Chapter 2 Options Considered (Alternatives)

FHWA and WSDOT worked with other governmental agencies, tribes, partner organizations, and the public from 1996 to 2008 in an effort to develop and consider a full range of reasonable alternatives that address I-90 project needs. Chapter 2 of the 2008 Final EIS describes the alternative identification process and the range of alternatives analyzed. The alternatives addressed the entire 15-mile I-90 project corridor and included project elements that are outside the limited scope of this Supplemental EIS.

This Supplemental EIS focuses on design options that address project needs associated with the Existing Snowshed. Chapter 2 briefly summarizes the options previously considered by FHWA and WSDOT, followed by a detailed description of the options carried forward for further analysis.

2.1 What options did FHWA and WSDOT previously consider?

FHWA and WSDOT previously evaluated the following options that were included as part of one or more alternatives in the 2005 Draft EIS or 2008 Final EIS.

- Existing Snowshed: The Existing Snowshed and highway would be maintained and active management of avalanches and unstable slopes would continue. This option was part of the No-Build Alternative, which did not meet the project needs and was rejected in the 2008 ROD.
- Long tunnels: The Existing Snowshed would remain in place to preserve it as a historic site, and two 1.9-mile-long tunnels with three lanes in each direction would be built along Keechelus Lake. This option would completely bypass the avalanche zone and unstable slopes in the design modification area. The long tunnels were part of Keechelus Lake Alignment Alternative 1, which was rejected in the 2008 ROD due to the tunnels causing greater engineering risks, maintenance cost, operational difficulties, and environmental consequences.

> NEPA requires evaluation of a **No-Action (No-Build) Alternative**, which consists of continuation of the current management direction. Other alternatives considered in an EIS are commonly compared to the baseline set by the No-Build Alternative.

- Viaduct bridges: The Existing Snowshed would remain in place to preserve it as a historic site, and two long viaduct bridges would be built over a portion of Keechelus Lake. The viaduct bridges were part of Keechelus Lake Alignment Alternatives 2, 3, and 4 in the 2005 Draft EIS but were eliminated from further consideration in the 2008 Final EIS due to safety, constructability, and operational concerns (refer to Section 2.4).
- Selected Snowshed: The Existing Snowshed would be demolished; the highway would be re-built with three lanes in each direction; and the Selected Snowshed would be constructed over the highway. The Selected Snowshed was part of Keechelus Lake Alignment Alternatives 2, 3 and 4 in the 2008 Final EIS. Alignment Alternatives 2 and 3 also included short tunnels and were rejected in the 2008 ROD for the same reasons as Alignment Alternative 1. FHWA and WSDOT selected Alignment Alternative 4, including the Selected Snowshed, for construction in the 2008 ROD. Construction of the Selected Snowshed represents the baseline condition.

Keechelus Lake Alignment Alternatives 1, 2, 3, and 4, described in detail in Chapter 2 of the 2008 Final EIS, represent the range of build alternatives for the highway along the east shore of Keechelus Lake.

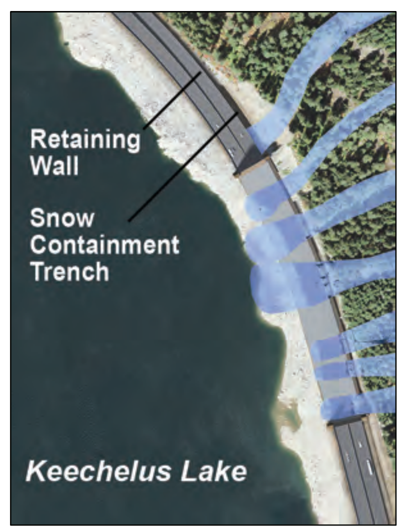
Alignment Alternatives 1, 2, and 3 included tunnels in different configurations and were rejected in the 2008 ROD due to the tunnels causing greater engineering risks, maintenance cost, operational difficulties, and environmental consequences.

2.2 What options are evaluated in this Draft Supplemental EIS?

This Draft Supplemental EIS compares the potential impacts of constructing and operating the Selected Snowshed to the potential impacts of the Proposed Bridges. The options that FHWA and WSDOT rejected during the NEPA process, concluding with the 2008 Final EIS and ROD, are not re-analyzed in this Draft Supplemental EIS.

Selected Snowshed

The Selected Snowshed option would include demolition of the 500-foot-long Existing Snowshed at MP 58.1 and replacement with a new 1,100-foot-long concrete structure (Exhibit 2-1). The Selected Snowshed would be constructed along the shoreline of Keechelus Lake, in the same general location as the Existing Snowshed. The foundation for the structure would be provided by a combination of spread footings and piers supported by drilled shafts that anchor into bedrock. The Selected Snowshed was designed in compliance with the WSDOT *Bridge Design Manual* (WSDOT 2011a).



The Selected Snowshed would cover all lanes of traffic and protect the traveling public from all but the westernmost avalanche path (design visualization shows avalanche paths in blue).

Exhibit 2-1
Selected Snowshed (Design Visualization)

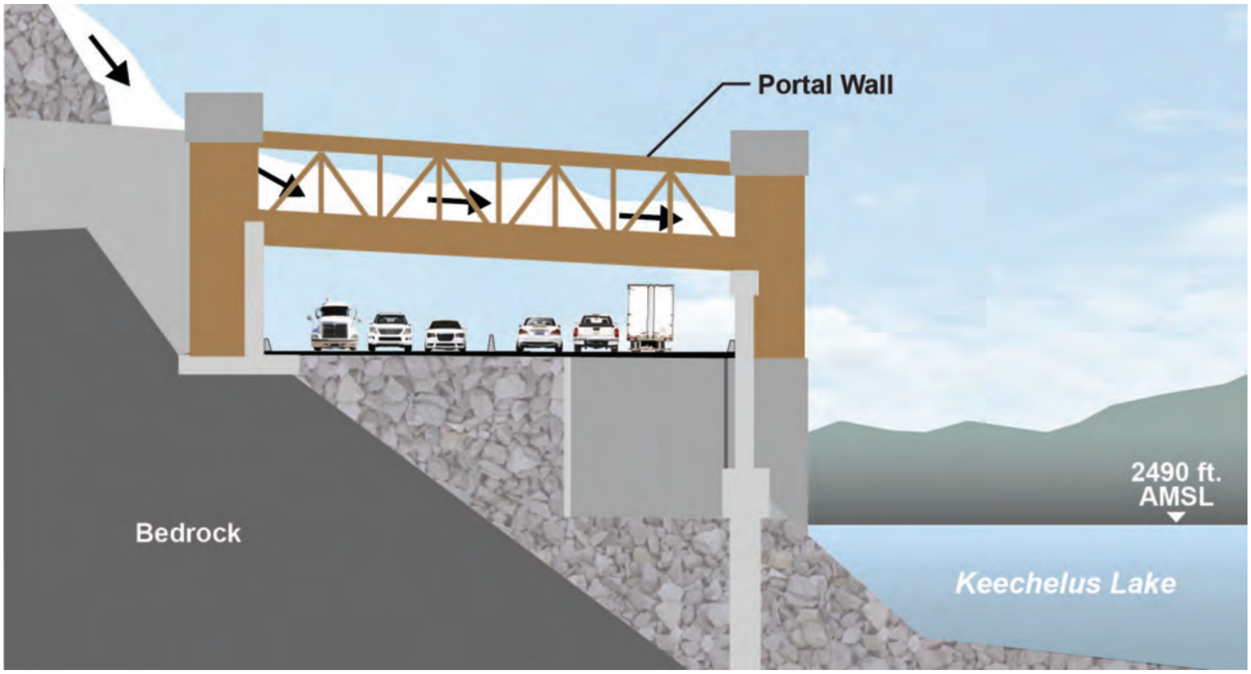
Lake elevation at 2,510 feet above mean sea level (AMSL)

This option would reduce risks associated with avalanches, rock fall, and landslides by covering all six lanes of traffic with a protective structure designed to withstand these events (Exhibit 2-2). Avalanches, rock, and debris from the adjacent hillside would pass over the top of the snowshed structure. The Selected Snowshed would protect the traveling public from all but the westernmost avalanche path, which does not produce powder avalanches that impact the highway in that area. A retaining wall and snow containment trench at the base of the hill along the westbound lanes would control the relatively small and infrequent dense flow avalanches known to originate from the westernmost avalanche path.

Avalanches occur when a mass of snow, ice, and debris fall rapidly down a slope. Those most commonly observed in the design modification area are characterized as **dense flow avalanches**, consisting of compacted, moist snow; and **powder avalanches**, consisting of fine particles of snow suspended in air.

An **avalanche path** is the natural route that snow takes as it travels down a slope.

Exhibit 2-2
Selected Snowshed Cross Section



The Selected Snowshed is designed to stabilize the abutting rock slope and protect traffic from falling rocks. Other measures to reduce rock fall include removing loose rock, rock bolting, shotcrete treatments, installing wire mesh over rock faces, and cutting back slopes to reduce steepness.

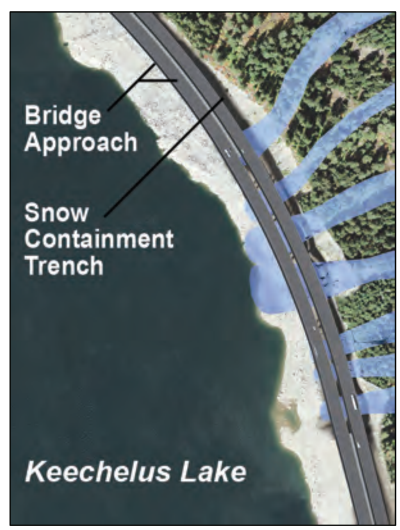
Proposed Bridges

The Proposed Bridges would replace the Existing Snowshed with eastbound and westbound avalanche bridges (Exhibit 2-3). The 1,200-foot-long bridges would accommodate three lanes of traffic plus shoulders in each direction along the shoreline of Keechelus Lake, in the same general location as the Existing Snowshed. A series of drilled shafts that anchor into bedrock would provide the foundation for the bridge structures. The eastbound bridge would be lower than the westbound bridge. Both bridges would be designed in compliance with the WSDOT *Bridge Design Manual* (WSDOT 2011a).

Exhibit 2-3
Proposed Bridges (Design Visualization)

Lake elevation at 2,510 feet AMSL

The Proposed Bridges would reduce risks associated with avalanches, rock fall, and landslides by removing and stabilizing loose material located upslope from the highway and by elevating and separating the highway from the hillside. This design allows avalanches, rock, and debris to pass under the highway without impacting traffic.



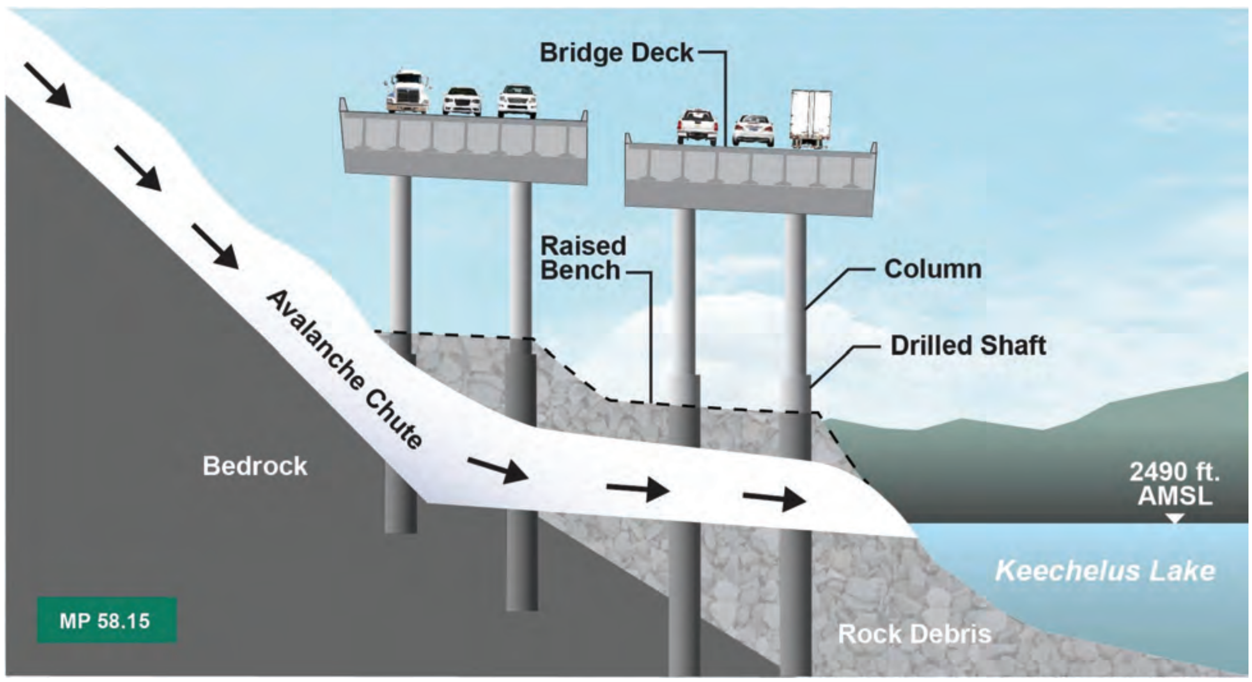
The Proposed Bridges would carry traffic over all but the westernmost avalanche path (design visualization shows avalanche paths in blue).

The Proposed Bridges would carry traffic over all but the westernmost avalanche path, which does not produce powder avalanches that impact the highway in that area. The west bridge approach, which functions as a retaining wall, and the adjacent snow containment trench would control the relatively small and infrequent avalanches known to originate from the westernmost avalanche path.

A combination of elevating the highway above the existing grade and excavating up to 50 feet of material below the existing grade would provide a total clearance beneath the bridge structures ranging between 40 and 70 feet. This space would accommodate accumulation of snow from snowfall, plowing, and avalanches with adequate space between the top of the accumulated snow and the bridge decks to protect motorists from additional avalanches. The storage area beneath the bridge structures would be engineered into a series of chutes that would direct sliding snow, rock, and debris between the bridge piers and toward the lake (Exhibit 2-4).

Avalanche chutes are the excavated and contoured paths underneath the Proposed Bridges that direct avalanches between the bridge piers.

Exhibit 2-4
Proposed Bridges Cross Section



The potential for the bridge piers to be directly impacted by avalanches and rocks is reduced by:

- locating bridge piers between avalanche paths where avalanche forces are less,
- placing the piers on raised benches, and
- building up fill material (rocks) around the piers to form chutes that direct avalanches and rocks between the piers.

However, the bridge piers are designed to withstand potential impact forces from avalanches, in the event that the chutes fill with snow and avalanches are diverted towards the piers.

The **bridge piers** include a drilled shaft and column, shown in Exhibit 2-4. A **raised bench** would protect the bridge piers from snow, rock, and debris directed into the avalanche chutes.

Techniques employed to stabilize slopes and reduce rock fall would include removing loose rock, rock bolting, shotcrete treatments, installing wire mesh over rock faces, and cutting back slopes to reduce steepness. These slope stabilization measures are designed to meet a factor of safety of 1.5, which indicates stable-slope conditions, accounts for variability of natural materials (soil and rock), and provides an extra safety margin. In addition, the westbound bridge would be horizontally separated from the hillside by 20 to 70 feet, providing space for falling rock and debris between the hillside and the bridge deck.

A **factor of safety** of 1 indicates driving and resisting forces are in equilibrium. A factor of safety less than 1 indicates driving forces are greater than resisting forces and the slope may move. A factor of safety greater than 1 indicates the resisting forces are greater than the driving forces and the slope is likely stable. Design standards often require a factor of safety between 1.25 and 1.5.

The design visualizations in Exhibit 2-5 illustrate the elevation of the Proposed Bridges relative to the Selected Snowshed (for a cross section graphic comparison, see Exhibit 3-15). The Proposed Bridges are designed at a higher elevation to accommodate the accumulation of snow and falling rocks under the highway.

Exhibit 2-5
Elevation Comparison of the Selected Snowshed and Proposed Bridges (Design Visualizations)

Selected Snowshed on Keechelus Lake shoreline at 2,490 feet AMSL (design visualization)

Proposed Bridges on Keechelus Lake shoreline at 2,490 feet AMSL (design visualization) with outline of Selected Snowshed shown in yellow

2.3 What are the avalanche design criteria?

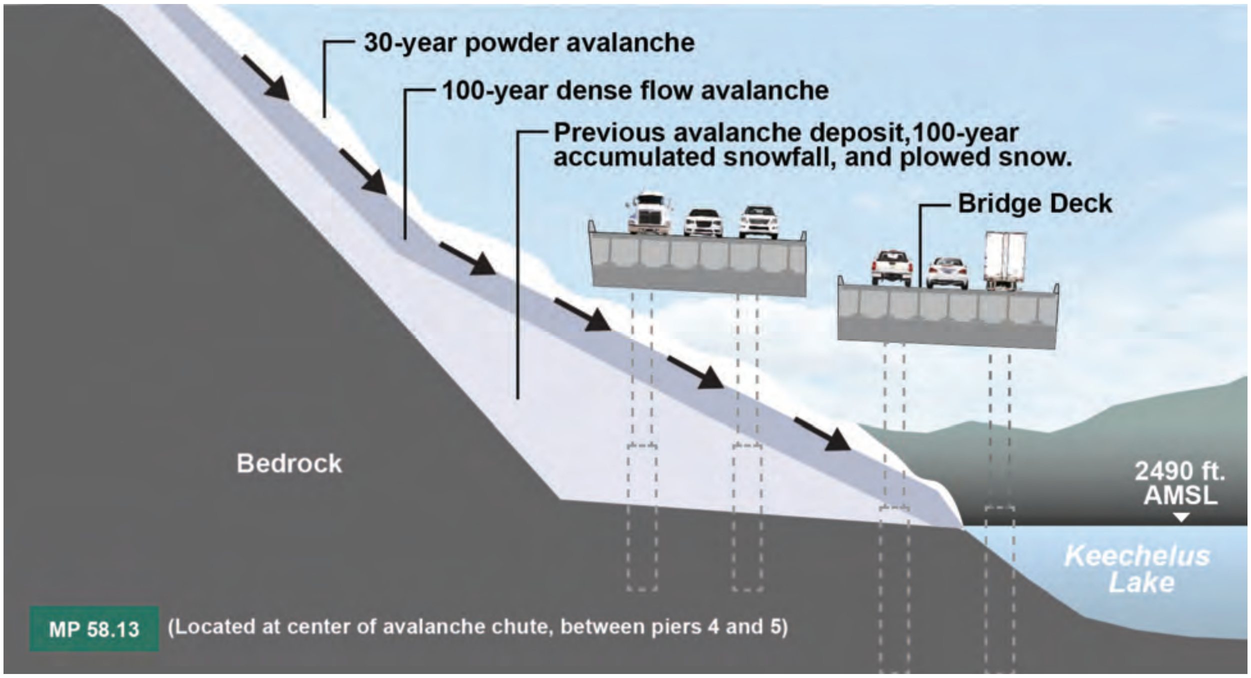
The following avalanche design criteria were established for the Proposed Bridges:

1. Dense flow avalanches up to a 100-year return period must pass underneath without impacting the structure.
2. The Proposed Bridges must provide sufficient clearance to accommodate the cumulative heights of the 100-year snowfall accumulation, plowed snow from the bridge deck, and prior avalanche deposits; plus a 100-year dense flow avalanche; plus a 30-year powder avalanche (Exhibit 2-6). This criterion is based upon these events occurring simultaneously to provide added protection.
3. The Proposed Bridges must be high enough so that vehicles are not impacted by powder avalanches more frequently than once in 30 years.
4. The bridge piers must be designed to withstand 100-year dense flow avalanche forces.

The Selected Snowshed was designed to meet equivalent criteria for 100-year snowfall accumulation and 100-year dense flow avalanches. These design criteria represent an adequate level of protection for the traveling public. The return periods used in these criteria were established based upon guidelines from Canada and Switzerland.

The terms **30-year or 100-year return period** are used to indicate the probability that an event of a certain magnitude will occur in any particular year. For example, a 30-year return period event has about a 3 percent chance of occurring in any particular year, and a 100-year return period event has a 1 percent chance of occurring in any particular year.

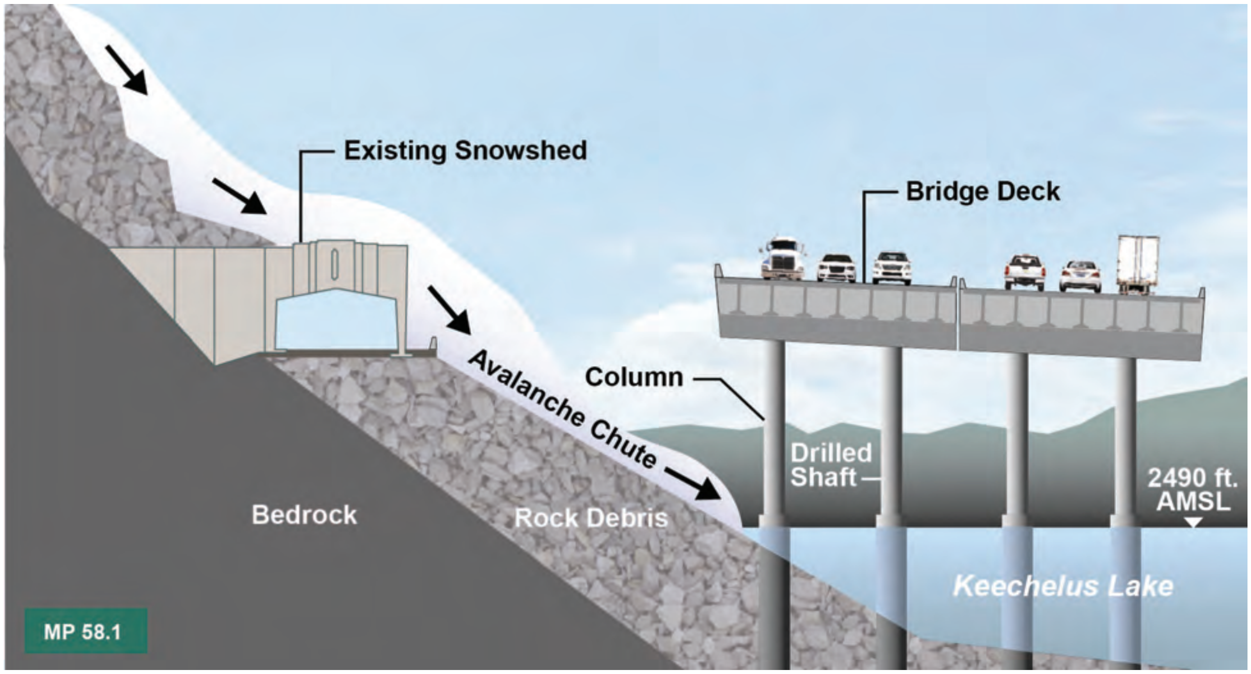
Exhibit 2-6
Maximum Snow Accumulation Underneath the Proposed Bridges



2.4 How do the Proposed Bridges differ from the viaduct bridges previously considered?

As noted in Section 2.1, FHWA and WSDOT previously considered viaduct bridges as part of Keechelus Lake Alignment Alternatives 2, 3, and 4 in the 2005 Draft EIS. The viaduct bridges option was designed to avoid impacts to the Existing Snowshed, which is a historic structure listed on the National Register of Historic Places (NRHP). As a result, the viaduct bridges were aligned farther from the hillside and spanned a portion of Keechelus Lake (Exhibit 2-7).

Exhibit 2-7
2005 Draft EIS Viaduct Bridges Cross Section



In November 2006, a value engineering (VE) team identified several serious concerns with the design of the viaduct bridges. These concerns ultimately led FHWA and WSDOT to consider "use" (removal) of the Existing Snowshed in the Section 4(f) Evaluation included as Chapter 5 of the 2008 Final EIS. Following a determination that there was no feasible and prudent alternative to avoid the use (demolition) of the Existing Snowshed, FHWA and WSDOT developed a Memorandum of Agreement with the Washington State Department of Archaeology and Historic Preservation (DAHP) that would mitigate for the removal of the Existing Snowshed. This resulted in replacement of the viaduct bridges with the Selected Snowshed as part of Keechelus Lake Alignment Alternatives 2, 3, and 4 in the 2008 Final EIS. Refer to Section 3.1 for a discussion of why the Programmatic Section 4(f) Evaluation in the 2008 Final EIS would apply to both the Selected Snowshed and the Proposed Bridges.

Exhibit 2-8 compares the viaduct bridges to the Proposed Bridges by presenting the design features side by side. It also summarizes the concerns with the viaduct bridges identified by the VE team and describes how these concerns are addressed by the proposed Bridges.

Value Engineering (VE) is a systematic method to improve the value of a project without sacrificing safety, necessary quality, or environmental attributes. VE involves a multidisciplinary team of people following a structured process.

Exhibit 2-8
Comparison between 2005 Draft EIS Viaduct Bridges and Proposed Bridges

	2005 Draft EIS Viaduct Bridges	Proposed Bridges
Design Features		
Bridge length	Two multiple span bridges (1,500 feet long and 1,200 feet long)	Two multiple span bridges (each 1,200 feet long)
Bridge height	Support structures 170 feet above bedrock	Support structures 110 feet above bedrock
Alignment	Spans a portion of Keechelus Lake	Stays along the Keechelus Lake shoreline
Value Engineering Team Concern with 2005 Draft EIS Viaduct Bridges		
Avalanche risk	Avalanche modeling indicated that a powder blast could deflect off the Existing Snowshed, causing white-out conditions that obscure visibility on the viaduct.	The Existing Snowshed and material from the hillside would be removed to provide sufficient clearance for dense flow and powder avalanches under the bridge structures, thereby minimizing white-out conditions.
Constructability	The lake in the location of the viaduct bridges is very deep, with a steeply sloping bottom and poor quality bedrock. Support structures would have been impractical to build.	Construction would occur on roughly the same horizontal alignment as the existing highway, avoiding very high support structures and deep in-water construction.
Construction safety and access	Access to the work area during construction would be limited by the narrow eastbound road shoulders and steep embankment slopes.	Access during construction would not be limited by the use of barges. Access along the shoreline would continue to be limited by narrow shoulders and steep slopes.
In-water work	Shafts would be constructed below the water level of Keechelus Lake.	Fewer shafts would be constructed, and they would be constructed in the dry, when lake levels are drawn down.

The engineering difficulties and construction risks associated with the viaduct bridges (Exhibit 2-8) approach the level of fatal flaws. The removal of the Existing Snowshed and the design of the Proposed Bridges along the Keechelus Lake shoreline address all of the concerns that made the viaduct bridges unacceptable.

2.5 How would the Proposed Bridges affect I-90 project costs?

Guy F. Atkinson Construction, the Phase 1C construction contractor, submitted a bid of approximately $177 million (2011 dollars) to construct Phase 1C of the I-90 project, which includes approximately

$71 million to construct the Selected Snowshed. Design, environmental analysis, and construction of the Proposed Bridges are anticipated to cost essentially the same amount (Exhibit 2-9).

Exhibit 2-9
Estimated Cost to Construct, Operate, and Maintain the Selected Snowshed and Proposed Bridges

	Selected Snowshed	Proposed Bridges	Difference
Estimated construction cost	$71 million	$71 million	None[1]
Estimated annual operation and maintenance cost	$750,000	$100,000	-$650,000
Estimated 75-year life-cycle operations and maintenance costs	$56 million	$8 million	-$48 million

[1] The construction contractor for Phase 1C submitted a no-cost change order to construct the Proposed Bridges instead of the Selected Snowshed.

The cost difference between the Selected Snowshed and Proposed Bridges is associated with operations and maintenance activities that WSDOT must perform to keep the highway open to traffic and in good condition. The estimated annual and 75-year life-cycle cost to operate and maintain each option is shown in Exhibit 2-9.

The Selected Snowshed would require ongoing maintenance of the electrical, lighting, ventilation, and fire and life-safety systems associated with the structure and infrequent clearing of debris from the snow containment trench. Maintaining these systems would require additional full-time WSDOT maintenance personnel in addition to standard upkeep costs. Local emergency service providers would also require specific training for a tunnel (snowshed) emergency response. The annual cost to operate and maintain the Selected Snowshed is estimated by WSDOT at approximately $750,000.

Ongoing maintenance of the Proposed Bridges would involve annual inspections, plowing and de-icing of the highway, and infrequent clearing of debris from the avalanche chutes and snow containment trench. For the first 20 years of the life of the bridge structures, existing WSDOT maintenance personnel would manage ongoing maintenance activities. Additional staffing may be required once the bridge structures age. Additional staffing is not included in the annual cost to operate and maintain the Proposed Bridges, which is estimated by WSDOT at $100,000. The potential annual savings in operations and maintenance costs ($650,000) is one of the primary benefits of the Proposed Bridges.

WSDOT is conducting additional analysis to determine the threshold at which an extreme avalanche event could affect each structure or impact traffic. The results of the analysis will help determine how often active avalanche control and snow removal may need to occur for each structure. These additional maintenance costs are expected to be minimal and are not included in the cost estimates provided in Exhibit 2-9.

The usable life of either structure can be extended by structural rehabilitation activities. Structural rehabilitation for the Selected Snowshed may include concrete roadway rehabilitation, roof expansion joints sealing, roof repairs, and corrosion repairs. Structural rehabilitation for the Proposed Bridges may include bridge deck rehabilitation, expansion joint replacement, and bridge column and grade beam repairs (R. Stoddard, pers. comm., July 26, 2012). Structural rehabilitation costs are not included in the operations and maintenance cost estimate for either option provided in Exhibit 2-9. However, WSDOT anticipates that these costs will be similar for either option (S. Golbek, pers. comm., August 3, 2012).