but note (3) states "with a corridor analysis, the design speed may be reduced to 60 mph for mountainous terrain and 70 mph for rolling terrain. Do not select a design speed that is less than the posted speed."

This project will not change the maximum posted speed within the corridor. Additional variable message signs will be added to expand the variable speed limit segment to include the portion of the corridor from Price Creek (MP 61.1) to Kachess River Bridge (MP 69.5). The variable speed limit segment will continue to have a maximum posted speed of 65 mph. The remaining portion of the corridor to MP 70.3 will continue to have a posted speed of 70 mph.

Terrain, environmental and constructability issues restrict the ability to achieve a desirable 80 mph design speed in the corridor. The WSDOT Design Manual allows for a minimum, as per Figure 440-4, design speed equal to but not less than the posted speed. Two design speeds are proposed for the corridor. A 65 mph design speed is proposed for the first section adjacent to Keechelus Lake and 70 mph for the second section from Keechelus Dam to Easton.

The rationale for the lower design speeds includes:

- The design of I-90 is limited by the topography throughout the corridor but is especially constrained by the Keechelus Lake shoreline and steep slopes above the highway. These features would constrain the design of specific curves, especially the 'Slide Curve' area, and deviations would be required regardless of the design speed selected.
- The existing geometry of I-90 across Snoqualmie Pass was not designed for higher design speeds. Immediately west of the project, the "Summit section" of I-90 is constrained by mountainous topography and has geometry well below the recommended Design Manual design speed of 80 mph with curves ranging

from 51 mph to 69 mph. Using a similarly low design speed of 65 mph along Keechelus Lake section will form a longer continuous stretch of highway with consistent geometry.

- More favorable topography within the second section of the corridor will allow of a slightly higher design speed of 70 mph without substantial impacts to adjacent sensitive areas. Using a slightly higher design speed in the second section of the corridor will also provide a transition between the lower speed geometry along Keechelus Lake and the higher speed geometry just east of the corridor.

- The design of I-90 should consider driver expectations associated with an improved alignment. It would be inadvisable to provide an improved alignment meeting a high design speed standard, when that high design speed can only be achieved in limited locations within the corridor due to terrain constraints.

Although operating speeds will likely continue to exceed both the design speed and the posted speed following the project, utilizing the proposed design speeds will correct substandard geometry, provide consistent design to meet driver expectations, and will provide a safer roadway than the existing conditions.

Design Decision

The use of a 65 mph design speed for the first section (MP 55.1 to MP 60.7) and 70 mph design speed for the remainder of the corridor (MP 60.7 to MP 70.3). See table 3

Table 3: Posted Speed and Design Speed within corridor

Segment	Limits[1]	Existing Posted Speed	Proposed Posted Speed	Existing Design Speed (Calculated)	Proposed Design Speed
Hyak to Keechelus Lake Dam	MP 55.1 to MP 60.7	Variable 65/60 mph max	Variable 65/60 mph max	51 mph – 79 mph	65 mph
Keechelus Lake Dam to Kachess River	MP 60.7 to MP 69.5	65/60 mph	Variable 65/60 mph max	49 mph – 104 mph	70 mph
Kachess River to West Easton Interchange	MP 69.5 to MP 70.3	70/60 mph	70/60 mph	61 mph – 76 mph	70 mph

1 The limits for the existing posted speed segments do not coincide exactly with those of the proposed posted speed segments. The limits shown in this table are for the proposed design speed and proposed posted speed segments.

Superelevation Rate Selection

WSDOT Design Manual Standard

Section 642.04 states "Base superelevation rate and its corresponding radius for open highways on Figure 642-3a, Superelevation Rate (10% Max.), with the following exceptions:

Figure 642-3b, Superelevation Rate (6% Max.), may be used under the following conditions:

1. Urban non-freeways.
2. Mountainous areas or locations that normally experience regular accumulations of snow and ice.
3. Short-term detours (generally implemented and removed in one construction season). For long-term detours, consider a higher rate up to 10%, especially when associated with a main line detour.

Figure 642-3c, Superelevation Rate (8% Max.), may be used for existing roadways, urban freeways, and areas where the 6% rate is allowed but will not work: for example, where a curve with a radius less than the minimum for the 6% rate at the design speed is required.

Proposed Design Standard

The use of the 8% maximum superelevation table, except for the use of the 10% maximum superelevation table for the westbound curve at MP 59.

Existing Conditions

The project corridor is in mountainous terrain and normally experiences regular accumulations of snow and ice. Many curves within the corridor and outlying areas have been constructed with superelevation rates ranging from 10% to normal crown.

Justification for an Alternative Design Manual Standard

Section 642.04 of the Design Manual states "Figure 642-3c Superelevation Rate (8% Max.), may be used for existing roadways, urban freeways, and areas where the 6% rate is allowed but will not work."

The design of I-90 is limited by the topography along the Keechelus Lake shoreline and steep slopes above the highway. These features constrain the design of specific curves, especially from Wolfe Creek (MP 57.2) to Resort Creek (MP 59.5). Multiple curves with radii's less than 1665 feet (the minimum radius for 65 mph design speed on the 6% chart) are needed to follow the shoreline of Keechelus Lake.

The corridor also contains one curve where the 8% maximum superelevation table will not work. It is located at 'Slide Curve'(MP 59) on the westbound alignment and is currently superelevated at 10%. This curve is constrained by steep rock slopes and the shoreline of Keechelus Lake, has a delta angle of approximately 90 degrees, and is impractical to realign. The existing radius of 1432 feet is less than the minimum radius for the 8% maximum superelevation table and for this curve, the 10% maximum superevelation table would be utilized.

Discussions with maintenance personnel and a review of the accident history at 'Slide Curve' do not indicate a problem with slow-moving vehicles sliding towards the inside of the curve during snow and ice conditions.

Design Decision

The 8% maximum superelevation rate table shown in Figure 642-3c will be used for the project corridor. At MP 59, where a curve with a radius less than the minimum for the 8% rate at the design speed is required, Figure 642-3a Superelevation Rate (10% Max.) will be used.